

**REPORT TO THE CONGRESS
FROM THE PRESIDENT OF THE
UNITED STATES**

**UNITED STATES
AERONAUTICS AND
SPACE ACTIVITIES
1961**

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January 1962

THE WHITE HOUSE
Washington

January 31, 1962

TO THE CONGRESS OF THE UNITED STATES:

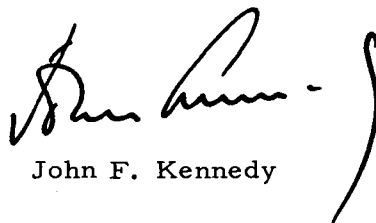
In accordance with Section 206(b) of the National Aeronautics and Space Act of 1958, as amended, I transmit herewith a report for the calendar year 1961, on this nation's aeronautics and space activities.

During 1961, major attention was devoted to establishing our policy objective of space leadership and to accelerating our efforts toward achieving that objective.

In my Message to the Congress on May 25, 1961, I stated that a leading role in space achievements may well hold the key to this country's future. That I reaffirm. Last year, we made necessary decisions and, with the support of the Congress, stepped up the pace of performance. Even greater strides must be made in the coming months and years, and thus the recommended budget which I submitted to the Congress earlier this month contains requests for funds for the Fiscal Year 1963 Space Program, totalling \$5.5 billion, an increase of \$2.4 billion over FY 1962 and \$3.7 billion over FY 1961.

It is the policy of the United States that activities in space be devoted to peaceful purposes and during 1961 we made significant progress in that regard. Such progress included space projects to help keep the peace and space projects to increase man's well-being in peace.

In summary form, the accompanying report indicates the contributions of the various departments and agencies of the government to a national space program.

A handwritten signature in black ink, appearing to read "John F. Kennedy", with a long, sweeping flourish extending to the right.

John F. Kennedy

TABLE OF CONTENTS

		Page
CHAPTER I	U. S. Aeronautics and Space Activities -- 1961 -- Summary.	1
CHAPTER II	National Aeronautics and Space Council. .	5
CHAPTER III	National Aeronautics and Space Administration	7
CHAPTER IV	Department of Defense.	33
CHAPTER V	Atomic Energy Commission	43
CHAPTER VI	Department of State	47
CHAPTER VII	National Science Foundation	51
CHAPTER VIII	Department of Commerce	55
CHAPTER IX	Space Science Board	67
CHAPTER X	Smithsonian Astrophysical Observatory. .	73
CHAPTER XI	Federal Aviation Agency	75
CHAPTER XII	Federal Communications Commission . .	81
CHAPTER XIII	United States Information Agency	85
APPENDIX A	Successful U. S. Launches -- 1961	91
APPENDIX B	NASA Launch Vehicles	103
APPENDIX C	The President's Policy Statement on Communication Satellites	105
APPENDIX D	Historical Summary and FY 1963 Budget Recommendations	107

Chapter I

U.S. Aeronautics and Space Activities 1961

SUMMARY

In 1961 the United States space program gained new impetus and breadth as vital decisions were made and essential actions taken.

Foremost was the national decision to land a team of U.S. explorers on the moon during the present decade -- a goal previously contemplated for the mid 1970's. This objective, moreover, became a part of a national space program, composed of many basic projects. To carry out this national program effectively and efficiently, the nation began marshalling scientific, technical, and physical resources.

Primarily for the lunar project but also for other space missions, actions to achieve far greater rocket thrusts and to build much larger spacecraft were undertaken during the year. For the same objectives, high priority was accorded projects to work out the techniques for rendezvous and docking (joining) of spacecraft in orbit around the earth.

Study was intensified on means and materials that will be required for safe return of the manned lunar spacecraft into the earth's atmosphere at 25,000 miles per hour, a speed that could heat the outside of the craft to about half the temperature of the sun's surface.

Programs to develop nuclear propulsion and power-generating equipment for a wide range of space missions were also accelerated and strengthened.

New emphasis was given to developing and putting to practical use, as rapidly as possible, technological capabilities for supporting manned space missions, with major attention to the essentials for the lunar project.

Concurrently, workable means were established to apply satellite technology for expanding world communications, weather observation and prediction, and navigational competence. In addition to the direct services performed, this effort contributed to the acceleration of the nation's economy, thus creating new products, processes, materials, and opportunities for employment of skills and investment funds.

This national space program, nourished by vital decisions and increased appropriations, was firmly based upon the awareness that space competence is as essential for national security as it is for national growth. Progress to help keep the peace through space capabilities is a basic feature.

In direct support of aeronautics, the United States embarked on a program to bring into operation by the end of the present decade an economically feasible supersonic transport airplane that will fly at 2,000 miles per hour -- three times the speed of sound.

In the aerospace sciences, fundamental knowledge on weather processes was gained, projects were begun to search for traces of life elsewhere in the universe, and the quest continued for knowledge of how the earth and the solar system originated.

The objective of this Nation is not solely to be first in exploring the space frontiers of knowledge -- although the United States is determined to be first. In the national interest, the United States must build the capacity to advance the most modern science and technology to the utmost, and extract from it the wealth of benefits it holds for this country's freedom, economy, professions, education, and standard of living. The defense aspects of this aerospace technology provide the opportunity to perform all such objectives by helping to insure against the possibility that the infinitely promising new dimension which human ingenuity has opened could be used for economic or military aggression against the free world.

Landing U.S. explorers on the moon will be a beginning, not an end. The expedition will establish a foundation of experience and competence upon which to build further progress in space. Even now, potentialities are being considered for a scientific base on the moon, just as there is at the South Pole. Also, unmanned and manned flights to Mars and Venus are being contemplated.

Our scientists are studying how to send unmanned, instrument-packed spacecraft to investigate the fiery regions near Mercury and the sun, and to the more remote reaches of the solar system where Jupiter, Saturn, Uranus, Neptune, and Pluto orbit in the frigid void, up to thousands of millions of miles distant from the sun.

During 1961, the Administration proposed, and Congress endorsed, accomplishment of the lunar mission before 1970 and a general acceleration and broadening of the nation's activities and goals in aeronautics and space. Among the many specific accomplishments during the year, the following are particularly noteworthy:

- ... Sites were selected for a complex of rocket and spacecraft fabrication plants and ground-testing and launching facilities bordering the Gulf of Mexico, in a year-around warm climate accessible to deep-water transportation.

- ... Industrial contractors, large and small, were put to work across the nation, designing and building the flight hardware and supporting ground installations most urgently required for the tasks ahead.

- ... The National Aeronautics and Space Administration was reorganized and highly qualified individuals were added to its staff.

- ... The first stage of the SATURN, the most powerful rocket known to exist in the world, was successfully flight-tested. In this test, the SATURN generated a thrust of almost 1,300,000 pounds at lift-off.

- ... Progress was made in accelerated efforts to develop nuclear rocket engines, as well as large solid- and liquid-fueled engines.

- ... In Project MERCURY, first stage of the U.S. manned space flight program, two American astronauts made suborbital flights; two

spacecraft -- one of them carrying a chimpanzee -- were flown around the world; and preparations were practically completed for the first manned orbital flight.

... Nuclear power sources (SNAP) were operated aboard earth satellites, for the first time in history.

... The North American Air Defense Command began operating a center to detect, track, and catalog objects in space, thus enhancing national security.

... Nine satellites -- the two in Project MERCURY and seven others in the DISCOVERER program -- have been recovered after orbital flights. Four of the DISCOVERER satellites were caught in the air as they parachuted toward the sea.

... The rocket-powered X-15 research aircraft established world speed and altitude records for the second successive year. The latest records were an altitude of 41.1 miles and a speed of 4,093 miles per hour, more than six times the speed of sound.

... Information obtained from a U.S. satellite appeared to discredit one version of a major theory of the origin of the universe, the so-called "steady state" theory.

... Three successful launches were conducted in Project TRANSIT, a program to develop a system of satellites that will make precise navigation at sea possible even when the stars are completely obscured by clouds.

... Two successful flights were conducted in Project MIDAS, a program to develop a reliable network of satellites that will detect ballistic missile launchings by the heat radiated from their rocket exhausts.

... Progress was made toward the establishment of an operational weather satellite network and the machinery for incorporating satellite information into weather forecasts. Meteorologists from 27 countries attended a conference sponsored by the Government to familiarize them with the system and necessary techniques for participating in it.

... The United Nations, at this nation's urging, unanimously adopted a resolution declaring that space and celestial bodies other than the earth are free for exploration by all nations and are not subject to national claims of sovereignty.

... The number of foreign countries and organizations with which the United States has agreements for peaceful space research grew to more than 50.

... The National Aeronautics and Space Act of 1958 was amended to make the Vice President Chairman of the National Aeronautics and Space Council. An Executive Secretary was appointed. The vitalized Council and its staff, in carrying out its statutory function, advised the President frequently during

1961 on important policy questions involved in planning the nation's space program, and engaged in a wide range of policy and coordination activities.

...A communications satellite policy, drafted and recommended by the Space Council and its staff, was issued. Steps were taken toward the development of an operational satellite communications system, with specific tests and basic legislation scheduled for 1962. (See Appendix C.)

The United States by law is required to share with the world the adventure, the scientific results, and the practical benefits emerging from its endeavors in aeronautics and space. Representatives of news media of many nations observed U.S. space launchings. Scientific results were reported promptly to the world scientific community. The U.S. Information Agency distributed information on the program abroad.

The United States placed more than 30 satellites in orbit during 1961, to bring our total above 60. A summary of successful launches is contained in Appendix A.

Chapter II

National Aeronautics and Space Council

The Vice President, as Chairman of the National Aeronautics and Space Council, made a summary report to the President on the Council's accomplishments in 1961. The text of that report follows:

Nineteen sixty one was a year of decision and progress in the space activities of the United States. Important strides were taken along the road of space successes through the combination of Presidential leadership, Space Council coordination and recommendations, and performance by the responsible operating departments and agencies. Private industry's participation and contribution increased accordingly.

While it is too early to make definitive comparisons as between our newly developing competence and the capabilities of the USSR, it is encouraging to note that the U.S. generated a greater rate of progress in 1961 than in any previous year or that of any other country.

The Space Council, authorized in 1958, was activated by the President in 1961. Initial actions to that end took the form of the appointment of an Executive Secretary in March and the amendment of the National Aeronautics and Space Act in April. The latter made the Vice President a member and the Chairman of the Council.

In performing its responsibilities of advising and assisting the President in the aeronautics and space field, the Council, directly and through its staff, engaged in a wide range of policy and coordinating activities. Among those activities were: recommending immediate step-up in the large booster program, which was translated into an FY 1961 supplemental request to the Congress; coordinating and assisting in the preparation of an across-the-board accelerated space program, which was reflected in a Presidential message and an expanded space budget for FY 1962; drafting and recommending a communication satellite policy, which was issued in July; coordinating the development of draft legislation on communications satellites, which is scheduled for submission to the Congress early in the coming session; obtaining greater uniformity in patent language, which is being reflected in defense contracts in the space field; coordinating the decision to include a nuclear power unit in a space satellite, which resulted in a world's first; and assisting in the drafting and coordination of the President's policy statement on the West Ford project.

Also, during the last nine months, a bill amending the National Aeronautics and Space Act was drafted; staff budgets were prepared for FY 1962 and FY 1963; a staff nucleus was employed; assistance was given in the drafting of a U.N. resolution on space; a number of space installations were visited; and testimony on various space problems was given before Congressional committees.

The Space Council held both formal and informal meetings on space budgets, communication satellites, organization of and coordination among agencies with space responsibilities, comparison of U.S. and USSR space accomplishments, and considerations of various recommendations for the President.

In addition, the Council staff maintained daily contacts between the various departments and agencies, received regular reports from and held frequent meetings with representatives of those agencies, initiated studies on the sovereignty limits of air space as well as in the field of aerospace medicine, and engaged in the coordination of the President's Annual Report to the Congress.

The Chairman understands that it is national policy to maintain a viable national space program, not a separate program for NASA and another for Defense and still another for each of several other agencies. Likewise, it is understood that the United States does not have a division between peaceful and non-peaceful objectives for space, but rather has space missions to help keep the peace and space missions to improve our ability to live well in peace.

The direction of the Council has been in accord with those principles.

Chapter III

National Aeronautics and Space Administration

INTRODUCTION

The National Aeronautics and Space Administration conducts a broad range of aeronautical and space activities. Major programs are manned space flight, including the development of powerful launch vehicles and advanced spacecraft; scientific investigation of the atmosphere, space, the moon, and nearby planets; practical applications of space technology; and advanced aeronautical and space technology. The key development in the space program during 1961 was the national decision to explore the moon before the present decade ends. NASA reorganized its management structure to meet the challenge of this and other objectives.

MANNED SPACE FLIGHT

Project MERCURY

The first U. S. manned space flight program, Project Mercury, neared the goal of placing an astronaut in orbit around the earth. The year saw a progression of accomplishments, highlighted by the manned suborbital flights of astronauts Alan B. Shepard, Jr., and Virgil I. Grissom, and the two-orbit flight of a spacecraft carrying the specially trained chimpanzee Enos.

The knowledge derived from Project Mercury to date has provided a firm foundation for the paramount objective of the Manned Space Flight Program -- landing a team of U. S. explorers on the moon within the decade.

Project Mercury has provided a basis for the development of spacecraft life support systems. The reactions of animals and men under high stresses of acceleration and deceleration, and weightlessness have been determined. The United States has learned how well men can operate controls and instruments, what they can observe to supplement the information obtained by automatic devices -- in short, how man's intelligence and abilities can be geared in as an operating component of a spacecraft system.

As the year ended, the knowledge and experience gleaned from previous suborbital and unmanned orbital flights were being utilized in final preparations for the first manned orbital flight.

Mercury Technical Progress -- Of 10 flights conducted in 1961 all but two accomplished their mission objectives. Major technical achievements included: (1) reliability improvement of the Atlas launch vehicle to meet the more stringent requirements of manned flight; (2) qualification of the Mercury spacecraft and its subsystems; (3) completion and staffing of the 18-station worldwide Mercury Tracking and Ground Support Instrumentation Network; and (4) achievement of operational status for launching, flight, and ocean recovery techniques.

"Little Joe" Escape and Recovery Systems Tests -- On March 18, in a launch from Wallops Island, Virginia, a Little Joe failed in a test of the spacecraft escape system when the escape rocket fired 14 seconds prematurely. The craft survived in sound condition, and provided an unexpected bonus -- a demonstration that it could withstand the shock of parachute-opening pressures greater than design limits.

The experiment was repeated on April 28, using the same Mercury spacecraft that had been flown on March 18, this time successfully. The spacecraft performed well and was recovered in excellent condition.

Redstone Suborbital Flight Tests -- Four flights -- two manned -- were conducted during 1961 in the suborbital phase of Project Mercury. A modified Redstone launch vehicle was employed.

On January 31, a Mercury spacecraft carrying the chimpanzee Ham was launched on a 16-minute flight, to an altitude of 156 miles, and over a distance of 420 miles. The mission objectives -- flight test of the spacecraft and its life-support system-- were achieved.

Knowledge gained from the flight enabled correction of malfunctions in the Redstone launch vehicle. As a result, the Redstone qualified for manned flight on March 24, when it successfully carried a boilerplate spacecraft to an altitude of 115 miles and a downrange distance of 311 miles.

The first manned suborbital flight, on May 5, carried astronaut Alan Shepard to an altitude of 116 miles and a peak velocity of 5,180 miles per hour. The 2,800-pound spacecraft touched down in the Atlantic Ocean 15 minutes and 22 seconds after lift-off, 302 miles downrange from Cape Canaveral.

Shepard underwent five minutes of weightlessness and experienced maximum acceleration of 11 times normal gravity on entry into the atmosphere. Nevertheless, he continuously carried out his assigned tasks, including manual control of spacecraft orientation, a task not known to have been previously performed in space.

During the launching, radar observations were continuously transmitted to Goddard Space Flight Center, Greenbelt, Maryland, where two electronic computers calculated the impact point. The calculation, made a few seconds after the engine cut off, was transmitted to the aircraft carrier USS Lake Champlain and enabled helicopter pilots to take off from the carrier and arrive at the impact point seven miles away, before the spacecraft. In the water, Shepard climbed out of the spacecraft, was hoisted into the helicopter, and was on the deck of the Lake Champlain 11 minutes later -- 26 minutes after Redstone liftoff.

Astronaut Grissom's suborbital flight, on July 21, carried him to an altitude of 118 miles and to a distance of 303 miles downrange. The launching and flight phases of Grissom's mission were successful. However, the spacecraft was lost in the sea. Premature opening of a new quick-acting escape hatch allowed sea water to swamp the spacecraft before the hovering helicopters could retrieve it.

Except for the information recorded by on-board cameras, all scientific data were telemetered to ground stations during the flight. Analysis of the information obtained on Grissom's flight indicated that the objectives of the suborbital phase of

Project Mercury had been achieved, and no further suborbital flights were scheduled.

Atlas Entry and Orbital Flight Tests -- Unforeseen structural weaknesses in the initial Mercury-Atlas vehicle were corrected and the vehicle was successfully tested during its second launching on February 21, 1961. At that time the spacecraft was fired on a trajectory that carried it to an altitude of 107 miles and 1,425 miles down-range from Cape Canaveral. The spacecraft withstood entry into the earth's atmosphere under conditions of the most severe heating that could occur in an emergency following orbital flight.

After a launching difficulty on April 25, when a faulty programmer caused the third Mercury-Atlas to veer off its flight path, the recovered spacecraft was launched by another Atlas on September 13, and successfully orbited the earth.

The spacecraft, which was recovered from the Atlantic Ocean 160 miles east of Bermuda, carried a fully operational life-support system, tested by a mechanical device simulating an astronaut, which consumed oxygen, expelled carbon dioxide, and discharged heat and moisture much as a man would in the course of normal breathing. A tape recorder broadcast pre-planned messages to stations in the world-wide Mercury tracking network.

The Atlas performed well again on November 29, when it launched a spacecraft carrying the chimpanzee Enos on a two-orbit flight. The flight was scheduled for three circuits but the spacecraft and its passenger were brought down at the end of its second orbit because the stabilization system was beginning to malfunction. The craft was successfully recovered from the Atlantic 220 miles southeast of Bermuda, and provided information of great value in preparations for the first manned orbital flight.

In 1962, NASA plans several manned flights of three orbits each. When the objectives of that phase of the program are completed, flights lasting up to 24 hours will be made.

Project GEMINI

NASA's second-phase manned space flight program -- approved December 7, 1961 -- is Project GEMINI (named for the twin stars Castor and Pollux). Its objectives are to: (1) develop and fly at an early date, a two-man spacecraft capable of rendezvous and being brought together (docking) with another vehicle in orbit about the earth, and (2) carry out orbital flights lasting from a few days to a week to study how man functions under prolonged conditions of weightlessness and to carry out a variety of scientific investigations of space that require men to participate and supervise.

Project GEMINI is supporting research and development for Project APOLLO, in which the technique of rendezvous and docking is expected to be used as the primary method of carrying out the mission of landing a manned expedition on the moon.

The GEMINI spacecraft will follow the same basic design as the one-man MERCURY spacecraft. The new craft will weigh about twice as much as the MERCURY spacecraft and is scheduled to be boosted into orbit by a TITAN II launch vehicle.

Plans call for the target vehicle for the rendezvous experiments to be an unmanned

AGENA B rocket stage, launched into orbit by an ATLAS booster. Ground tracking stations will observe its orbit and feed the information into a computer, which will calculate the proper moment for launching the TITAN-boosted GEMINI spacecraft. Then, with both craft in orbit, rockets aboard the GEMINI and the AGENA B can be used to maneuver the two for rendezvous and docking.

NASA's present seven astronauts will be eligible to serve as pilots in the GEMINI program. Additional crew members will probably be trained during later phases of the project.

Project APOLLO

Beyond GEMINI is Project APOLLO, the development of a three-man spacecraft for up to two weeks' orbit about the earth, flights around the moon, and manned lunar landing.

Flight hardware development for APOLLO began during 1961. Since analysis showed that the longest lead time was involved in the guidance and navigation system and its associated computer, a contractor for that part of the system was selected August 9, more than three months in advance of the selection of the prime spacecraft contract.

November 28 the prime contractor was selected to design and develop two of three major APOLLO units or "modules." The first is the command center, housing the three-man crew; the second is the service unit, containing fuel, electric power supplies, and propulsion units for lunar take-off. A contract to develop the third unit containing rockets to decelerate the spacecraft for a gentle landing on the moon will be awarded during 1962.

Rendezvous Approach Selected -- In December 1961, it was decided that the rendezvous approach offers the earliest chance of accomplishing the manned lunar flight. However, the direct ascent approach, which will require a larger launch vehicle, will also be pursued.

Launch Vehicles for Manned Space Flight

Five launch vehicles are planned for the manned space flight programs leading to the manned lunar landing. In ascending order of size, they are the ATLAS, the TITAN II, the SATURN C-1, the ADVANCED SATURN, and the NOVA.

Of the five vehicles, ATLAS was operational, SATURN C-1 first stage was successfully flight-tested once during 1961, and the TITAN II was nearing the flight-test phase by the end of the year. Development of the ADVANCED SATURN was begun in late 1961, while NOVA development is to be started during 1962.

First Stage SATURN Test Successful -- On October 27, NASA conducted from Cape Canaveral a successful initial flight test of the first stage of the SATURN C-1 -- the most powerful rocket known to exist in the world. The SATURN first stage (designated S-1) is a cluster of eight engines that produce 1,500,000 pounds of thrust -- more than four times the lift-off thrust of the ATLAS, the most powerful U. S. launch vehicle now in use for space projects.

The take-off thrust achieved on October 27 was 1,296,000 pounds. The vehicle, carrying two water-filled upper stages as ballast, reached a peak altitude of 84.8 miles

and maximum velocity of 3,607 mph before plunging into the Atlantic Ocean 214.7 miles downrange from Cape Canaveral 8 minutes and 3.6 seconds after launching.

A contractor was selected on November 17 to fabricate, check out, and test later models of the S-I at the NASA Michoud Operations, New Orleans, Louisiana.

Earth-orbital APOLLO flights will utilize a two-stage SATURN launch vehicle. The second stage, under development in 1961, utilizes a high-energy rocket fuel, liquid hydrogen, with liquid oxygen, and consists of a cluster of six engines similar to those used in the upper stage of the CENTAUR vehicle. Total thrust will be 90,000 pounds.

ADVANCED SATURN for Circumlunar Flight -- During 1961, NASA began developing a much larger launch vehicle, the ADVANCED SATURN, which will propel the APOLLO spacecraft on its second mission, the flight around the moon. Five single-chamber F-1 rocket engines will make up the first stage. Each will generate a thrust of 1,500,000 pounds, equal to the thrust of all eight engines of the SATURN C-1 first stage. A prime contractor was selected on December 15 to develop the first stage at Michoud.

The second stage will also have five clustered (J-2) engines, each of which will burn liquid hydrogen as fuel and will generate 200,000 pounds of thrust. The vehicle will be capable of completing missions even if one of the engines in the second stage fails. On September 11, NASA announced selection of a contractor to develop this stage.

On December 20, NASA announced selection of a prime contractor to develop and build the third stage, a modification of the SATURN C-1 second stage, which will utilize a single J-2 engine.

The three-stage ADVANCED SATURN will stand about 275 feet tall, about the height of a 27-story building. As noted above, the ADVANCED SATURN may also be employed for the lunar landing itself, if the rendezvous technique proves feasible in time.

NOVA Vehicle for Direct Ascent -- The NOVA, a vehicle still larger than the ADVANCED SATURN, will be required to propel a manned spacecraft to the moon by direct ascent from a single launching, and for manned exploration beyond the moon.

NOVA will be about 280 feet tall. Its first stage will consist of eight F-1 engines with a total thrust at take-off of 12 million pounds. This stage will have a diameter of about 50 feet and will carry more than 3,000 tons of liquid oxygen and kerosene. Since it is only through the use of liquid hydrogen fuel in upper stages that a NOVA of manageable size can be built, NASA decided at the end of the year to develop a third liquid hydrogen engine, which will deliver 1.0-1.2 million pounds of thrust, six times the power of the J-2. The new engine is termed the M-1.

The second stage of the NOVA will consist of four M-1 engines, with a thrust totaling 4,800,000 pounds. It will carry about 1,000 tons of liquid oxygen and liquid hydrogen and will have the same diameter as the first stage.

The third stage of NOVA will be similar in many respects to the third stage of ADVANCED SATURN. This is the reason: when two ADVANCED SATURN launch vehicles attempt rendezvous, they will place the third stage and the APOLLO spacecraft into orbit in separate packages. After the two have docked together, the rocket stage will be ignited in orbit for the flight to the moon. NOVA will place its third stage and the APOLLO spacecraft into orbit as a single package. Then the NOVA third stage will be ignited in orbit for the flight to the moon.

The characteristics of launch vehicles, scheduled for NASA projects, are summarized on the accompanying chart. (See Appendix B.)

Facilities Construction -- Construction of facilities -- for fabrication, ground testing, and launching -- is the portion of the large rocket development work that sets the pace, because it must take place earliest. During 1961, NASA took steps to acquire these facility sites for ADVANCED SATURN at New Orleans, southwest Mississippi, and Cape Canaveral.

SPACE SCIENCES

Scientific Advances

The year 1961 saw a great outpouring of advances in knowledge resulting from space experiments conducted by the United States, both from flights made during the year and analysis of information obtained earlier.

It is noteworthy that so much of the U. S. space program is conducted in the open, with prompt announcement of results to the scientific community, both in this country and abroad. This practice of "openness" has not only made clear to all that our space objectives are peaceful but it has contributed to the quality of the scientific accomplishments. The interchange of results and theories has enabled scientists to test interpretations against those of their colleagues and increase thereby man's understanding of the unknown.

One Version of Steady State Theory Discredited -- A most important scientific result was the discrediting of one major theory of the origin of the universe, a version of the so-called "steady state" theory. The steady state theory holds that matter is being continuously created in space at a slow rate, thus creating in time new stars and galaxies in the voids between those existing, which appear to be rushing apart at enormous velocities. The theory held that the appearance of new stars and galaxies would maintain a steady state of star and galaxy distribution in any given region of the universe.

However, if matter were being created continuously, there would have to be steady production of gamma rays in space. The gamma rays could not be detected from the earth's surface, because they would be absorbed by the atmosphere. However, they would be detected by instruments aboard a satellite orbiting above the earth.

On April 27, 1961, NASA launched a satellite, EXPLORER XI, with instruments to detect gamma radiation. The radiation detected was 1,000 times less than it would have to be in the case in which both matter and antimatter are created at equal rates. Antimatter is material which combines with ordinary matter as we know it to the annihilation of both. Thus, as a result of the EXPLORER XI experiment that version

of the steady state theory which assumes that both matter and antimatter are created at equal rates must be discarded. This still leaves the possibility of a continuous creation of matter, however.

Other Advances -- Major scientific advances during the year included:

... Discovery that a layer of helium surrounds the earth between altitudes of 600 and 1,500 miles. This was found through analysis of information gathered by EXPLORER VIII, launched November 3, 1960.

... Magnetic fields in the space between the planets were found to be far more intense than had previously been believed. EXPLORER X, launched on March 25, 1961, also discovered that the terrestrial field merges with the interplanetary magnetic field at a distance of about 40,000 miles from earth.

... The radiation zone surrounding the earth -- named after its discoverer, James A. Van Allen of the State University of Iowa, -- was found to consist of a single system of charged particles, trapped by the earth's magnetic field, rather than several belts. Data from EXPLORER XII, launched on August 15, showed that the outer portion of the Van Allen zone contains a large number of low-energy protons, and that the intensity of electrons in this portion is one thousand times less than interpretation of previous measurements had indicated. The EXPLORER XII data did not materially change previous findings that the inner portion of the zone is dominated by high-energy protons.

... Seventy "sounding" rockets were launched from Wallops Island, Virginia, Fort Churchill, Canada, and Woomera, Australia, on short-range flights to gather scientific information in space.

... Observations of nine very hot stars with instruments carried above the atmosphere by sounding rockets indicated that these stars behave in quite a different manner than can be explained on the basis of present knowledge, acquired from observations of the sun. Scientists at NASA's Goddard Space Flight Center believe that the laws of chemistry are reversed on such stars, allowing the element helium to form compounds.

Spacecraft and Launch Vehicles for Unmanned Scientific Projects

During 1961, substantial progress was made in the development and testing of spacecraft and launch vehicles for use in far-reaching experiments scheduled for 1962 and the years following.

Spacecraft Tests -- During the year, the RANGER spacecraft, boosted by the ATLAS-AGENA B launch vehicle made its first two test flights. The ATLAS performed properly, but the AGENA B upper stages failed to re-ignite on both occasions. As a result, the spacecraft remained in low earth orbit, instead of following its programmed trajectory, a highly elliptical path that would have carried it several hundred thousand miles from the earth.

Orientation control in the RANGER spacecraft operated satisfactorily on the first flight. On the second, the control equipment was not operated. Corrective action has been taken to prevent repetition of the AGENA-stage re-ignition failures. The schedule calls for three missions to rough-land instrumented RANGER spacecraft

on the moon, during 1962.

In August 1961, the RANGER program was augmented by four additional flights planned for 1963. The purpose will be to obtain information about lunar conditions upon which to base plans and spacecraft design for manned flights. High-resolution photographs will be made and televised to earth as the spacecraft approaches the moon. Six cameras will obtain pictures in far greater detail than would be possible with earth-based telescopic techniques.

Vehicle Changed for Venus Flight -- During the year, a decision was made to employ the ATLAS-AGENA B launch vehicle to power two unmanned missions to the vicinity of Venus. Both are selected for the summer of 1962, so that they will arrive near Venus at the time of that planet's closest approach to the earth. Earlier plans called for use of the CENTAUR, a much more powerful launch vehicle. However, the CENTAUR will require testing beyond that date before it will become operational.

The CENTAUR will be the first U. S. launch vehicle to burn liquid hydrogen, a fuel that provides 30 percent greater performance than conventional liquid-rocket fuel, a refined form of kerosene.

During 1961, a CENTAUR ignition fault that had caused a series of explosions on the test stand was corrected. Recent static runs give assurance that the engine is now qualified for flight testing, for which final preparations were under way at Cape Canaveral as the year ended.

Vehicle Development Progress -- All in all, five launch vehicles for unmanned missions are being developed. In descending order of size, they are CENTAUR, ATLAS-AGENA B, THOR-AGENA B, DELTA, and SCOUT.

The THOR-AGENA B vehicle has been used extensively in the DISCOVERER program. The first NASA flights, however, will be in 1962, when the vehicle will be employed to launch a Canadian scientific satellite and a NIMBUS meteorological satellite from Point Arguello, California.

DELTA is a two-stage vehicle consisting of a modified THOR and an improved version of the second stage of VANGUARD. Following an initial failure in 1960, DELTA scored a series of five successes, proving a high degree of reliability. Originally, the program called for only 12 vehicles. However, in view of its reliability and relatively low cost, NASA decided in 1961 to procure an additional 14 vehicles. DELTA is to be used to launch further weather satellites in the TIROS series, experimental communication satellites (TELSTAR, RELAY, SYCOM), and several scientific satellites.

The all-solid-propellant SCOUT, smallest and least expensive of the U. S. launch vehicles, boosted its first satellite into orbit on February 16, 1961. This satellite EXPLORER IX, an aluminum-coated plastic balloon 12 feet in diameter, was also the first launched from Wallops Station, Virginia. Continued analysis of the orbit of EXPLORER IX is being made to learn more about the density of the gases between altitudes of 400 and 1,500 miles.

By the end of 1961, seven of eight launches in the SCOUT development program had been completed. Four were successful. At present, 30 operational SCOUT vehicles are on order.

Spacecraft Programs Take Form -- Nineteen experimenters were chosen to take part in the first flight of the Orbiting Geophysical Observatory (OGO), scheduled for late 1963. The OGO is a heavy, multi-purpose scientific spacecraft, which will be launched at regular intervals, carrying whatever scientific experiments are ready for flight at the time.

Plans to investigate the possibility of life on Mars were added to the NASA program during 1961. Instruments to detect the presence of bacteria and other living organisms will be landed on that planet in 1964 and 1966.

APPLICATIONS

Communication Satellites

Research and development work in the area of communications satellites has been expanded and accelerated to provide the technology upon which to base an operational system.

Satellites orbiting far above the surface can increase greatly the range of radio transmissions around the curvature of the earth. Radio signals in many channels, or frequency ranges -- FM and television are familiar examples -- pass through the ionosphere and are not reflected back to earth. Such signals can be reflected back from satellites and distributed.

Communications satellites now under development are of two main types, active and passive. Equipped with radio receivers and transmitters, an active satellite receives signals from the earth surface and transmits them back to earth where they may be received at properly equipped terminals. The passive satellite carries no radio equipment. It serves as a mirror or reflector in space from which electronic signals can be bounced.

NASA's first communications satellite, ECHO I, launched August 12, 1960, was of the passive type. A 100-foot aluminum-coated plastic balloon, orbiting at about 1,000 miles, ECHO proved the feasibility of using passive satellites as radio communications reflectors. A larger ECHO, 135 feet in diameter and having a more rigid construction, has been developed for launching in 1962.

NASA has also initiated three active communications satellite programs, all scheduled for test launchings during 1962. They are: RELAY, TELSTAR, and SYNCOM.

The RELAY and TELSTAR satellites will be launched into orbits having maximum altitudes of 3,000 miles. Although differing in some technical details, both satellites are designed to demonstrate transoceanic television, and multi-channel voice and telegraph communication. Each will carry scientific experiments to produce information about effects of the space environment on electronic components.

For the RELAY experiments, NASA will make use of ground stations owned by two private communications concerns at Andover, Maine, and Nutley, New Jersey. Overseas, ground stations will be provided by communications organizations in England, France, West Germany, and Brazil.

Under the terms of the agreement on Project TELSTAR, which is being funded by a private company, the Government will obtain the right to make inventions arising out of work under the agreement generally available to interested U. S. companies on a royalty-free basis. The Government will have similar rights with regard to inventions arising out of work by the private company on satellite communications systems during the life of the agreement.

In Project SYNCOM, an experimental 55-pound satellite will be launched into an orbit 22,300 miles above the earth. At that altitude, the satellite will revolve about the earth once in every 24 hours -- in other words, the orbit will be synchronous with the rotation of the earth. A synchronous satellite above the earth's equator will appear to hover in a stationary position above a fixed point on the surface. However, in this first experiment, the orbit will not be directly over the equator, but will be inclined at an angle of 30 degrees. As a result, the satellite will appear to wander north and south of the equator. Three so-called "24-hour" satellites -- one above the Atlantic Ocean, one above the Pacific Ocean, and one above the Indian Ocean -- could provide communications relay between almost every area on earth. The Department of Defense is cooperating in Project SYNCOM by furnishing ground stations and performing voice and telegraph experiments.

Also during 1961, NASA initiated industry studies of a program for orbiting three or more ECHO II satellites on a single launching. The program, called Project REBOUND, has the aim of reducing the unit cost of communications satellite launchings.

Telecommunications Channels -- NASA is using the present radio communication channels set aside for space research and has continued its efforts to obtain additional channels, leading toward allocations for a commercial communications satellite network. In addition, effort is being made to protect already assigned frequencies against interference from other radio users.

The main NASA activity in this field consisted of promoting and assisting in the preparation of the preliminary views of the United States on space frequency allocation and organizing the U. S. space telecommunications study group of the International Radio Consultative Committee, both providing the groundwork for a special meeting of the International Telecommunications Union (ITU), tentatively scheduled for late 1963. NASA worked with the Federal Communications Commission and the Inter-agency Radio Advisory Committee in preparing the U. S. position. Present allocations of frequencies are based on agreements reached at the last world-wide radio conference, held at Geneva, Switzerland, in 1959. At that time, 13 narrow frequency bands were set aside for use in space research. Present experiments and those clearly foreseeable will have much greater requirements.

During the year, NASA represented U. S. civilian space interests on the Telecommunications Planning Committee (TPC); advised the Office of Emergency Planning (OEP); prepared technical space-communications studies for the Study Groups IV (Space Telecommunications) and VIII (Broadcast Monitoring) of the International Radio Consultative Committee of the ITU; and regularly consulted with the Space Science Board of the National Academy of Sciences, the International Radio Scientific Union (URSI), and the National Bureau of Standards' Central Radio Propagation Laboratory (CRPL). Informal consultations with the communications and frequency offices of the military services were held.

Meteorological Satellites

Substantial progress has been made in the development of meteorological satellites and in arrangements for other nations to participate in and especially to benefit from the program. Among the 1961 highlights:

... TIROS II and III were launched successfully and furnished quantities of meteorological data of high value for both research and day-to-day forecasting.

... Decision was made and funds were appropriated for the development of a satellite observing system to become an integral part of the over-all weather observing and forecasting system.

... Representatives of 27 nations attended the first International Meteorological Weather Satellites Workshop, held in Washington under the auspices of NASA and the Weather Bureau.

Results of the TIROS II and TIROS III satellite tests, and discussion of international cooperative arrangements, and of future plans are contained in the chapter on Weather Bureau activities later in this report.

TIROS Series Progress -- TIROS II, launched November 23, 1960, far exceeded the original three-month estimate of its useful lifetime. Until late in October 1961, this developmental weather satellite continued to provide useful meteorological information. In January, for example, TIROS II photographed sea ice in the Gulf of the St. Lawrence. About two months later, its photos for several days progressively recorded the changes in the ice-covered area. The pictures were excellent indications of how weather satellites can be employed to show clearly the boundaries between ice pack and open water, data obviously of great utility for assessing weather and navigation conditions in sea lanes near the Arctic and Antarctic and for similar analyses of freeze and thaw circumstances in inland regions such as the Great Lakes.

TIROS II also aided forecasters with information on weather conditions for the Project MERCURY suborbital flight in May and for the launching of RANGER I in July.

TIROS III was launched on July 12, 1961, and was placed in a near-circular orbit at an altitude of about 475 miles. Popularly known as the "Hurricane Hunter," TIROS III further demonstrated the feasibility of operational weather satellites by again showing that the data could be used for daily weather analysis. Details are set forth in the Weather Bureau chapter of this report.

ADVANCED RESEARCH AND TECHNOLOGY

Research Supporting Space Activities

During 1961, NASA conducted research on the problems of atmospheric entry, spacecraft rendezvous, launch from the moon, navigation, propulsion systems, aerodynamic heating, spacecraft shielding, and many other related areas.

Navigation-- A manually controlled spacecraft navigation system for lunar landing was built and tested. The system is simple to operate and weighs only 10 to 15 pounds. It consists of a timing device, a gunsight-like optical instrument, and a

specialized radar unit, all of which would enable the pilot to orient the spacecraft and its lunar landing unit by fixes on various stars and by other navigational techniques.

There is significant advantage to the lightweight of the system because this reduces the amount of propellant required for take-off and the weight to be fired into an escape trajectory for the voyage back to earth.

Rendezvous -- NASA researchers advanced understanding of the first phase of space rendezvous, which calls for maneuvering space vehicles within 100 to 1,000 feet of one another in earth orbit. Later phases of rendezvous will call for actual coupling of two spacecraft.

NASA scientists concluded that simultaneous firing of the spacecraft to be brought together in space would be superior to launchings separated in time. This so-called "salvo rendezvous" method would require less fuel and would involve simpler guidance and control problems.

Spacecraft Entry and Landing -- It was found that a spacecraft with ballistic shape and no wings, like that in Project MERCURY, can select its landing area within a zone ranging from 1,000 to 15,000 miles long and up to 1,000 miles wide. The spacecraft, however, must be designed to take best advantage of lift, resistance, and other factors of high-velocity flight into the atmosphere. For the range up to 15,000 miles, a spacecraft would skip along the top of the atmospheric layer like a flat stone on water, between the altitudes of 80-90 miles and 400 miles, the lower edge of the Van Allen radiation belt in some regions.

Moon Trajectories -- NASA studies compared the relative merits of two kinds of trajectories for flight around the moon -- direct trajectories, in which the spacecraft enters the earth's atmosphere in the direction of the earth's rotation, and retrograde trajectories, which enter in the opposite direction. The studies showed that retrograde entry is a superior method of navigation because greater margins of error can be allowed in the required speeds and altitudes of approach for achieving the proper entry flight path.

Liquid-Propellant Engines -- NASA is supporting three major liquid-propellant engine development programs, all of which are necessary phases of the Manned Lunar Landing Program. The three are the F-1, the J-2, and the CENTAUR engine, of which there are two models, the A-1 and the A-3.

The F-1 is a single-chamber rocket that generates 1.5 million pounds of thrust, as much as all eight engines of the SATURN-C-1 first stage. It uses the conventional propellant combination of liquid oxygen (LOX) and RP-1, a refined form of kerosene. The J-2 and the CENTAUR engines burn high-energy liquid hydrogen and LOX.

... F-1 Progress -- Nineteen successful test firings of the first F-1 engine, complete with all flight components, were conducted before an inspection of the engine became necessary. A second test stand was completed and fired for the first time in September.

... J-2 Development -- At the year's end, the contractor had nearly completed the check-out of the major components of the J-2, whose thrust will be 200,000 pounds. Results with most components have been good. Some delays up to about three

months, however, have been encountered in the work on the thrust chamber and the turbopump, because the first designs were not satisfactory. When the components have been successfully tested, the contractor will assemble them into the first J-2 engine.

... CENTAUR Engines -- The A-1 and A-3 engines, delivering about 15,000 pounds of thrust each, use liquid hydrogen and liquid oxygen. Two A-1 engines will power the upper stage of the ATLAS-CENTAUR vehicle, while a cluster of six A-3 engines will power the second stage of the SATURN C-1. The A-1 engine performed satisfactorily during 20 selected test firings which qualified it for experimental flight use. In November, a 30-second tandem firing of two A-1 engines was conducted successfully and during the same month other firings simulated the use of these engines as the upper stage of the ATLAS-CENTAUR. Also, in November, full-duration test firings of the A-3 engine took place.

Solid Propellant Engines -- NASA has completed a series of studies on employment of solid propellant engines in stages of large launch vehicles for manned lunar flights.

As an outgrowth of the studies, a contractor ground-tested a very large, tapered, and segmented solid-propellant engine for NASA in August. The engine, 27 feet long, and with maximum diameter of 86 inches, weighed 73,000 pounds. It developed 200,000 pounds of thrust -- somewhat greater than that generated by one of the eight engines of the SATURN C-1 -- and burned for a period of 70 seconds. By NASA-Air Force agreement, the Air Force assumed responsibility for directing later phases of that program and directed a successful test of a two-segment version of the engine, weighing 140,000 pounds.

NASA contractors also carried out:

... Two investigations of symptoms of impending malfunction of solid-propellant engines to provide information needed in the design of escape systems for manned spacecraft boosted by solid-propellant vehicle stages.

... An inquiry into the effects on electronic and mechanical equipment, propellant, and vehicle structure, and ground support equipment of the noise fields developed by launch vehicle stages generating up to 20,000,000 pounds of thrust.

... A study of inspection methods for very large solid-propellant engines to improve the means of predicting failure.

Nuclear Propulsion -- The nuclear-rocket engine program (Project ROVER) has emerged as a major phase of the national space effort. Analysis has indicated that the technology being developed in the KIWI reactor and NERVA nuclear-rocket engine work now in progress could lead to another approach for manned exploration of the moon. Substitution of a nuclear-rocket engine for a chemical engine in the third stage of the ADVANCED SATURN vehicle could make the manned lunar landing and return mission possible without requiring rendezvous and docking in orbit.

The nuclear-rocket engine program is completely integrated. It involves the reactor, the engine, the test-flight vehicle and test-facilities development. The program is jointly supported by NASA and AEC.

... Reactor Progress -- The reactor research part of the program is being conducted by the AEC. In 1961, that agency completed the first of the KIWI-B reactor test series to establish a basic design leading to flight reactors. The test was cut short because of a hydrogen leak. Nevertheless, valuable information was provided on the reactor-control system, the rocket nozzle, and data to aid in selection of one of the several reactor designs from which the final flight reactor will be selected.

All tests thus far have been made with gaseous hydrogen as the reactor coolant. Completion of liquid hydrogen test facilities at the Nevada Test Site in 1962 will permit the reactor to be tested with liquid hydrogen. A KIWI-B series test, using liquid hydrogen, is scheduled for early in 1962.

... Engine Work -- NERVA (Nuclear Engine for Rocket Vehicle Application) development is being conducted under contract to the AEC-NASA Space Nuclear Propulsion Office. The flight-test vehicle and program for the nuclear rocket will be developed under NASA guidance.

NERVA will be flight-tested in an upper stage compatible with the ADVANCED SATURN vehicle. The design and development program has been termed RIFT, for Reactor-In-Flight-Test. The goal of the NERVA program is development of flight engines for operational upper-stage nuclear rocket vehicles.

Nuclear Energy Power Generation -- SNAP-8 (Systems for Nuclear Auxiliary Power) is the highest power (30-60 kilowatts) space nuclear electric system currently under development in this country. It is a joint AEC-NASA project with AEC responsible for the nuclear reactor, its controls and reactor shielding, and NASA for the energy conversion equipment, system integration, and eventual system flight testing.

SNAP-8 will serve as the power source for first generation electrically propelled spacecraft which will perform unmanned space science missions. The system will also generate large quantities of electric power for other space applications.

During 1961, intensive component development continued; system ground test facility requirements were established; and plans for system flight testing were prepared.

NASA conducted a broad program to solve advanced systems problems and develop system technology. The program included work on experimental high-temperature, high-powered vapor turbines; liquid metal lubrication; two-phase alkali metal heat transfer; compact refractory heat exchangers, and projects dealing with system materials development.

Electric Propulsion -- Three concepts of electric-propulsion engines are being developed, under 48 research and development contracts. These comprise ion, arc-jet, and plasma engines, each of which will require a nuclear-electric power generating plant, such as the SNAP-8 system.

... Arc-Jet Engine -- NASA is developing a 1-kw arc-jet engine for spacecraft orientation-control and stabilization systems. The program was expanded in April to include design, development, and fabrication of a model scheduled for launching by a SCOUT vehicle on a flight test late in 1962.

A contract to develop an arc-jet engine laboratory model, drawing 30 kw of power for primary propulsion of spacecraft, was awarded in July. NASA let a parallel contract to a second concern for further study. The engine will be about the size of a thermos bottle and produce one-half pound of thrust.

...Ion Engine -- Development continued on a laboratory-model cesium ion engine with .002 pounds of thrust for flight tests launched by SCOUT vehicles late in 1962. The tests will establish whether ion engines can operate under true space conditions.

...Plasma Research -- NASA is sponsoring a number of studies of plasma techniques and their possibilities for space propulsion. Plasma technology is not considered advanced enough to warrant an engine-development program.

Materials Research -- Studies of ablative materials to protect spacecraft from the intense heat of entry into the atmosphere are being made. Ablative materials are plastics, ceramics, or other materials which are converted to gases by aerodynamic heating. The gases dissipate much of the heat as they flow back over the vehicle. For relatively low heating rates, Teflon plastic was found fully effective. Polyethylene plastic was found to be less effective than Teflon because it ablates in liquid form.

...Passive Satellite Materials -- NASA scientists found that for passive communication balloon satellites fine wire mesh bonded to plastic withstood exposure to the equivalent of one year of radiation.

...Structures Research -- During the year greater understanding of flutter -- a destructive vibration of the outer skin panels of hypersonic and entry vehicles -- was obtained. It was found that aerodynamic heating can cause a panel to become unstable, but that additional heating may eventually stop flutter.

...Cooling Panels -- Aircraft that encounter severe heating in hypersonic flight may employ water in "tubed sheet," a structural material with internal passageways, to absorb the heat. Tests of two designs of tubed material indicated that it could probably be used in hypersonic craft.

Aeronautics Research -- Wide-ranging studies in advanced aeronautics have been progressing. Important investigations during the year were related directly to studies of a civilian supersonic transport -- under development jointly by NASA, the Department of Defense, and the Federal Aviation Agency. The study urged "a well-organized national effort...to produce an economically competitive commercial supersonic transport by 1970..." to preserve the position of the United States in world commercial aviation.

Aerodynamics -- NASA investigation of designs for the supersonic transport progressed during the year through wind-tunnel tests of a variable-sweep wing that can be mechanically extended at low speeds (take-off, climb, approach, landing) or swung back at high speeds. The wind-tunnel tests indicated that this wing design has satisfactory flight characteristics at practically all speeds.

Investigations were conducted in regard to the use of supersonic aircraft engine power (ordinarily employed fully at cruise speed) to supply more lift during approaches and landings. These experiments held promise that performance can be

improved by deflecting the engine jets downward.

Operating Problems -- Supersonic aircraft research has demonstrated that the pilot of a supersonic transport will need a single, compound instrument for reference in order to maintain a steady flight path during climb from take-off. The requirement is for a device showing changes in speed and altitude simultaneously. It will be especially needed when the pilot cannot locate landmarks or other guides due to the nose-high pitch of the airplane. Research on such an instrument is under way.

Problems of cruising stability for supersonic aircraft are also being studied. Data collected corroborated NASA findings that a versatile device is needed before pilots of supersonic transports can keep the aircraft stable and under full control at all times.

Noise will be a severe problem with supersonic transports as it is with military jets. The sonic boom (a thunder-clap passing through the sound barrier caused by an aircraft at the speed of sound or beyond it) can crack windows and damage buildings. Through NASA laboratory and flight research with supersonic aircraft, it has been learned that the sonic boom increases two to four times when an aircraft accelerates or turns. This information is being used in further research to predict the boom and devise ways to reduce its force.

V/STOL Research -- Studies of VTOL (Vertical Take-Off and Landing) and STOL (Short Take-Off and Landing) aircraft moved forward. The conclusion was reached that a combination V/STOL aircraft is preferable to two separate types because it will be able to take off either vertically or with a short run.

Flight Tests -- Typical of NASA V/STOL flight tests were those utilizing the X-14, a deflected turbojet airplane, modified to stimulate characteristics of various aircraft of the V/STOL type. The X-14 has been flown in both hovering and forward flight and has made in-flight transition from one type to the other. Information from instruments and evaluation by the pilot are being used in conjunction with wind-tunnel studies to further V/STOL design progress.

Another type of VTOL used in flight investigations is the VZ-2, a two-propeller, tilt-wing aircraft. Progress was made in overcoming the tendency of the VZ-2 to stall (lose lifting ability) by changing the design of the wing. Solution of this problem will provide information valuable in the design of other aircraft.

Improving Helicopter Design -- Investigations were conducted to ascertain the effects of the fuselage shape and external components (hubs, pylon, antennas, rotors, landing gear) on the performance of helicopters. The study resulted from U. S. Army needs for a helicopter with longer range and greater cruise efficiency than those now in service. Research showed that the drag (resistance) of fuselage and other parts dissipated much of the helicopter's total power.

Data from wind-tunnel tests indicated that smoothing and streamlining fuselage and skid landing gear reduces resistance substantially.

Flight Safety -- In 1961, much research effort was expended on problems of civil aircraft operation. Investigations were made of the effects of slush on runways with a specially-designed, 100,000-pound test car. It was found that one-half inch

of slush requires 1,000 feet of extra runway for take-off of a jet transport. Another finding was that in a high-speed run, slush is thrown into all openings of the aircraft. This can damage the vehicle and seriously interfere with operational safety.

Tire Designs for Safety -- Another problem investigated during the year was the poor braking ability of jet aircraft on wet runways. Aircraft tires reinforced with fabric are satisfactory for propeller-driven aircraft that can reverse thrust to aid in braking. Jets, however, have much less reverse thrust than prop-driven aircraft and are thus more dependent on tires for braking. Research showed that fabric-reinforced tires, with simplified tread design had, in some cases, only one-third the braking efficiency at high speed as tires of older design. NASA developed a design for a fabric-reinforced tread, which is about equal in braking efficiency to the older type, and has made the results available to aircraft tire manufacturers.

SPECIAL FLIGHT RESEARCH PROJECTS

The X-15 Experimental Airplane

The rocket-powered X-15 is the latest in a series of experimental aircraft built in the last 15 years to explore the conditions of manned flight at ever-greater speeds and altitudes. A joint NASA-Air Force-Navy project, the X-15 was built to meet design requirements of 4,500 mph speed and altitude capability in excess of 50 miles.

The three aircraft in this project continued to set world speed and altitude records again in 1961 as performance was increased by stages to build up to design performance levels. All but one of the 1961 records followed the installation of the new high-thrust XLR-99 engine. Maximum speed was 2,756 mph.

On March 30, NASA pilot Joe Walker flew to an altitude of 169,600 feet (32.12 miles) on his first flight with the new engine.

On October 11, Air Force Major Robert M. White flew to an altitude of 217,000 feet (41.10 miles).

Five successive speed records were set by the X-15 during 1961, four by White and one by Walker. On February 7, White attained a speed of 2,275 mph in the final flight powered by the XLR-11 engines, and reached an altitude of 75,000 feet (14.2 miles).

On March 7, White attained a speed of 2,905 mph at an altitude of 75,000 feet in the first flight with the high-thrust engine.

On April 21, White attained a speed of 3,074 mph and an altitude of 105,100 feet (19.9 miles).

On May 25, Walker attained a speed of 3,307 mph and an altitude of 110,000 feet (20.9 miles).

On November 9, White pushed the X-15 to its maximum speed in the current series of flights -- 4,093 mph -- 6.04 times the speed of sound -- and a maximum altitude of 101,600 feet (19.3 miles). The rocket engine burned at maximum throttle for 86 seconds. White was launched from a B-52 at 52,000 feet over Mud Lake, Nevada, and landed at Edwards, 200 miles away, about 10 minutes later. Some cracking took place in the right outer windshield during descent. The cause is under study.

On November 28, the President presented the Harmon International Trophy to X-15 pilots White, Walker, and Scott Crossfield, an employee of the X-15 contractor.

The next objective in the X-15 flights will be the accomplishment of design altitude-- about 50 miles. Flights above that altitude -- possibly as high as 80 miles -- will begin after the installation of a backup stability augmentation system. There is little doubt that the propulsion system can send the plane to those altitudes -- and even higher, perhaps. But only experimentation can establish the maximum altitude from which the X-15 can safely enter the dense lower atmosphere.

Many experiments have been proposed to make use of the X-15 as a test aircraft to obtain scientific information between the altitudes of 30 and 70 miles -- heights greater than those attained by balloons but lower than satellite altitudes. Experiments would capitalize on the availability of the pilot for on-the-spot input in the conduct of the experiment. The proposals are being evaluated by a joint NASA-Air Force-Navy Committee.

DYNA-SOAR SUPPORT

During 1961, NASA made progress in research on aerodynamic, structural, propulsion, navigational, operational, and human factors problems in support of the DYNA-SOAR project. Progress was made in studies to improve stability and control characteristics of the DYNA-SOAR glider at speeds as high as Mach 18.

NASA scientists served on review teams which conducted an engineering inspection and evaluation of the DYNA-SOAR Step I mock-up in September 1961. Responsibility of the teams is to assure completeness and correctness of requests for design alterations.

TRACKING AND DATA ACQUISITION

Substantial progress was made during 1961 in the establishment of NASA's ground tracking and data acquisition networks. Vital to the space program, they support operational missions involving vertically fired sounding or research rockets, manned and unmanned earth satellites, and deep space probes requiring communications over vast reaches of space.

Network Progress

During 1961, NASA completed the network of 18 globally deployed stations, a computing and communications center and a control center for the MERCURY Program. This complex successfully supported the first MERCURY single-orbit mission (MA-4) and the second MERCURY mission (MA-5), which resulted in a two-orbit flight.

Also completed was the Deep Space Network, consisting of three stations located at Goldstone, California; Woomera, Australia; near Johannesburg, Republic of South Africa, and a communication, computation and control center at the Jet Propulsion Laboratory, Pasadena, California. Only the Goldstone station had been operational in 1960.

This network can now support missions such as those of the unmanned lunar spacecraft RANGER. During the year, two RANGERS were launched, but both failed to leave their earth "parking" orbits, and thus performed as earth satellites rather than as lunar probes. Nevertheless, the network was operated successfully during both missions.

New Antennas

Another accomplishment was the erection of a new 85-foot diameter parabolic antenna near Fairbanks, Alaska. This antenna and its associated electronic devices will aid in obtaining data when large satellites are launched on scientific and applications

missions. The station will be entirely operational before its first scheduled task of supporting a satellite mission. A similar station will be built at Rosman, North Carolina, on a site selected during 1961.

Minitrack Advances -- Numerous changes were also made in the NASA earth-satellite tracking network known as Minitrack. New stations became operational at Fairbanks, Alaska; Newfoundland; and Winkfield, England, as well as at new sites in Australia, South Africa, and Goldstone, California. Some of them will be consolidated with the Deep Space tracking network. These facilities permitted deactivation of stations at Antigua, B. W. I., and San Diego, California--constituting significant progress in a long-term program of shifting the operational frequency of Minitrack from 108 Mc to a permanent frequency of 136 Mc.

Other Activities

No changes were made in connection with the Baker-Nunn Satellite Tracking Camera Network, operated for NASA by the Smithsonian Astrophysical Observatory.

In another advance, a high-gain antenna at Wallops Station was modified during the year to support the TIROS mission. This modification introduced Wallops to a new role of supporting the orbital phase of NASA missions.

INTERNATIONAL PROGRAMS

Space activities are a significant factor in international policy. From its beginning, the space program accomplishments have influenced world opinion with respect to national strength and prestige. Moreover, this country's policy of "openness" in sharing knowledge with other nations is bringing about a growing appreciation abroad of the significance of the U. S. program to the free world.

Satellite Projects

In March 1959, the United States pledged -- through the Committee on Space Research (COSPAR) of the International Council of Scientific Unions -- that it would support projects for orbiting individual experiments or complete satellite payloads, of mutual interest, prepared by scientists of other nations. Subsequently, NASA has offered to make available launching vehicles, spacecraft, technical guidance, and laboratory support for valid scientific experiments or payloads developed by scientists abroad.

The first satellites under this program are being prepared by the United Kingdom and Canada. The U. K. satellite will carry devices to study electron temperatures and concentrations in the ionosphere, and instruments to determine electron densities in the vicinity of the satellite, to measure solar radiation and correlate it with ionospheric phenomena, and to observe primary cosmic rays and study their interactions with the earth's magnetic field.

Experiments were selected by scientists of the United Kingdom in consultation with NASA scientists. U. K. scientists are building the experiments. They will also be responsible for data analysis. NASA will design, fabricate, and test the prototype and flight models.

The Canadian project centers around a TOPSIDE SOUNDER satellite, which will be employed to study the upper ionosphere by radio-echo sounding -- a technique, similar to radar, used for years to study the ionosphere from below. The nature of the ionosphere makes it impossible to obtain information about its upper reaches from the ground because radar pulses penetrate the region and continue on into space instead of reflecting back to earth. The TOPSIDE SOUNDER will apply radio-echo sounding of the ionosphere's top surface from above. The satellite (christened "ALOUETTE" by Canada) is being funded and built by Canada. The United States will supply the THOR-AGENA launching vehicle.

The first U. K. -U. S. satellite and the Canada-U. S. ALOUETTE advanced to the pre-flight test phase in 1961. Both will be launched by NASA in 1962. A second British satellite has been agreed upon, for possible launching in 1963.

NASA's design and test requirements for such projects call for the closest relationships between scientists of the participating nations. For example, in the satellite program with the United Kingdom, a joint U. S. -British working group meets regularly to resolve technical problems. A similar group of U. S. and Canadian scientists serves the ALOUETTE TOPSIDE SOUNDER program.

None of these international projects involves exchange of funds.

Sounding Rocket Projects

Much valuable information about the earth's atmospheric envelope and its near-space environment has been gained from experiments carried aloft by relatively cheap and uncomplicated sounding rockets. NASA is cooperating with a number of nations which are conducting scientific investigations with sounding rockets. The first launchings in these international programs took place in 1961. In Sardinia, the Italian National Space Committee carried out six successful experiments, using payloads provided by NASA. An upper-air experiment, employing an American rocket, was made in Sweden. Four U. S. astronomical payloads were launched on British SKYLARK rockets in Australia.

NASA and the Japanese Radio Research Laboratory, the Norwegian Space Committee, and the Pakistan Upper Atmosphere and Space Research Committee have made arrangements for joint rocket-research experiments in 1962.

Weather and Communications Satellite Programs

Twenty-eight nations agreed to conduct special observations of weather phenomena, to be coordinated with the cloud-cover photographs made by the TIROS III weather satellite as indicated elsewhere in this report. In November, NASA and the U. S. Weather Bureau co-sponsored an International Meteorological Satellite Workshop in Washington.

Under agreements with NASA, the post and telegraph agencies of England, France, West Germany, and Brazil are building ground terminals at their own expense, for experiments in overseas television, telephone, and telegraph transmissions via communications satellite in 1962.

Training Personnel

Scientists and technicians from Chile, Ecuador, Peru, the United Kingdom, and Canada visited Goddard Space Flight Center for extended periods of training, in preparation for the operation of tracking and data acquisition stations in their own countries.

Also during 1961, NASA initiated a university fellowship program for foreign graduate students, administered by the National Academy of Sciences. Beginning in 1962, the program will accommodate up to 100 foreign graduate students at American university laboratories engaged in space research. Students must be sponsored by their national space committee or research councils. Sponsoring countries will provide travel and subsistence for their nationals. NASA will fund university costs.

These programs are designed to aid nations wishing to help themselves to share in the benefits of space research.

The programs are expanding U. S. research without export of dollars.

NASA ORGANIZATIONAL CHANGES

During 1961, NASA reorganized in line with the goals of the accelerated and broadened national aeronautics and space program, to achieve:

- ... Unification of the management of major programs, so as to bring all important functions within a single office and facilitate prompt decisions.
- ... Easy direct communications between headquarters and the centers, to increase the effectiveness of the center directors as co-equal contributors to NASA policy.
- ... Recognition of the centers as institutions, and functional management of activities carried on at more than one center -- such as tracking and communications, or advanced research.
- ... Increased flexibility in assigning and shifting missions and resources among the centers and headquarters program offices.

Headquarters-Center Relationships

The general management of NASA, represented by the Administrator, the Deputy Administrator, and the Associate Administrator, now share in making broad policy, major decisions, and general direction. Headquarters program and administrative offices are responsible for planning, programming, and supervising specific programs, projects, and administrative activities. The field centers are responsible for execution of programs, projects, and administrative activities. On institutional matters, the general management of each field center reports to the Associate Administrator. On programs, projects, and administrative activities, the personnel involved in the field centers are under the functional direction of the appropriate program or administrative offices in headquarters. Technical offices in headquarters were realigned to provide clearer focus and major emphasis on programs.

Field Centers

The following major organization changes took place at NASA field centers during the year:

In January, the Institute for Space Studies was established in New York City, near the campus of Columbia University, as an extension of the Theoretical Division of the Goddard Space Flight Center.

The selection of the Government-owned Michoud Ordnance Plant, near New Orleans, as a fabrication site for large launch vehicle stages was announced September 7. Operations at the plant will be conducted by industrial contractors under the technical direction of the Marshall Space Flight Center, beginning about the fall of 1962.

On October 25, NASA announced the selection of a 13,500-acre site in southern Mississippi where six or more stands for the ground-testing of large launch vehicle stages will be constructed. In addition, NASA will acquire easement rights to about 128,000 acres in Mississippi and Louisiana as a buffer zone. The Government will own the central site, but will merely move residents out of the buffer zone, where

farming, lumbering, grazing, and mineral operations will still be possible.

On September 19, NASA announced the selection of a thousand-acre site in Harris County, 15 miles from the center of Houston, Texas, for the Manned Spacecraft Center, which incorporates the former Space Task Group. The Houston laboratory will carry out and supervise work in-house and by industrial contractors on the design, development, evaluation, and testing of manned spacecraft. In addition, it will train flight crews for space missions. The Manned Spacecraft Center has already begun to move personnel and activities to Houston from its present site at Langley Field, Virginia. The bulk of the staff will move on completion of Project Mercury orbital flights.

With the selection of four sites at Houston, New Orleans, southwest Mississippi, and Cape Canaveral, NASA now has a complex of facilities at warm-water ports near the Gulf of Mexico, connected by deep-water transportation. It will be possible to work outdoors most of the year at all four sites and to transport by water the large rocket and spacecraft units that will be required for the landing on the moon and the more ambitious space flight missions that will follow.

COOPERATION WITH OTHER GOVERNMENT AGENCIES

Coordination of space research plans and programs with other Government agencies became closer during 1961. The cooperative activities were aided by advice and consultation with the National Aeronautics and Space Council and its staff. Among major interagency activities in which NASA is engaged are the following:

... The Aeronautics and Astronautics Coordinating Board, established September 13, 1960, chaired jointly by the Deputy Administrator of NASA and the Director of Defense Research and Engineering. The Board has the function of coordinating the activities of NASA and the Department of Defense to avoid undesirable duplication and to achieve efficient utilization of available resources, identifying problems requiring solution by one agency or the other, and exchanging information. The Board operates through six specialized panels. Major joint NASA-Department of Defense activities during the year include the agreement for expansion of facilities and operations at the Atlantic Missile Range, a joint bioastronautics plan in preparation, and agreement on plans for future large launch vehicle configurations.

... Joint projects with the U. S. Weather Bureau, Department of Commerce, and the Department of Defense, under the auspices of the Joint Meteorological Satellite Advisory Committee; and cooperation among NASA, the Weather Bureau, the Department of the Treasury, the Department of Defense, the Federal Aviation Agency, the Civil Aeronautics Board, and the Bureau of the Budget on the National Coordinating Committee for Aviation Meteorology. These and other organizations are concerned with developing satellites and facilities for expanding weather research, observation, and prediction.

... Research in cooperation with the Federal Aviation Agency and the Department of Defense in the development of a supersonic jet transport plane. FAA has overall management of the program.

... Joint programs with the Atomic Energy Commission to develop nuclear-rocket propulsion and spacecraft power sources. A NASA-AEC Space Nuclear Propulsion

Office manages Project Rover, a program to develop nuclear rocket propulsion. Other programs are integrated through the SNAP-8 Coordinating Committee and a joint agreement between AEC and NASA.

NASA receives scientific advice from the Space Science Board of the National Academy of Sciences, and conducts cooperative programs with the National Bureau of Standards, the Smithsonian Institution, and the National Science Foundation.

Chapter IV

Department of Defense

INTRODUCTION

In 1961, military space activity expanded both in volume and scope as the Department of Defense (DOD) sustained a vigorous interest in the advancement and exploitation of space technology for the enhancement of the national defense posture. Space efforts of the Department are integrated with the over-all military program, supplementing or complementing other military activities.

Some of these space efforts are systems oriented in those areas which are definable today such as navigation and communications. Others are oriented toward the development of future space capabilities such as rendezvous and inspection. Finally, there are developments in basic technology, the building blocks necessary for a flexible capability to move rapidly into systems needed in the future as specific defense requirements and missions are defined. These building blocks include structures, guidance and control systems, maneuverable re-entry vehicles, propulsion, and man himself.

Many significant accomplishments were achieved in the military portion of the national space program during 1961. The United States Military Space Detection and Tracking Center (SPADATS) attained full operational status. SPADATS is an essential element of the North American Air Defense Command's Combat Operations Center. Nuclear power sources, developed through the Atomic Energy Commission, were used for the first time in space to power TRANSIT navigational satellites. LOFTI, the very low frequency satellite, launched pick-a-back on TRANSIT, provided data to confirm that the ionosphere is not opaque to very low frequency radio energy. Three satellites were launched simultaneously on a single space booster. The technology and technique of recovering capsules from orbit was improved.

Space activities of the military departments are closely coordinated by the Director of Defense Research and Engineering. On March 6, 1961, the Secretary of Defense issued a directive assigning a primary responsibility for military space research and development to the Department of the Air Force. Exception is made, however, in any case where the particular interests, responsibilities, or unique capabilities of one of the other military departments properly justifies a specific assignment. Current examples are the Navy's navigational satellite program, TRANSIT, and the Army's communications satellite project, ADVENT.

In addition to the space programs conducted by the Department of Defense, planning for potential military applications of the future must also take into account all aspects of research and development in space. This is essential to insure that all of the technology and techniques already developed, being developed, or planned for development, are incorporated into national defense plans and programs.

For these reasons, and because the NASA programs help make our country stronger in many fields of science and technology, the DOD and NASA operate in close accord at management and operating levels to insure that the collective efforts are complementary.

The NASA-DOD Aeronautics and Astronautics Coordinating Board continued to function effectively during the year to ensure close working relationships and to effect integration of DOD and NASA effort essential to the prosecution of a single national space program. Through the Board membership and six functional area panels, projects and project support were defined, planned, revised, and adjusted to eliminate duplication, and to apportion, adjust, or augment effort as required.

Major DOD programs and joint planning efforts are discussed in following sections:

MAJOR PROGRAMS

ADVENT

The objective of this program is to demonstrate the feasibility of instantaneous microwave communications using an active repeater in a synchronous equatorial orbit. This program calls for the placing of communications satellites in orbits 19,300 nautical miles above the earth where they will rotate at the same rate as the earth and remain fixed with respect to the ground. This satellite is designed to meet military communications requirements of security and resistance to jamming and interception. Two ground stations are nearing completion at Fort Dix, New Jersey, and Camp Roberts, California. The initial launches next year call for the placing of satellites in 5,000-mile orbits, utilizing the ATLAS AGENA B as a preliminary step. The following year orbiting at the synchronous altitude may be possible. Three such satellites, properly spaced in equatorial orbit, could provide instantaneous communications between almost any two points in the world. ADVENT ground stations will also be used to support the NASA SYCOM communications satellite program.

ARENTS

The ARPA Environmental Test Satellite (ARENTS) project is a task under the VELA HOTEL program. Its objective is (1) to investigate the space environment at the 24-hour orbit altitude of 19,300 nautical miles, (2) to measure the fluctuations of this environment with time, and (3) to determine the long-term behavior of critical satellite-system components in this environment. The ARENTS data will be of general scientific value and will support other space programs, especially those such as the Army ADVENT communications satellite program which will operate in a 24-hour orbit. Of particular interest to VELA HOTEL are experiments to measure the radiation background.

The ARENTS spacecraft is scheduled to fly with a NASA payload on three of the ten CENTAUR vehicle development flights. The mission assignments of these vehicles are under review.

BAMBI (PROJECT DEFENDER)

The purpose of this program is to conduct research necessary to identify and

solve the problems involved in intercepting enemy ballistic missiles during or immediately after the burning phase. The program derives its name from Ballistic Missile Boost Intercept.

As presently foreseen, the BAMBI concept involves high performance space-based platforms and interceptors. The conceptual and preliminary investigations to date have not established feasibility or firm values for design and operational parameters. Detailed technical assessments of the work to date indicate that considerable additional research is required in a variety of areas before the technical, operational, and economic feasibility of the BAMBI concept can be verified.

BLUE SCOUT

The BLUE SCOUT program is directed toward providing a simple, reliable and versatile space booster system which can be used to perform selected, lightweight space missions for much less cost than the larger ballistic missile-derived boosters. The family of BLUE SCOUT vehicles utilizes standard hardware developed by NASA. With certain modifications and developments, and by combining various size solid propellant booster stages, flexibility is provided to match a wide variety of military requirements.

During 1961 there have been seven launches of the BLUE SCOUT family, of which five were successful in achieving their design mission. The successful shots placed various probes to altitudes from 1,000 to 56,000 nautical miles. Both of the failures occurred shortly after lift-off and were destroyed by the range safety officer.

DISCOVERER

The Air Force has continued a vigorous DISCOVERER satellite program during the past year. The program consists of testing components, propulsion, guidance systems, and techniques used in various U.S. space projects. Included is the gathering of scientific data in such areas as space radiation, cosmic rays, micro-meteorites, radio wave propagation, biomedicine, temperature, pressure, density, and general engineering using both recoverable and non-recoverable packages. Capsule recovery is foremost among techniques being studied.

Seventeen launches were attempted this year with twelve satellites attaining orbit successfully. Of that number, seven have been recovered from orbit. Four of these were caught in the air by specially equipped aircraft and three by parachute dropped rescue teams equipped with scuba diving gear. There have been a total of 36 DISCOVERER launches to date. Impact predictions and recovery techniques have been steadily improving with the accumulation of knowledge and refinement of equipment. The C-130B aircraft have now replaced the slower and lower flying C-119s for recovery missions.

The AGENA B, second stage and satellite vehicle which is currently being used, is also being employed or planned for use in other Air Force programs such as MIDAS, SATELLITE INSPECTOR, and some of the NASA programs. Action has been initiated to develop and test a standardized AGENA, the AGENA D, for future use by the Air Force and NASA. The testing of this vehicle has been assigned to the DISCOVERER program.

DYNA-SOAR

DYNA-SOAR is a manned test vehicle capable of maneuverable re-entry from orbit to a conventional controlled landing at an air base which can be selected by the pilot.

The development is a joint USAF-NASA program, financed and administered by the Air Force, to construct and test a manned military space research vehicle which will explore the problems and conditions of hypersonic flight over the range between the X-15 research aircraft and orbital velocity. The program will demonstrate the capability for positive, pilot controlled re-entry and recovery from orbit. The pilot of the DYNA-SOAR glider will have the ability to control his return to Earth by extending his flight path by several thousand miles straight ahead or to either side followed by conventional landing. This will enable the pilot to select the time when he will initiate re-entry and to control the point where he will land.

During 1961, design details of the DYNA-SOAR glider were finalized culminating in a full scale mockup of the vehicle and its subsystems in September. Wind tunnel testing of the glider-booster combination has been nearly completed and sub-contracts for development of the high temperature nose cap, flight control electronics, auxiliary power system, reaction controls, acceleration (abort) rocket, environment (cockpit) control system, generators and test instrumentation have gotten well under way. Other contracts for guidance, communications and data link subsystems are also in effect. Current program progress indicates that the development is proceeding on schedule and confidence has increased in the successful attainment of program objectives.

GREB

The Naval Research Laboratory's Solar Radiation Research Satellite, GREB III, was launched pick-a-back on TRANSIT IV A, on June 29, along with INJUN I. Due to a malfunction in the mechanism connecting GREB and INJUN these two satellites are orbiting the earth still connected together. Despite this malfunction, however, GREB III has emulated its predecessors in providing continuous information on solar activity in the X-ray and ultraviolet radiation bands. These data are correlated with other ionospheric and ground level measurements in order to determine the effects of solar activity on radio and radar propagation, weather activity, and related phenomena.

LOFTI

Launched pick-a-back on TRANSIT III B on February 21, the Naval Research Laboratory's Very Low Frequency Satellite, LOFTI, opened a whole new field of scientific investigation that may lead to significant advances in military communications and space vehicle navigation. From data gathered during LOFTI's six week lifetime in space, Navy scientists have been able to confirm their belief that the ionosphere is not opaque at low frequencies, as previously assumed, and that VLF radio waves pass through the ionosphere into the exosphere with relatively little attenuation. This information points, among other uses, to the possible use of trans-ionospheric VLF radio waves emanating from ground stations as navigational aids to manned or unmanned space vehicles and,

conversely, to the possibility of world-wide communications with VLF communications.

MIDAS

The objective of the MIDAS program is the development of a reliable satellite-borne missile defense alarm system. The MIDAS system will consist of a net of satellites equipped with infrared payloads which can detect ballistic missiles during the powered phase of their ascent trajectory.

During 1961 the third and fourth MIDAS flight vehicles were launched into successful, high altitude orbits from the Pacific Missile Range. Valuable vehicle performance and infrared data were obtained from these orbital flights.

MIDAS IV, launched on October 21, carried pick-a-back the Project WEST FORD package containing 75 pounds of very small copper dipoles imbedded in naphthalene. The dipoles were to have dispersed in space to form an earth-girdling belt for communications relay. There has been no evidence that the dipoles spread as scheduled. Occasional radar contacts have been made with an object in space thought to be the WEST FORD package but causes for failure of the experiment are, as yet, speculative.

Rocket Probes

During this year the DOD made extensive use of instrumented rocket probes for research in the upper atmosphere and space environment. Experimental objectives ranged from purely scientific to the determination of features of the natural environment directly influencing material design and operational performance.

Vehicles employed included the NIKE-CAJUN, AEROBEE, ASTROBEE, EXOS, and ARCAS sounding rockets. In addition, seven development test shots of the BLUE SCOUT vehicle were made with research payloads on board. Payloads weighing from 40 to 200 pounds were carried aloft to altitudes between 40 and 700 miles. A few of the more important scientific results of these programs included:

- a. The acquisition of a high resolution ultraviolet spectrum of the sun by an AEROBEE rocket carrying newly designed instrumentation which demonstrated an order of magnitude improvement over previous techniques for mass spectroscopy by sounding rockets.
- b. The measurement of absolute radiation fluxes in the ultraviolet region of the 40 brightest stars.
- c. The discovery of what appears to be a dense band of micro-meteorites encircling the earth at altitudes of about 100 miles. This dust, of barely visible particle size, was measured at densities of about 10 particle impacts per second per square centimeter.

SATELLITE INSPECTOR

Work continued on a SATELLITE INSPECTOR program. During March 1961 contracts were let to design, fabricate and test the SATELLITE INSPECTOR spacecraft. This program will, in the near future, provide the United States the capability to rendezvous in space with selected objects and to inspect them. The DOD and NASA are closely coordinating their efforts in the field of space rendezvous technology and both the SATELLITE INSPECTOR and manned space flight programs should benefit from anticipated advances in this field.

SPADATS

On July 1, 1961 the Space Detection and Tracking Center at Ent Air Force Base, Colorado, became operational. This center, operated by the Air Defense Command for NORAD, is the heart of the Space Detection and Tracking System over which CINCNORAD assumed operational control during the latter part of last year. While the ability to detect, track, and catalog space objects is still limited, the system now in being has a real capability in this area.

In June of 1961 the addition of a new transmitting station to the Navy Space Surveillance System (NAV SPASUR) raised the detection ceiling of this NORAD SPADATS element from a previous 1000 miles to a present capability in excess of 3000 nautical miles. NAV SPASUR is currently reporting in excess of 20,000 observations per month on the more than one hundred objects (satellites and assorted "space junk") currently orbiting the earth.

During 1961 action was initiated to develop both optical and radar sensor for space surveillance which will give the military services a capability to detect and track space objects well beyond current ranges. Such sensors will be integrated into automatic systems capable of completely processing these observations for tactical evaluation in a matter of seconds after an object is first detected.

TRANSIT

The TRANSIT satellite navigation system developmental program is progressing as planned on a schedule directed toward the availability of this system for worldwide fleet operational employment in the last quarter of calendar year 1962. During 1961 principal research efforts were concentrated on increased system reliability and accuracy, the refinement of refraction and geodetic data, satellite power and stabilization technology, and the development of shipboard navigation equipment.

There were three TRANSIT satellite launches during 1961:

- a. TRANSIT III B: Launched from the Atlantic Missile Range on February 21 into a highly elliptical orbit (536 nautical mile apogee and 94 nautical mile perigee) inclined 28.5 degrees to the equator. The Naval Research Laboratory's very low frequency research satellite LOFTI I was launched pick-a-back with this experiment. Despite a poor initial orbit and the failure of the LOFTI satellite to separate, both caused by launch vehicle malfunctions, TRANSIT III B

effectively demonstrated the requisite capability for data injection, storage, and retransmission before burning up on re-entry on March 30.

- b. TRANSIT IV A: Launched from the Atlantic Missile Range on June 29 into a near-circular (500 nautical mile) orbit inclined 67.5 degrees to the equator. This launch achieved the first "triple-decker" payload launch and the first utilization of a nuclear power source for satellite auxiliary power. TRANSIT IV A and its pick-a-back companions, the Naval Research Laboratory's solar radiation research satellite, GREB III, and the State University of Iowa's space research satellite, INJUN I, are still in orbit and fully functional.

- c. TRANSIT IV B: Launched from the Atlantic Missile Range on November 15 into a near-circular (500 nautical mile) orbit inclined 32.5 degrees to the equator. TRANSIT IV B again carried aloft the AEC's SNAP III type nuclear auxiliary power source. Carried pick-a-back with this equipment was an additional payload called TRAAC (Transit Research and Satellite Control) designed by the Applied Physics Laboratory, of the Johns Hopkins University to explore a method by which satellites could be stabilized in space by natural gravitational forces. Other instrumentation is providing data on several of the space environmental factors which will influence satellites' lifetimes and operational performance.

The launch of TRANSIT IV B marked the last planned launch of a TRANSIT satellite by the THOR-ABLE-STAR vehicle used to date in this program. All future launches are programmed for SCOUT vehicles to be launched by the Air Force. During 1962 all TRANSIT launch activity will be shifted to the Pacific Missile Range.

When operational the TRANSIT system will provide reliable, world-wide, all-weather navigation for ships of all nations to a degree of accuracy (1/2 mile or less) heretofore unattainable with conventional navigational methods. To insure that world-wide commercial shipping can avail itself of this mode of navigation, the Navy is coordinating with appropriate organizations.

VELA HOTEL

The Department of Defense Project VELA consists of programs of research, experimentation and systems development for improving the detection of nuclear explosions both underground and at high altitude. It is subdivided into three research and development programs:

- a. VELA UNIFORM: detection of underground nuclear explosions;

- b. VELA SIERRA: ground-based detection of nuclear tests in space;
and

- c. VELA HOTEL: satellite-based detection of nuclear tests in space.

VERA HOTEL is a joint DOD/AEC program. Its objective is to confirm experimentally detector sensitivity, reliability, and system performance capability in the space environment by conducting experiments to obtain data on the background effects of the natural radiation environment in space. Of particular interest are possible natural radiations in space which might be similar to those expected from a nuclear detonation in space. The progress consists of pick-a-back flights on vehicles scheduled for other space programs and high altitude flights of spacecraft designed specifically for VELA HOTEL. In the former category -- pick-a-back -- are instrumentation packages developed by the AEC Lawrence Radiation Laboratory and the Los Alamos Scientific Laboratory to be flown on DISCOVERER, RANGER, BLUE SCOUT JR, and ATLAS missiles. In the latter category -- high-altitude spacecraft flights -- five launches during 1963-64 are planned. Each launch will consist of two spacecraft which will be injected into circular orbits at altitudes of about 50,000 nautical miles, and separated by about 140 degrees. The ATLAS/AGENA B booster combination will be used, and final injection into orbit will be accomplished by an injection motor included in the spacecraft. The payload will consist of X-ray, gamma-ray and neutron detectors.

X-15 Research Aircraft

Program Objectives

The X-15 research aircraft program will gather needed scientific and engineering data on manned hypersonic flight for application in future aerospace systems.

Progress

The X-15 program, a joint endeavor of the USAF/NASA/Navy, was initiated in the spring of 1952. At this time, the NASA directed its team to study problems likely to be encountered in flight beyond the atmosphere and recommend methods to explore the problems. Very early in 1954 a team was assigned by NASA to determine the characteristics of an airplane capable of exploratory flight studies and the feasibility of building such an airplane. In June 1954, NASA representatives met with the Air Force and Navy to develop a program. In December 1955, a contract was let for the construction of three airplanes. The first X-15 was completed in October 1958, and made the first captive flight on March 10, 1959. Since the first powered flight on September 1959, a continuing research program has been in progress. To date, the flight envelope has been expanded to flight conditions of 6,005 feet per second (speed) and 217,000 feet (altitude) to validate design criteria.

Flight Summary

As of December 18, 1961, there had been 45 flights (launches) of the X-15 aircraft. The planned performance was achieved on 42 of those flights, and the prime research objective was achieved on 40 of those flights. A 98% launch success has been achieved on the X-15 aircraft. The success is attributed to the use of alternate modes for subsystems

and having a pilot present to detect malfunctions in the subsystems. This can be compared to a 43% achievement for an unmanned missile with no alternate modes in the subsystems.

SPACE FLIGHT SUPPORTING RESOURCES

During 1961, 19 NASA and 30 DOD space launches were supported by the Atlantic Missile Range (AMR) and Pacific Missile Range (PMR). Support activities for the MERCURY project were also conducted at White Sands Missile Range (WSMR). The capabilities of these national ranges were augmented and expanded throughout the year by the addition of more ground based and shipboard instrumentation to provide better world-wide tracking and data collection. In mid-1961 a contract was initiated for two new range instrumentation ships which, when operational in 1962, will provide the most advanced shipboard instrumentation in the Free World for missile and space vehicle tracking missions. Primary among the ground facilities additions during 1961 were the completion of SATURN and ATLAS/CENTAUR launch complexes of AMR and ATLAS/AGENA sites at PMR.

The AMR-PMR-WSMR national range facilities were closely integrated with the NASA MERCURY tracking network to provide support for all phases of Project MERCURY in 1961. In addition, military ships and aircraft were actively engaged in MERCURY capsule recovery operations. The last of these, involving the orbital primate-carrying vehicle, saw 18 ships, 51 fixed wing aircraft, and 9 helicopters deployed along the Atlantic Missile Range for recovery operations alone.

AMR activity for the year was highlighted by the MERCURY launches and support, the first launch of the SATURN vehicle, and three successful launches of the TRANSIT navigational satellite. Major PMR activity centered on support for Project MERCURY and rocket probe launches, and the DISCOVERER program-- the latter marked by several successful capsule recoveries in the Hawaiian Island area.

During 1961, an agreement was signed by the United States and the emerging West Indies Federation (WIF) which provides for necessary base rights for AMR activity in the WIF area through 1975.

DOD-NASA JOINT PLANNING AND COORDINATION

In the national interest, it is mandatory that all resources be effectively used in the conduct of the National Space Program. The DOD and the NASA have continuously planned their respective efforts on a joint basis whenever and wherever possible.

In the spring of 1961, under the auspices of the National Aeronautics and Space Council, the Secretary of Defense and the Administrator of NASA jointly evolved and forwarded a report to the Vice President (Chairman of the Council), recommending an expansion of the National Space Program which included manned lunar landing, development of large solid rocket motors and use of the TITAN missile as a space booster vehicle. These recommendations, coordinated into an over-all acceleration of the national program, were approved by the President and supported by the Congress.

In July, the Secretary of Defense and the Administrator of NASA established the DOD-NASA Large Launch Vehicle Planning Group (LLVPG) to develop a plan leading to a national launch vehicle program to meet the requirements of both agencies and to meet the national space objectives. The LLVPG has completed its planning assignment. Many of the recommendations made have been implemented already by joint agreement, such as initiation of the development of certain large liquid launch vehicles, the development of large solid motors, and the development of the TITAN III launch vehicle for payloads in the 5,000 to 25,000 pound near-earth orbit equivalent.

Additional examples of DOD-NASA agreements, to avoid duplication and insure effective use of resources and planned programs, include joint participation in the NASA GEMINI manned rendezvous program and mutual use of the DOD bioastronautics capability.

A joint DOD-NASA study on facilities and resources required at a launch site to support the national manned lunar landing program was completed during 1961. This study resulted in:

- a. Selection of Cape Canaveral as the launch site for the program. This involved expansion by purchase of 80,000 acres of land. The Corps of Engineers is now purchasing this additional land.
- b. An agreement between DOD and NASA which places the Air Force in the role of range manager in support of the manned lunar landing program with NASA funding for the additional land purchase and special facilities required for the program.

Chapter V

Atomic Energy Commission

INTRODUCTION

The Atomic Energy Commission's main contribution to the national space program is made through its development of Systems for Nuclear Auxiliary Power (SNAP) and through its nuclear rocket propulsion program designated Project ROVER. A major milestone was achieved in 1961 when a small plutonium 238-fueled thermoelectric generator was successfully placed in orbit as a power source in a navigational satellite. This was the first use of nuclear energy in space.

PROJECT SNAP

The objective of the SNAP program (Systems for Nuclear Auxiliary Power) is to develop small, lightweight, nuclear power sources for satellites, space craft, and for other special applications. SNAP projects are divided into those that utilize heat from decay of selected radioisotopes, and those that utilize heat from the operation of very compact reactors.

Radioisotope Space Power Systems

The first use of nuclear energy in space was achieved on June 29 when a small plutonium-238 fueled thermoelectric generator was successfully placed in orbit as a power source in the TRANSIT-4A navigational satellite. The five pound, 2.7 watt generator is powering two of the four navigational transmitters in the orbiting satellite and is expected to continue satisfactory operation for several years. A second navigational satellite, TRANSIT-4B, was launched on November 15 and is also transmitting signals successfully using a similar nuclear power source. These small generators are the first step in the program now under way to develop a radioisotope thermoelectric generator (designated SNAP-9A) for the operational TRANSIT navigational system which will provide a world-wide means for ships and aircraft to determine accurately their positions electronically rather than through celestial observations. The SNAP-9A generator also will be fueled with plutonium-238.

NASA has evaluated the results of preliminary generator design and safety studies performed under contract for the AEC in the spring of 1961. These studies established the feasibility of using a 25-watt curium 242-fueled thermoelectric generator designated SNAP-11 on the SURVEYOR unmanned soft lunar landing missions planned by NASA. This evaluation indicated that such a power source would increase substantially the scientific value of the SURVEYOR missions. A prototype development program for SNAP-11 is being formulated.

In September the program to develop a low powered, curium 242-fueled, thermionic generator to demonstrate the feasibility of the close-spaced vacuum diode as a space power supply was terminated. Test results indicated that a generator efficiency of 2.5 percent was the maximum to be expected from this type system. The vacuum diode approach was thus abandoned in favor of the very promising cesium

diode. It is planned to fuel a thermionic cesium diode generator, designated SNAP-13, in late 1962.

Reactor Space Power Systems

The goal of the SNAP-2 effort is to develop a compact three electrical kilowatt reactor-turboelectric system for space applications. This project also provides for basic research and development technology of compact reactors and miniaturized conversion equipment.

The first SNAP-2 reactor, the SNAP Experimental Reactor, successfully completed initial testing on November 18, 1960, and has been disassembled. The second reactor, the SNAP-2 Developmental Reactor, went critical in April, 1961 at the AEC facility at Santa Susana, California. After a period of testing, the reactor began power operation in August. Integrated tests of the reactor with the power conversion system are expected to be performed in the first half of 1962.

The SNAP-8 effort is a joint AEC-NASA effort to develop a nuclear electric generating system for the NASA space program. It will be used for power in orbital test of experimental electrical propulsion generating devices. The reactor is to have the capability to run one or two 30 electrical kilowatt turboelectric units. Fabrication of the first SNAP-8 experimental reactor began in March and will be completed in the spring of 1962. Construction of the SNAP-8 ground prototype nuclear test facility was started at Santa Susana in December and should be completed in one year.

The SNAP-10A project is designed to produce a low-power, lightweight, electric power source for space operation. A SNAP-2 reactor operating at 30 thermal kilowatts will be mated to a static thermoelectric power conversion system. The sodium-potassium liquid metal coolant is pumped by an electromagnetic pump from the reactor core to the thermoelectric elements where the heat is converted into electricity. After orbital start-up, the system will not require active control and will have no moving parts. The system will produce 500 watts of electricity at a design weight, including shielding, of 750 pounds. The first mass mock-up of the system for environmental shock and vibration tests has been fabricated. Parallel development effort on thermoelectric converters has been conducted to select the most effective system.

The orbital flight testing of SNAP-2 and SNAP-10A devices is to be a coordinated AEC-Air Force effort designated SNAPSHOT, designed to demonstrate the feasibility of use of small compact reactors in space.

ATMOSPHERIC ENTRY TEST PROGRAM

Accidental impact of a SNAP device in populated areas of the earth is of major concern to the AEC. At present it is not feasible to control the entry point of satellites; therefore, the decision has been made to design the nuclear components to burn up on entry into the earth's atmosphere.

Initial experiments on entry burn-up have been started in cooperation with the Air Force. These experiments were carried out as accessory experiments on Atlas missiles. Three experiments were flown successfully on July 31, November 22,

and December 1. Two other experiments were flown on December 12 and 21, but were unsuccessful because of missile failure. A program of testing using boosters designed specifically for entry burn-up is being developed. In the first three tests, the pod attached to the Atlas missile was loaded with specifically designed spheres and cylinders containing colored flare material which were ejected at predetermined intervals. The position of the capsules at the time of burn-through was determined by release of flare material and was recorded with high speed color cameras.

The purpose of the experiment was to check aerodynamic heating equations under actual re-entry conditions. The heat pulse created on entry is a function of capsule geometry, tumble, altitude, and velocity. The flare-camera technique will provide the time and altitude of burn-through, and as the other variables are known (except tumble for cylinders), the heat equation can be checked.

PROJECT ROVER

The objective of Project ROVER is to develop nuclear rocket engines for manned or unmanned space missions. The major current effort is aimed at the development of a Nuclear Engine for Rocket Vehicle Application (NERVA) based upon a series of experimental reactors, designated Kiwi-B, which are under development at the Los Alamos Scientific Laboratory (LASL). A major step in the development of NERVA to operational use will be the initial in-flight test series which may reasonably be anticipated in the 1966-67 period. It is presently planned to test a NERVA engine in an upper stage of a Saturn-class launch vehicle.

Reactor development for Project ROVER has been carried forward by a series of reactor tests held at the Nevada Test Site (NTS). Three reactors in the Kiwi-A series were tested in 1959 and 1960. They all used hydrogen gas as propellant. The Kiwi-B test series was begun in December 1961 with the testing of Kiwi-B1A, also using gaseous hydrogen. The Kiwi-B series will be continued in 1962 using liquid hydrogen, which is a requirement in a flyable system.

The major technical effort during 1961 was devoted to additions and modifications to the Kiwi ground test facilities at NTS for the more complex higher-power tests needed as the next step in the development of flyable reactors.

In July, the joint AEC-NASA Space Nuclear Propulsion Office, which managed the nuclear rocket program, contracted with a private corporation for initial work in the development of the NERVA engine using the reactor technology developed in the Kiwi effort. The present contracted work includes preliminary design of the NERVA engine, assistance to LASL in connection with reactor tests, assistance in the design of facilities, preparation of a detailed plan for development of NERVA, and a number of research and development tasks.

Every effort is being made to develop the nuclear rocket technology as rapidly as is possible so that the performance potential of these systems may be applied to the long range space missions for which they are well suited.

Chapter VI

Department of State

INTRODUCTION

Throughout 1961, the United States continued to pursue an active policy of international cooperation in space research and exploration, in the development of practical applications of space technology, and in fostering the growth of a regime of peace and law in outer space.

The Department of State initiated and secured adoption of appropriate proposals in the United Nations, and effected international arrangements required abroad to provide support of United States space programs and to facilitate participation of other countries in cooperative experimental programs. The Department has worked closely with the National Aeronautics and Space Council and others within the Executive Branch in considering political and legal aspects of the exploration and use of outer space, and in developing approaches to the new opportunities and problems arising from increased outer space activities of additional nations, in particular multilateral efforts emerging in Western Europe.

The Department has been particularly active in recommending that United States space programs should enhance foreign policy objectives, as in the case of the President's policy statement of July 24, 1961, concerning communications satellites.

ACTIVITIES WITHIN THE UNITED NATIONS GENERAL ASSEMBLY

During 1961, the United States continued its efforts to strengthen the United Nations' role with respect to outer space and to encourage the development of international outer space cooperation. In his address before the General Assembly on September 25, President Kennedy stated that the United States would recommend adoption of specific proposals". . . extending the United Nations Charter to the limits of man's exploration in the universe, reserving outer space for peaceful use, prohibiting weapons of mass destruction in space or on celestial bodies, and opening the mysteries and benefits of space to every nation. We shall propose further cooperative efforts between all the nations in weather prediction and eventually in weather control. We shall propose, finally, a global system of communications satellites linking the whole world in telegraph, telephone, radio, and television."

The disarmament aspect of the President's proposals was included in The United States Program for General and Complete Disarmament (circulated in the General Assembly on September 25) which called, among other things, for the prohibition, subject to effective verification, of the orbiting or stationing in outer space of weapons of mass destruction.

On December 4, the United States, with the co-sponsorship of three other nations, introduced before the General Assembly a draft resolution which covered the remaining points the President had made in his September 25 address, with regard to the peaceful uses of outer space. In presenting this resolution Ambassador Stevenson pointed out that ". . . we cannot afford to delay. The space programs of the great powers are well advanced. Our own nation is proceeding with the development of satellite systems for weather forecasting and communications. In the months ahead, important decisions will have to be made. If the opportunity for United Nations action is missed, it will be increasingly difficult to fit national space programs into a rational pattern of United Nations cooperation." In the talks which followed, all members of the United Nations Committee on the Peaceful Uses of Outer Space, including the Soviet Union, co-sponsored the resolution in an amended form.

As adopted unanimously by the General Assembly on December 20, the space resolution endorsed the applicability of international law, including the United Nations charter, to outer space and celestial bodies and declared that these are free for exploration and use by all states and are not subject to national appropriation. The resolution further provided that the United Nations Secretary General should maintain a public registry of launchings of space vehicles into orbit or beyond and should assist the Outer Space Committee in the conduct of space studies and arrangements for the exchange of information relating to outer space activities. The resolution proposed early and comprehensive study of measures to advance the state of atmospheric science and technology, to develop existing weather forecasting capabilities, and to help member states make effective use of such capabilities through regional meteorological centers. In the field of communication satellites, the resolution noted the potential importance of this new capability for the United Nations, recommended that the International Telecommunication Union examine those aspects of space communication in which international cooperation will be required, and called attention to the need for technical and other assistance for the development of domestic communication systems in less developed countries so that they might make effective use of satellite communications.

Finally, the resolution continued the mandate of the Committee on the Peaceful Uses of Outer Space and enlarged its membership in recognition of the increased membership of the United Nations. The Committee was requested to meet not later than March 31, 1962, to review the activities provided for in this resolution and to undertake the tasks assigned it by the General Assembly when the Committee was originally established in December 1959. It is expected, therefore, that the Committee will proceed early in 1962 with its work which includes: a study of practical and feasible means for activating programs in the peaceful uses of outer space which could appropriately be undertaken under the auspices of the United Nations; an examination of legal problems rising from the exploration and use of outer space; and consideration of an international scientific conference under the auspices of the United Nations for exchange of experience in the peaceful uses of outer space.

OTHER INTERNATIONAL ACTIVITIES

During 1961, bilateral negotiations for the establishment of the world-wide tracking network for Project Mercury were completed, and additional support for manned orbital flight program was prepared. Other arrangements in support of the National Aeronautics and Space Administration and Department of Defense programs were also completed or initiated.

Bilateral arrangements were completed with the United Kingdom, France, the Federal Republic of Germany, and Brazil looking toward their active participation in communications satellite experiments which will be initiated in 1962, and informal understandings were reached which may lead to participation by additional countries.

In anticipation of future operational capabilities in the field of communications satellites, preliminary United States proposals for the allocation of radio frequencies for space communications were developed and presented for initial comment to members of the International Telecommunication Union. Arrangements were completed for Study Group IV on space of the International Radio Consultative Committee (CCIR) to meet in Washington in 1962.

There was continuing support and consultation with NASA in connection with the expansion of international cooperative programs in other areas.

Chapter VII

National Science Foundation

INTRODUCTION

The National Science Foundation has as a primary objective the support of basic research of a pioneering nature. In most instances, this is achieved through grants to nonprofit institutions in support of research projects proposed by their own staff scientists. Scientific investigations which seek an understanding of the fundamental laws of the physical universe constitute a substantial portion of these efforts. In addition, a limited number of grants have been made, and contracts awarded, to develop special instrumentation or facilities of particular importance in improving some specific types of space-related research. For example, two telescopes under construction in 1961 (scheduled for completion in 1962) will surpass any similar instruments in the world.

PROGRAMS IN BASIC SCIENCE RELATED TO SPACE

The basic nature of the programs sponsored by the Foundation produces a pattern of support for space sciences which is largely indirect. Moreover, an important by-product of the Foundation's programs is the creation of a reservoir of well-grounded scientific talent which becomes available for activities directly related to the aeronautics and space program.

It is often difficult, however, to determine the precise relationship of a given project to the space sciences. Physics research projects, such as nuclear and plasma physics, low temperature research and solid state research, almost invariably have some application to science or technology in space. In addition, the Foundation supports an extensive program of research in the biological and medical sciences, which will have vital applications in the space sciences.

Several space-related projects in the regular program in support of basic research deserve special attention here:

THE NATIONAL RADIO ASTRONOMY OBSERVATORY (WEST VIRGINIA)

During 1961, the instrumentation at the observatory included one 85-foot equatorially-mounted radio telescope which is fully operational. A similarly mounted 140-foot telescope was under construction during the year, and is planned to go into operation in the near future. Both telescopes are or will be usable over the entire range of wavelengths employed in radio astronomy, down to 3 centimeters.

Construction was also undertaken in 1961 on a 300-foot telescope, which will be the largest movable parabolic reflector in the world, with a surface area of 78,000 square feet, or 1.8 acres. To achieve economy, the telescope is designed to be movable in elevation only, at angles from 30 degrees above the southern horizon through the zenith to 30 degrees above the northern horizon. It will be useful for a wide variety of astronomical observations which do not require extended viewing,

including the measurement of the quantity and distribution of hydrogen gas within our own and other galaxies, for measuring the spectra of distant extragalactic radio sources, and for surveys of distant faint radio sources. Initial electronic equipment for the instrument will consist of a multichannel receiver for exploring radiation from galactic and extragalactic hydrogen, and other receivers operating at various frequencies lower than 1420 megacycles per second.

The Observatory is being constructed and operated under a contract with a group of universities. All qualified U.S. astronomers will have access to these facilities, with priorities determined by the scientific merit of their respective projects.

THE KITT PEAK NATIONAL OBSERVATORY (ARIZONA)

During 1961, a 36-inch reflector and a 16-inch telescope were operated at this Observatory. Meanwhile, construction proceeded on an 80-inch and a 60-inch solar telescope, which will be several times larger than any instrument of its kind now in existence.

Constructed under contract with a group of universities, the Observatory will be available for use by all qualified U.S. astronomers, with priorities determined by the scientific merit of their respective projects.

The Kitt Peak Observatory has also undertaken long-range studies on a moderately large space telescope with an aperture of about 50 inches, to be placed in orbit and remain operable for at least a year, perhaps 10 years. This instrument will be valuable in a number of research problems involving spectroscopy, direct photography and photometry in the ultraviolet region. The telescope will have an optical resolution as close as possible to the theoretical limit determined by the aperture.

The Foundation has not established a time schedule for completion or launching of the instrument, in order that the preliminary work remain free from the pressure of launching schedules. The work is proceeding in close liaison with NASA, and when it is agreed that a working instrument can be produced vehicles capable of placing it in orbit will probably have been developed.

New Photoelectric Recording Devices

Research proceeded during 1961 on new devices for recording information collected by telescope from extended areas of sky such as those occupied by a galaxy or a star cluster. At present, this is achieved through use of photographic plates, but even the fastest emulsions available are inefficient, and require about 10,000 times as long to photograph a faint galaxy as should be necessary.

Photoelectric devices, some developed as early as 1945, promise greatly increased efficiency in the photographic procedure. While only one photon in 1,000 which strikes a photographic plate forms a distinct blackened image, photons which strike an appropriate photoemissive surface will cause one electron to be emitted for approximately ten photons. Accelerating electrodes can then provide each electron with high energy, subsequently producing a distinct blackened image on the plate.

The image tube projects were undertaken to develop simple, inexpensive and efficient light amplifiers for astronomical purposes. In effect, they multiply the aperture of an existing telescope by 5 to 10 times in certain applications.

THE NATIONAL CENTER FOR ATMOSPHERIC RESEARCH (COLORADO)

The Center was established during 1961 to meet a national need for a broader, more intense attack on fundamental problems in the atmospheric sciences. It is anticipated that the knowledge gained through the program at the center may lead to greater understanding of fundamental theories underlying weather prediction or shortened long time-scales, as well as to a realistic appraisal of the possibilities of weather control.

HIGH ALTITUDE ASTRONOMY

Another difficulty in taking astronomical photographs from ground-based observatories is the limitation of angular resolution by the fluctuations in the refraction of the earth's atmosphere. These same fluctuations are responsible for the "twinkling" of the stars, and produce the condition known as poor astronomical "seeing." Night photographs taken with existing telescopes produce an angular diameter of a point image (such as a star) which is never less than 0.3 seconds of arc.

To obtain better resolution in astronomical photographs, it is desirable to mount the telescope on a platform well above most or all of the earth's atmosphere. Ultimately, this may be achieved through the use of space vehicles. Meanwhile, a project at Princeton University has already succeeded in photographing the sun with a 12-inch reflector suspended from a balloon at an altitude of 80,000 feet.

During 1961, design and construction proceeded on a 36-inch balloon-borne telescope for observing objects in the night sky. First flights are currently planned for 1962, and if successful, should greatly increase our detailed knowledge of the surface features of the moon, Mars, and other such objects.

This project is supported by the Foundation in cooperation with the Office of Naval Research and NASA.

PHYSICS PROGRAM

Cosmic rays originate in outer space, come from the sun, or are influenced by it, and the energy and particle spectra of these rays are directly related to physical processes occurring in outer space. Directional studies of cosmic rays at high energies help to determine the galactic origin of cosmic ray particles, and what can be learned about the particle spectrum bears directly on the origin of the universe and its composition.

Measurements obtained from neutron flux studies are of particular interest to scientists because of the information they reveal on the sun and the magnetic fields between the earth and the sun.

Rockets and satellites have added greatly to the store of information on cosmic ray particles in their virgin state before they break up in the earth's atmosphere--information previously obtainable only from balloons. Such high altitude studies are also concerned with the earth's magnetic field and solar activity, and may utilize emulsions, counters or ionization chambers. Terrestrial telescopes which are sensitive to air showers also provide information on the cosmic source of very high energy particles.

ATMOSPHERIC SCIENCES PROGRAM

Problems concerning the atmosphere around us have long been studied, but new facilities, such as satellites, have significantly enhanced scientific opportunity to obtain observations and improve research. Included are such studies as the physics of atmospheric motions; the earth's planetary albedo; photochemical and hydromagnetic phenomena in the ionosphere; the effect of solar activity on atmospheric circulation and distribution of meteorological phenomena in the stratosphere; the variability in the composition of the stratosphere, and tidal oscillations within it.

ENGINEERING SCIENCES PROGRAM

During 1961, the Foundation continued to sponsor studies that will aid in solving engineering problems related to the supersonic flight of a high-speed vehicle, or missile, in the upper atmosphere. In such flight, frictional drag quickly heats the solid surface to extreme temperatures which endanger the structure of the vehicle and change its flight behavior. The gaseous molecules in the gas layer adjacent to the heated surfaces become ionized, and so electrically conducting. These extreme conditions drastically alter and complicate flow behavior.

Theoretical studies aimed at understanding these flow patterns are made at high speed of the drag of various shapes, and measurements are also made of the rate of heat loss, the influence of ionization and the nature of the gaseous medium on the maximum temperatures encountered.

The properties of a high temperature, ionized gas are so unusual that it has been the subject of a large amount of theoretical and experimental study, particularly when the pressure is also low. Known as "plasma," its influence on the electromagnetic radiation characteristics of the antennas for control and telemetry is also an important problem. Other studies have been undertaken to explore the thermal conductivities and other properties of substances at the extreme temperatures involved.

Chapter VIII

Department of Commerce

INTRODUCTION

The space program activities of this Department are conducted in the Weather Bureau, the National Bureau of Standards and the Coast and Geodetic Survey.

WEATHER BUREAU

The successful meteorological satellite experiments conducted as part of the United States space program have had a major impact on the plans and operations of the Weather Bureau. On September 30, 1961, legislation was enacted to provide funds to the Weather Bureau to "establish and operate a system for the continuous observation of world-wide meteorological conditions from space satellites" The Weather Bureau is establishing an organization to be known as Meteorological Satellite Activities (MSA), which will have the responsibility for implementing this obligation. MSA will have a division which will eventually operate the National Operational Meteorological Satellite System (NOMSS). MSA also will include the Meteorological Satellite Laboratory (MSL), which will continue to conduct research both in support of the satellite activity and to further meteorological knowledge. Close cooperation among the Weather Bureau, NASA, and all user agencies will continue under this organizational structure.

The international aspects of meteorological satellites are also receiving close attention in the Bureau's activities and planning, in close cooperation with NASA.

In other aspects of the space effort, the Bureau is cooperating with other agencies to probe the atmosphere with meteorological sounding rockets; and furnishes meteorological support to the Pacific Missile Range, NASA's Wallops Station, and Project Mercury.

TIROS II and Radiation Measurements

The TIROS II satellite was launched by NASA November 23, 1960. Despite the relatively poor quality of the pictures from the wide-angle camera, the experimental program for the operational use of the satellite cloud pictures was successful, and continued as long as usable pictures were available. The last nephanalysis, or cloud analysis map, was made from pictures received on April 28, 1961. However, useful pictures were still being received occasionally at the beginning of December 1961, more than a year after launch.

TIROS II carried instruments for measuring solar and terrestrial radiation as well as the cameras.

Radiation data are received in a form that requires a considerable amount of processing before they can be used. The Weather Bureau's Meteorological Satellite Laboratory (MSL), in cooperation with NASA, developed methods for processing these data on digital computers. To date, all usable radiation data from TIROS II

have been processed, and recorded on reels of magnetic tape (for research use with computers). From these tapes, MSL and NASA have produced a series of maps of radiation measurements which are being used extensively in research. A catalogue, published by NASA, contains 344 of these radiation maps from TIROS II.

The radiation measurements in the 8 to 12 micron water-vapor "window" region of the terrestrial radiation spectrum are being used to study the distribution of cloud patterns under both day and night conditions. Studies are under way to find means of using these data to determine the temperatures and the heights of cloud tops from the satellite. In addition, other TIROS II radiation data will also be used, in preliminary fashion, for general circulation studies.

TIROS III - Experimental Operational Use of Satellite

Information

TIROS III, the third experimental meteorological satellite, was launched from Cape Canaveral, Florida on July 12, 1961. The launch date was chosen so the satellite would be operational during the hurricane season. During the period July 12 to October 12, TIROS III photographed tropical cyclones, including hurricanes and typhoons, on more than fifty separate occasions. Five hurricanes and one tropical storm were seen in the Atlantic; two hurricanes and a tropical storm were seen in the eastern Pacific. Typhoons Kathy through Tilda, nine storms in all, were followed over the central and western Pacific. A total of fifty advisories on these tropical storms, and other significant weather patterns were phoned, radioed, or otherwise transmitted to Weather Bureau, Air Force, or Navy offices at Miami, San Francisco, New Orleans, San Juan, Guam, Honolulu, and Tokyo, and to the weather services of Mexico, the Philippines, Japan, Hong Kong, and the Republic of China. Japan and the Philippines acknowledged these messages with thanks and requested continued advisories. These advisories were sent under a special Weather Bureau operating procedure to provide warnings of tropical storms or other hazardous weather to all concerned both in the United States and abroad.

Hurricane Esther, by means of TIROS III pictures, was discovered at 11°N, 30°W at 1:00 P. M. EST, September 10, 1961. The San Juan and Miami hurricane warning centers were notified. At 5:00 P. M. EST, September 12, after receiving a second picture from the satellite (at about 1:00 P. M. EST, September 11) and confirming evidence of aerial reconnaissance and ship reports, Bulletin No. 1 on hurricane Esther was issued by San Juan. Thus Esther became the first fully developed hurricane ever discovered and reported operationally by a meteorological satellite. Had the meteorologists at the data acquisition station had more experience with the appearance of tropical storms as viewed from space, hurricane Anna might have been the first satellite discovery of a hurricane. Post analysis undertaken during research, showed that the tropical storm, which developed into Hurricane Anna, could have been identified on July 17, 1961, two days before conventional data revealed her presence.

In addition to special warnings, routine dissemination of cloud analysis maps, or nephanalyses, to United States weather stations and to the weather services of other nations was accomplished. The nephanalyses were transmitted in diagrammatic form by facsimile, or in coded form by radio teletype. A total of 781 of these analyses, derived from TIROS III data, had been transmitted by November 1, 1961.

The poorer quality of the pictures, because of deterioration of electronic components aboard the satellite, forced a sharp curtailment of the operational program after October 1. Few nephanalyses were transmitted after that date. Reports from recipients of the nephanalyses, both in the United States and abroad, indicated that the information was used extensively in both analysis and forecasting to augment standard sources of weather information.

The information was also used routinely at the National Meteorological Center (NMC) of the Weather Bureau for comparison with standard weather analyses. MSL organized a temporary experimental operational analysis unit to assist NMC in this program, and on seventeen days, NMC used TIROS III pictures data to improve its analyses.

In all, during the first three months of full operation, TIROS III viewed 60 significant storm circulations, discovered a hurricane, and saw 18 tropical cyclones.

TIROS III has acquired over 25,000 pictures, and several hundreds of orbits of radiation data, all of which are being used to further meteorological knowledge through research. The most dramatic data, the hurricane photographs, are the subject of intensive research at this time. There are many theories on how and why hurricanes form. Scientists have not been able to examine these hypotheses in detail because observations over the ocean areas, where these tropical cyclones form and travel, have been almost unobtainable. The data from satellites should now enable research meteorologists to examine these storms in detail, to confirm or refute existing theories, and perhaps to develop new ones.

Research Programs

Research programs conducted by MSL fall into three categories: that based on the cloud pictures from the TIROS satellites, that using the radiation data from the satellites, and a program of basic research on the radiation transmission characteristics of the atmosphere in specific spectral regions.

The striking cloud patterns photographed by TIROS are the subject of intensive study. When pictures of large-scale cyclonic vortices (or storms), sometimes more than a thousand miles in diameter, were studied together with conventional meteorological data, Weather Bureau scientists learned much about the structure of moisture fields, the cloud patterns associated with frontal zones and jet streams, and the relation of the spiral cloud bands of the storms to the wind flow. This knowledge has been useful for interpreting pictures of cloud photographed over remote ocean areas, and for improving standard meteorological analyses both in remote ocean areas and over land areas.

Studies of TIROS data are making important contributions towards an increased understanding of the physical processes associated with storms and other areas of widespread cloudiness. Cellular arrangements of clouds over ocean areas have been linked to the vertical temperature structure of the atmosphere and tentatively to the transfer of energy and moisture from the ocean surface to the atmosphere. Long, narrow lines of clouds, or cloud "streets" seen in TIROS pictures have been associated with the wind field. The pictures of cloud cells and "streets" are being compared with conditions prescribed by theory or prevailing in laboratory experiments.

The pictures are also used in advancing the study of severe local storms. These studies have already demonstrated the possibility of using satellite pictures for detection and warning purposes.

Other phenomena revealed in TIROS pictures are snow cover and clouds in mountain regions, ice on sizeable bodies of water, and sun "glint" on the oceans. These pictures are or will be under study to determine the meteorology of remote mountain regions, the possibility for using the satellites for routine ice reconnaissance, and to measure sea conditions and surface winds over sea and ocean areas.

The radiation data from TIROS II, which has been mapped, will be used in studies of the heat budget related to the general circulation, and of sources of atmospheric energy. These data will also be used in studies correlating the heights of cloud tops with temperatures in the atmosphere, and in studies of the temperature distribution within the atmosphere and at the earth's surface.

Basic research on the infrared transmission characteristics of atmospheric gases is a major program. The results of this research are being used to evaluate infrared data being acquired by TIROS, and in the development of future meteorological satellite experiments.

International Meteorological Satellite Workshop

The International Meteorological Satellite Workshop held in Washington, D. C., November 13 through November 22, 1961, was organized jointly by the Weather Bureau and the National Aeronautics and Space Administration. The purpose of this workshop was to acquaint other nations with the results of the current United States meteorological satellite program, and possibilities for the future, and to furnish sufficient information so that:

- a. The weather services of other nations may acquire a working knowledge meteorological satellite data for assistance in their future analysis programs both in research and in daily synoptic application, and guidance in their own national observational support efforts.
- b. The world meteorological community may become more familiar with the TIROS program.
- c. The present activity may be put in proper perspective relative to future operational programs.

Thirty-five participants from 27 nations attended the workshop; one additional nation sent an observer only. Observers from the International Civil Aviation Organization (ICAO), the International Union of Geodesy and Geophysics (IUGG), the Committee on Space Research (COSPAR), the World Meteorological Organization (WMO), the National Aeronautics and Space Council (NASC) of the United States, the U. S. House of Representatives' Committee on Science and Astronautics, and the National Academy of Sciences were also invited and present at the workshop.

During the workshop, lectures were given on the research programs on meteorological satellites and tours were made to nearby Weather Bureau and NASA facilities. Laboratory sessions gave participants practical experience in assessing and using

weather satellite data, The foreign visitors had an opportunity to discuss their own plans for using satellite data.

The consensus of the sponsors is that the IMSW was very successful and the participants also expressed informally their satisfaction.

The nations which sent participants are Argentina, Brazil, Canada, Republic of China, Denmark, El Salvador, Finland, France, Federal Republic of Germany, Honduras, Iran, Ireland, Israel, Italy, Netherlands, Netherlands Antilles, New Zealand, Nigeria, Norway, Pakistan, Portugal, Sudan, Thailand, United Arab Republic, United Kingdom, and the West Indies Federation. The Republic of South Africa sent an observer to the workshop.

International Cooperation

On July 19, 1961, subsequent to the successful launch of TIROS III, the Weather Bureau and NASA sent a joint letter inviting 105 WMO nations and Colombia to participate in the experiment in order to provide them with the opportunity to correlate their own observations with those from the satellite. Thirty-five countries, including Poland and Czechoslovakia, indicated their intent to cooperate, and established programs to intensify and augment their regular observation programs during satellite passages over their territory. Included in the intensified programs are whole-sky and aerial photography, special cloud observations, and extra radiosonde ascents.

To assist other nations in the cooperative programs, alert messages on the areas to be photographed by TIROS III were transmitted from the United States over international meteorological circuits. Planning messages were sent seven days in advance, and more precise alert data on individual orbits 24 to 48 hours in advance. As a special service, positive film strips of TIROS photographs were forwarded to each of the cooperating nations within a few months after the satellite observations were made. A total of 390 such film strips were furnished. In turn a number of the cooperating nations sent copies of their special observational records to the United States.

Other International Activities

In addition to the International Cooperation Program, and the International Meteorological Satellite Workshop, the Weather Bureau has a continuing program to stimulate progress in international meteorological programs. The Bureau, representing the United States in the World Meteorological Organization (WMO) has kept the WMO membership informed about the U. S. meteorological satellite programs. Panels and working groups have been established in the WMO, largely through the influence of the Weather Bureau, to stimulate progress and to plan and coordinate the international use of meteorological data acquired by satellites. In addition, Bureau personnel serve on other international scientific bodies such as the Committee on Space Research (COSPAR) and the International Union of Geodesy and Geophysics (IUGG).

As a further spur toward international cooperation in the use of satellite data, the Weather Bureau and NASA have sent to WMO nations catalogues of the picture data and radiation data, which are available to all at moderate cost.

Advanced Meteorological Satellite Experiments

The Meteorological Satellite Laboratory of the Weather Bureau has been working closely with NASA on developing the NIMBUS satellite, the first of which is scheduled for launching during FY-1963. A prototype infrared spectrometer for satellite use has been developed, and is being laboratory tested. This instrument will determine world-wide temperature distribution in the stratosphere and upper troposphere by measuring radiation in the 15-micron carbon dioxide band. The spectrometer will also obtain measurements in the 11.1-micron water vapor "window", which can be used to determine temperature at the earth's surface or at cloud top level.

An engineering feasibility study on the use of satellite-borne radar to detect precipitation has been completed and forwarded to NASA for review and further study. Theoretical studies have also been completed on a technique for measuring the world-wide distribution of atmospheric ozone from meteorological satellites.

National Operational Meteorological Satellite System

A plan for a National Operational Meteorological Satellite System (NOMSS) was prepared in April 1961, by an ad hoc Panel on Operational Meteorological Satellites under the auspices of the National Coordinating Committee for Aviation Meteorology. The panel was made up of representatives from the NASA, the Department of Commerce, the Department of Defense, and the FAA. The report of the panel described and recommended the establishment of a national system to exploit the present and planned capabilities of the United States meteorological satellite experimental program. It further recommended that the responsibility for the management of the system be placed on the Weather Bureau.

The report of the panel formed the basis for the President's request to the Congress for funds to implement the National Operational Meteorological Satellite System. Funds for this program were appropriated to the Weather Bureau in September, 1961.

The proposed system is designed to phase into operation at the earliest date possible, consistent with the progressing state of technology, and with the requirements of the U. S. weather services. It is to have a progressively increasing capability to meet the needs of the United States and the international meteorological communities.

Following the TIROS program will come the NIMBUS satellites which have augmented capabilities, principally by being oriented to point their cameras toward the earth at all times. With more ground stations and further experience, it is expected that substantial progress will be made toward an expanded operational weather satellite system.

Meteorological Support for Space Activities

The Weather Bureau provides a team of meteorologists to make special observations, prepare forecasts, and provide meteorological advice to support operations at NASA's Wallops Station.

The Bureau also provides extensive meteorological support for the Pacific Missile Range by the operation of weather observing stations in California and downrange in the Pacific. Some of the Pacific Stations were established specifically for range

support.

The Weather Bureau's Project MERCURY Weather Support Group provides meteorological assistance to NASA for Project MERCURY. This group, with units at the National Meteorological Center, Cape Canaveral, and Miami, provides climatological information for planning purposes. For each MERCURY shot, it provides a forecast and briefing service for the launch area and the ground track of the vehicle. This support will continue throughout Project MERCURY. It is also expected that the Bureau will provide similar support for future NASA manned space-flight projects.

The Weather Bureau also serves in a consultant capacity to other groups engaged in space activities by providing climatological data and studies in support of their activities.

Meteorological Rocketsondes

The Weather Bureau is continuing to participate with other government agencies in the use of meteorological sounding rockets to extend the range of observations above the maximum altitudes that can be obtained by conventional balloon soundings. The Bureau has been especially active in reducing and interpreting the data for meteorological uses particularly in the stratosphere. The preliminary meteorological rocket network, established in 1960, and operated by NASA and the Department of Defense, continued to provide meteorological data for research. These data are also being used to determine what atmospheric conditions high altitude vehicles can expect to encounter.

During 1961, DOD and NASA recommended an orderly transition from the current network status to an operational Meteorological Rocket Network (MRN) to be managed by the Weather Bureau. A Joint MRN Steering Committee, chaired by the Weather Bureau, has been established for this purpose. This steering committee expects to complete plans for the operational network by mid-1962.

NATIONAL BUREAU OF STANDARDS

The research programs conducted by the National Bureau of Standards to provide the basis for the national system of physical measurement in the United States are basic to all research in the physical sciences. NBS continued its efforts to meet measurement-standards needs of particular importance to space and aeronautical science and technology.

The expanding national space effort has generated many demands for precise data on the basic properties of matter and materials, for more accurate determinations of physical constants, and for specialized consultative and advisory services from the Bureau. To meet these varied but related needs, steps have been taken to formulate and emphasize within NBS certain closely coordinated research programs which cut across traditional disciplinary and organizational lines. These programs are intended to bring the full weight of the Bureau's competence to bear on important new national objectives. The Bureau's programs in laboratory astrophysics and plasma physics and in space telecommunications are of this nature.

Laboratory Astrophysics and Plasma Physics

Lack of knowledge of the physical behavior of extremely hot gases or "plasmas" has delayed progress in a number of major national programs in science and technology including space exploration and astronomy, rocket propulsion, hypersonic aerodynamics, thermonuclear power, ionospheric communication, and ballistic missile defense systems. All of these areas involve interactions in highly ionized gaseous systems--some of extremely high density and some of very low density. All have in common their dependence upon the solution of basic problems which can be approached through development of better laboratory techniques and standards for the measurement of fundamental properties of highly ionized gases. To help solve these problems, NBS in 1960 began a special effort to unify and strengthen its work in plasma physics and astrophysics. During the past year with the cooperation and support of other interested agencies, considerable progress has been made in this program.

The most immediate need for such knowledge and services arises in the space sciences, where satellites are used to carry equipment outside of the earth's atmosphere to study the sun and the stars. The value of the spectroscopic data thus obtained can be greatly enhanced if they can be accurately described in measurement units based on precise laboratory standards. The Bureau is making accurate measurements of atomic properties to provide the data necessary for quantitative interpretation of these astronomical observations.

To study the probabilities of atomic transitions associated with hydrogen and oxygen lines observed in solar and stellar spectra, the Bureau developed a wall-stabilized high-current arc chamber operating in hydrogen at 12,000°K, a temperature twice that of the sun. A characteristic red light emitted by the hydrogen through slits in the arc chamber is photoelectrically recorded with a spectrometer and provides information to determine temperature and particle concentrations within the plasma.

A tabulation of the relative intensities of 39,000 spectral lines was completed during the year, providing intensity values on a uniform energy scale for 70 elements over the wavelength range from 2000 to 9000 Angstrom units. The new tables will supply spectroscopists with much-needed quantitative intensity values for those elements most commonly encountered in their analyses. The intensity values may be transformed into atomic transition probabilities and used to determine temperatures of laboratory light sources emitting atomic spectra and of stellar atmospheres.

Besides the well-known hydrogen line at 21 cm wavelength, the spectra of extra-terrestrial radio sources may contain sharp lines characteristic of other atoms, ions and small molecules. The detection and study of such line spectra would add considerably to present information on the composition of interstellar gas clouds and, perhaps, planetary atmospheres. To facilitate a search for interstellar radio line spectra using high sensitivity radio telescopes it is essential to have precise foreknowledge of the line frequencies of the most likely producers of detectable radio emissions. A research program in free radical microwave spectroscopy has been started at NBS for this purpose. During the past year the frequencies of two strong spectral lines by which OH may be identified in interstellar gas have been determined. Similar experiments on other radicals are planned.

Data centers were established to gather and index all published information on

atomic transition probabilities and on atomic collision cross sections. Other activities in the broadly based but closely coordinated laboratory astrophysics program included work in photoionization, molecular spectroscopy, vacuum ultraviolet photochemistry, and completion of a six year program on transport properties of air.

Through the production of radio waves from plasmas in the laboratory, a major step was taken toward duplicating under controlled conditions the electromagnetic processes which occur in the upper atmosphere. Plasmas were produced by a high-velocity shockwave travelling over 100 times the speed of sound in helium. When the plasmas were studied in the presence of a transverse magnetic field, radio waves resulting from interaction between the shockwave and the magnetic field were observed.

New facts about the interplanetary medium also have been revealed by studies of the relation of solar emission of medium-energy particles to other types of solar activity. The presence of these solar particles in the earth's atmosphere has been detected and their effects studied by means of VHF forward-scatter radio signals.

Space Telecommunications

Through its Central Radio Propagation Laboratory NBS has a central responsibility for radio propagation research, for prediction of radio propagation conditions, and for technical advice and assistance in conservation and use of the radio frequency spectrum. The critical nature of the radio problems associated with control of space vehicles and communication to and from such vehicles, plus the major emphasis being given to the development of satellite communications systems prompted the Bureau to examine its responsibilities in this area and to formulate a broad program of research to meet these needs. Portions of this program were implemented during the past year.

Particular attention has been given to studies directly concerned with the technical factors pertinent to spectrum utilization and frequency allocation problems arising from the space programs of this and other nations. The possibility of mutual interference between surface and satellite communication systems operating on the same frequency is being studied to assure adequate safeguards for the systems involved and at the same time make efficient use of the frequency spectrum. Examination of the influence of the atmosphere on radio propagation at frequencies above 10,000 Mc has received emphasis with the objective of developing methods to predict the expected performance of space communication systems using these frequencies with terminals located anywhere on the earth's surface. Tropospheric radio propagation theory is being extended to space communications problems to take account of satellite heights, atmospheric differences, changes in refractive index and turbulence.

Other projects are concerned with basic information needed to optimize equipment and system specifications for space communication systems, ground to space links, and satellite and missile tracking system. This includes work on methods of encoding information and modulating radio carriers for the very wide band systems needed to handle large quantities of various types of information as required for world-wide satellite communication systems. Also in progress is a study of effects of the lower atmosphere on the accuracy of tracking systems.

A third category of projects is concerned with obtaining basic information and

understanding required for space telecommunications as well as conventional systems. In this area NBS for many years has provided a focal point for collection of current data on solar flares and associated phenomena and data on various kinds of ionospheric and magnetic disturbances. With the support of NASA the network for collection of these data is being extended and strengthened to provide the coverage needed for the national effort in space research.

Two important new tools for investigation of the upper atmosphere and outer space will soon be available. Installation of a high-power scatter radar facility is nearing completion near Lima, Peru. Preliminary observations using relatively low power and only part of the antenna system have given electron density profiles to heights of 1,200 kilometers. The facility will be used to study electron densities and the kinetic temperature of ions at heights up to 3000 km. It also will be used in limited observations of radar echos from the sun's corona and from solar gas clouds, and for studies of small scale irregularities in the outer atmosphere.

The feasibility of the proposed S-48 Topside Sounder satellite was demonstrated during two suborbital rocket firings from the Wallops Island launching site in June. NBS has overall planning responsibility for this satellite program under NASA sponsorship. Data collected during the suborbital firings confirm that the Topside Sounder should be a valuable new source of information concerning the ionosphere. For many years properties of the ionosphere have been studied with radio probes from below. The satellite technique will permit observation from above the ionosphere which will contribute to understanding of its structure. Vertical movements, tidal fluctuations, and storm mechanisms all of which are of importance to space research and long-distance communications.

Cryogenic Engineering

The work of the NBS Cryogenic Engineering Laboratory is strongly oriented toward requirements of the nation's space program. Increasing use of normally gaseous materials in their liquid state as propellants for rockets and missiles has created many demands for information on the properties of materials at the very low temperatures necessary to handle the gases in their liquid form. Under Air Force sponsorship, NBS has compiled a data handbook containing over 500 data sheets on materials used in cryogenics. A data center has been established to provide a continuing central source of information in this field. Laboratory determinations of important physical properties are being made where data are lacking or are inadequate.

Precise measurements were made of the pressure-volume-temperature characteristics of liquid and gaseous para hydrogen from 20 to 100°K and at pressures up to 350 atmospheres to aid in the design of advanced chemical and nuclear rocket propulsion systems. Other work included studies of two-phase (liquid and vapor) flow in cryogenic systems, studies of the bulk density and density distribution of boiling fluids, and investigations of various instruments and components for use in cryogenic systems.

Standards and Measurement Methods

In recent years, NBS has been faced with rapidly expanding demands for calibration and measurement services to insure the accuracy of the measurements made in

laboratories, shops and plants engaged in space science and technology. The ever increasing complexity of new propulsion, guidance, and communication systems require constant improvement in our ability to measure the performance of thousands of individual components if reliable operation of such systems is to be achieved. Recent surveys of the measurement needs of some 70 firms in the aerospace industries and among Air Force contractors revealed many critical measurement problems. Over 100 of these needs were for service not then available from the Bureau with the required measurement range and accuracy.

During the past year a series of measurement conferences was conducted with industry specialists to identify specific problems and more clearly define measurement needs in areas such as temperature, infrared radiation, humidity, vacuum and flow, force and acceleration, shock and vibration, surface flatness and finish, gear calibration and measurement, pulsed voltage, radiofrequency impedance and phase, radio-frequency voltage and field strength, microwave power and attenuation, and many others. The conferences identified many areas in which the aircraft and space industries face severe measurement problems. As a result of these meetings the Bureau's planning in all measurement areas that were covered has benefited and immediate steps were taken to place greater emphasis on calibration and related work in the most critical areas such as microwave power and attenuation, infrared radiation, high temperature, and vacuum standards.

To provide continuing liaison with those who use the Bureau's services a new Technical Advisory Committee on Calibration and Measurement services was established. It is composed of industry specialists who will advise the Bureau of current and anticipated measurement needs of industry. The Bureau also has taken steps to strengthen its liaison with other agencies of Government including NASA and DOD to better anticipate the measurement needs emerging from national programs under their cognizance.

Properties of Materials

One of the major difficulties of obtaining data on the properties and behavior of materials in the extreme environmental conditions encountered by space vehicles is our lack of knowledge of how to make these measurements under entirely new conditions. At NBS emphasis is being given to the development of new measurement techniques and precise measurement of basic properties of a variety of materials which should contribute to improved understanding of their behavior in radically new environments.

A continuing study of the thermodynamic properties of light-element compounds has produced information badly needed by those concerned with rocket propulsion systems. Studies in progress on the vaporization and thermionic emission of selected substances are needed to advance the design of thermionic heat engines being developed for space applications. Also important are investigations of the high temperature properties of a variety of materials including ceramics, polymers, glasses, and metals.

COAST AND GEODETIC SURVEY

The Survey's Magnetic Observatory and Laboratory, located near Fredericksburg, Virginia, has contributed significantly to the space technology programs of the

United States.

During 1961, NASA made extensive use of the unique coil facility at the laboratory. This set of specially designed coils about 18 feet in diameter provides a working space in which geomagnetic fields at any point on the earth's surface or in interplanetary space can be duplicated.

Moreover, for certain programs such as the RANGER and EXPLORER X projects, the laboratory has operated comparable magnetometers on the ground for monitoring terrestrial magnetic conditions for direct comparison with telemetered magnetic data received from the space vehicle. This activity has been in addition to the regularly operated geomagnetic programs which provide continuous records of magnetic conditions.

The Fredericksburg coils were also used extensively for testing and calibrating geomagnetic instruments for artificial satellites and high altitude rockets (including moon shots). The facility was utilized in the EXPLORER X, EXPLORER XII, RANGER I, and RANGER II projects, and the proposed lunar and interplanetary space probes.

The Survey is developing a capability for photogrammetric determination of satellite orbits and for the application of geodetic satellite information in the development of geodetic science. A mobile optical observing system will utilize both passive and illuminated satellites.

Preliminary surveys have also been made preparatory to construction of NASA's own coil facility at the Fredericksburg site, to obviate any restriction which expanded NASA use might impose on the Survey's requirements for use of the existing coil building.

Chapter IX

Space Science Board

INTRODUCTION

The Space Science Board of the National Academy of Sciences is advisory and consultative to agencies of the Federal Government having executive responsibilities in the field of space science. It furnishes advice and recommendations on a variety of subjects relating to basic research; serves to represent the interests of scientists; and provides a broad scientific base for current and future U. S. space science efforts by stimulating the scientific community to interest and activities in space research.

The Board is also engaged in cooperation with scientists of other countries. The international vehicle for such cooperation is the Committee on Space Research (COSPAR) of the International Council of Scientific Unions (ICSU), to which the Academy adheres in behalf of American science. Adherence to COSPAR is provided through the Board's Committee on International Relations, whose chairman serves as the Academy's delegate to COSPAR. The Board, its committees, and Academy staff have devoted considerable effort to problems of international cooperation during 1961.

The members of the Board serve as chairmen of fifteen specialized committees covering the various scientific disciplines and fields of activity associated with the country's space science program. The Board and its committees are composed of approximately 150 leading scientific specialists.

DOMESTIC ACTIVITIES

The Board devoted a major portion of its time and attention during 1961 to the longer range objectives of space science. Except in specialized cases, the Board had earlier completed its initial objectives of providing the Federal Government with recommendations in the selection of specific projects in each scientific field to be included in the space science program. Consequently during the present year only a limited number of the Board's regular committees in each discipline were convened. In contrast, the Board convened a number of specialized groups and an even greater number of informal discussion sessions, to consider problems and programs, including objectives relating to the national effort as defined by the President and outlined by the NASA for the 1960 decade. A total of thirty such meetings took place during the period.

A summary description of the activities of the Board during 1961 follows.

SSB Policy Position on Man's Role in the National Space Program

Studies of the role of man in space led to the preparation of the Board's position officially transmitted to the Government in late March. In essence, the Board pointed out that, while it is not yet possible to say when man will be able to journey

into space, there is little question that his presence will be necessary for the scientific program as soon as it becomes technologically feasible for him to participate. Moreover, the scale of program development to support man's activities in space for scientific objectives is likely to be little different from the scale required to conduct a complex and extensive scientific program of investigations by instruments alone. Accordingly, the program for man in space in the national research program should be pushed vigorously and in parallel with the program for the investigation of space and the moon and planets by instruments alone.

Basic Research

The Board also developed a policy position concerning the need for a broad, imaginative program of fundamental research, not immediately oriented to flight experiments, based upon the broadest possible collaboration by the national scientific community. In this recommendation the Board stressed the role of universities and academic science in general, emphasizing these sources as the foundation from which must spring the support and participants for the national space science program in the years ahead.

Increased SSB Emphasis in Biology

The Board increased its emphasis in the biological sciences by the creation of three committees (Exobiology, Environmental Biology, and Man in Space), which met initially early in 1961. The first two of these committees have vigorously pressed on with their consideration of fundamental biological investigations in space. Consonant with the Board's policy on man's role in the national space program, by far the greatest activity, however, in the biological fields has been undertaken by the Man in Space Committee. Here the Board has undertaken an analysis of the known facts of physical radiations which will be encountered in near and interplanetary space and is evaluating its findings in terms of their biological effect upon man. The Board also convened a group of national and international specialists on the subject of the effects on man from high gravity accelerations and similar stresses to review the current state of knowledge in this field and to define the most urgent objectives of future investigations. The findings of both of these groups should be available in early 1962 for application to the national space program. The Board's Man in Space Committee also plans to consider other important parameters such as weightlessness, disorientation, the gaseous environment, and temperature considerations, in a manned spacecraft, nutritional problems, medical selection criteria and crew training.

ECHO Inflatable Sphere Study

In response to a request from the NASA-DOD Unmanned Spacecraft Panel, the SSB Committee on Optical and Radio Astronomy carried out an analysis of the effects of multiple inflatable spheres of the ECHO type simultaneously in orbit on fundamental scientific radio and optical astronomical observations. In summary, the report found that many inflatable sphere satellites of this type, simultaneously in orbit, could cause serious interference to fundamental ground-based observations in astronomy, the extent of the damaging interference depending upon the number of such spheres which were placed in orbit. This report was formally transmitted to the Government for its use and guidance in planning future communications experiments utilizing spheres of the ECHO type.

Satellite Tracking Requirements

Acting upon a request from NASA, the Board established a special study group to assess the present NASA program for satellite tracking and orbit determinations in terms of scientific needs. This report, concluded and formally transmitted to NASA in early November 1961, summarized the scientific requirements for satellite tracking and precise orbital information for each field of investigation. These separate fields of interest include geodesy and gravitational studies, meteorology, atmospheric physics, air drag studies, ionospheric physics, magnetic fields, cosmic rays and trapped particles, ultraviolet, X- and gamma rays from the outer atmosphere and extraterrestrial sources, and the interplanetary medium.

Balloon and Rocket Research

The Board presented the views of scientists throughout the country on proposed Federal Aviation Agency regulations to govern the launching and flights of balloons and rockets in the United States. Since the draft regulations appeared to place very serious limitations on launching of balloons and rockets for scientific research, with consequent adverse implications to the future of other aspects of space research as well, the Board solicited the views of a large number of scientists throughout the country. A special report summarizing the views and suggestions of the scientific community was forwarded to the FAA in May 1961. The Board has continued to work closely with the FAA in its revision of the original draft regulations and, in particular, assisted in arranging that representative scientists should participate in a hearing on this matter before the FAA on December 7.

Geodetic Satellite

Continuing activities begun in 1960, the Board has represented the interests of fundamental science to the Government regarding the need for a geodetic satellite which can be used for fundamental scientific investigations. A geodetic satellite program would supply, with immediacy and directness, data for scientific problems or objectives falling broadly in the following three categories: (i) the establishment of a world-wide coordinate system on which all separate land masses can be placed with a precision about an order of magnitude higher than presently attainable; (ii) mapping the coarser structure of the earth's gravitational field, which is the only direct way to locate the regions of excess or deficient density in the earth's interior; (iii) discovery of possible variations of the so-called "gravitation constant" with time, position, or direction, which certain physical theories predict and which would profoundly alter our views of the universe. The Board has reported to the Government that it has carefully examined the scientific needs for such a program and believes they are most important for advances in geodesy.

Planetary Atmospheres Report

Following a symposium convened by the Board in June 1960 to examine the state of current knowledge of the atmospheres of the planets, a special study group was assembled to investigate more thoroughly our present knowledge of these atmospheres and to prepare a report concerning the most important unknown aspects which should be investigated as part of the Nation's space research effort. A report in five chapters was published by the Academy in December 1961, as an authoritative compilation of current knowledge of planetary atmospheres and as a reference work

for designing planetary missions.

Project WEST FORD

A special Board study group worked closely with the organizations responsible for the conduct of Project WEST FORD in order to assess the scientific impact of this experiment, particularly as to radio and conventional astronomy. Continuing effort has been made to bring the facts and implications of this experiment to the attention of scientists both at home and abroad. In pursuance of these aims, the SSB arranged for the publication of four articles in the April 1961 issue of the Astronomical Journal, under the heading Project WEST FORD -- Properties and Analyses.

In August, the Academy issued a report summarizing its activities on the WEST FORD Project. Included in this review was an official policy statement on Project WEST FORD obtained from the Government: this statement said, in essence, that competent astronomers in consultation had concluded that the effects of the initial experiment would be harmless, and guaranteed that no further experiments would be conducted until after the results of the first experiment had been carefully evaluated. This statement was distributed at the General Assembly of the IAU in August. Since that time the Academy has secured the publication of the predicted lifetime calculations for the dipole belt (Science, 134, 973, 6 October 1961), to provide an additional point of information. Steps have been taken to secure the collaboration of both foreign and domestic scientists in observations and measurements of the dipole belt when it is erected. The Board's special committee continues to provide scientific advice and information regarding the program to project personnel as well as to Government authorities responsible for policy decisions.

Radio Frequency Allocations

The Board has continued to provide advice and assistance to Federal agencies concerned with frequency allocations and assignments needed for the space research program. The pressures from all quarters to make maximum use of all the available radio spectrum are so great, and the spectrum has become so crowded, that the needs of scientific research are often in danger. In response to this situation, in the spring of 1961 the Academy established a Committee on Radio Frequency Allocations for Scientific Research, to which the Board has named two members. The Board looks to the Committee to represent and protect the frequency needs of space science and related fields. These include not only frequency allocations for the telemetry of experimental data and radio command links between ground stations and satellites, rockets, and balloons, but also clear channels for radio and radar astronomy.

World Data Center A for Rockets and Satellites

In 1961 the Academy continued the operation of World Data Center A for Rockets and Satellites as a means for the international exchange of scientific data resulting from research programs employing these tools. Staff of the Center and the Board have collaborated in the international distribution of scientific information concerning each successful NASA launching of scientific satellites and space probes. During the year the center issued Report numbers 13 and 14 in the Satellite Report Series.

INTERNATIONAL ACTIVITIES

1961 COSPAR Meeting and Symposium: Established by The International Council of Scientific Unions in 1958, the Committee on Space Research held its fourth meeting and its Second International Space Science Symposium in Florence, Italy, April 7 to 18, 1961. The Symposium was attended by approximately 300 scientists from 28 countries and 117 scientific papers were presented by scientists from 14 countries. The Space Science Board organized a U.S. delegation of about 65 scientists and a U.S. scientific presentation of 56 papers. The following is a list of the countries and the number of papers presented: Argentina (1), Belgium (1), Canada (4), Czechoslovakia (1), Denmark (1), France (8), Germany (7), Italy (12), Japan (8), Netherlands (2), Sweden (1), UK (5), USA (56), USSR (12).

The Symposium was divided into the following seven sessions: Rocket and Optical Tracking; Magnetic Observations; Telemetry and Data Recovery; The Special Geophysical Events of July 1959 and November 1960; Recent Results from Instrumented Satellite and Spacecraft; International Reference Atmosphere; and Scientific Research by Means of Small Sounding Rockets.

The working sessions of the Fourth COSPAR Meeting produced a number of significant resolutions including COSPAR development of a world list of tracking stations; a COSPAR study of the need for more tracking facilities in the Southern Hemisphere; endorsement of satellites of the TRANSIT type for ionospheric research; COSPAR development of an international program of contributions by rocket and satellite experiments for the International Year of the Quiet Sun and World Magnetic Survey; measures to increase the effectiveness of the world-wide SPACEWARN system for rapid communication of satellite information; and COSPAR action to revise the IGY guide to World Data Centers for rockets and satellites, which establishes the character of international information exchanges. A COSPAR International Reference Atmosphere was adopted.

The Space Science Board, with the cooperation of NASA and the Smithsonian Astrophysical Observatory, has prepared a comprehensive list of tracking stations which report their results to the U.S. and has submitted this list to COSPAR for its use when similar information is available from other countries.

COSPAR Planning for IQSY and WMS. A meeting of COSPAR Working Group II on scientific experiments was held at Kyoto, Japan, in September 1961. This meeting took advantage of the presence in Kyoto of a large number of the world's leading experts in cosmic rays and geomagnetism further to develop plans for the IQSY and WMS. In cooperation with the Academy's Geophysics Research Board, the Space Science Board is developing proposals for the U.S. program of activities for the IQSY and WMS.

Information and Data Exchange. A new Guide to Rocket and Satellite Information and Data Exchange has been drafted and is now being circulated internationally to the members of Working Group II for agreement. The Draft Guide, an expansion and extension of the IGY provisions, sets forth in detail procedures for announcement of rocket and satellite launchings, designation of satellites and space probes, distribution of acquisition and tracking data, exchange of scientific results, and presentation of reports and bibliographies of national space programs.

Improvements in the SPACEWARN System. A unified code for the transmission of satellite information is being developed and steps are being taken to improve the effectiveness of the SPACEWARN system for world-wide rapid communication of satellite information. This plan provides for the appointment of national contacts within member countries of COSPAR for SPACEWARN matters to review the problems of end-users and the addition of radio broadcasts on satellite information to the present telegraphic communications network.

COSPAR International Reference Atmosphere. The availability of new and more precise data as a result of the IGY, and of new tools for research conducted in space gave rise to the need for an internationally recognized set of reference data on pressures, temperatures, densities, etc., of the high atmosphere above 32 km. In response to this need COSPAR convened a group of appropriate experts to develop the basis for an International Reference Atmosphere.

Chapter X

Smithsonian Astrophysical Observatory

INTRODUCTION

The Smithsonian Astrophysical Observatory is involved under grants and contracts in three programs of the National Aeronautics and Space Administration: optical satellite tracking, the orbiting astronomical observatory, and the orbiting solar observatory.

OPTICAL SATELLITE TRACKING PROGRAM

The Observatory's Satellite Tracking Program consists of: (a) twelve photographic tracking stations equipped with Baker-Nunn cameras, which are the most powerful optical means available for the precise observation and determination of satellite positions; the cameras are capable of photographing a very faint object (13th magnitude) to an accuracy of 4 seconds of arc and 2 milliseconds of time; (b) 95 volunteer Moonwatch teams in 18 different countries; these Moonwatch stations supply additional approximate observations and act as a reacquisition system for lost satellites; and (c) photoreduction, computation, data, and communication divisions and a staff of scientists who analyze the data. To date, approximately 38,000 satellite passages have been photographed by the camera stations, and 40,000 recorded by Moonwatch.

Last year, major developments in operational techniques of the Baker-Nunn camera stations were accomplished in two fields: the automation of matched track and off-culmination observing methods; and the design and development of auxiliary equipment to synchronize the entire network to within several milliseconds of time. These developments will prove extremely valuable in geodetic research using direct triangulation methods.

The Research and Analysis Division has made valuable contributions to our basic knowledge of the earth and the upper atmosphere. The division has achieved greater accuracy in the analysis of the earth's gravitational potential field, established the gravitational ellipticity around the earth's equator, and determined the geodetic positions of the observing stations with greater exactness. The division has measured variations of atmospheric density in relation to solar activity and interplanetary storms; and studied the effect of solar light pressure on satellites. Its new model of the terrestrial atmosphere has been accepted as a tentative standard by the International Committee of Space Science.

During the year, four leading scientists from England, Belgium, Republic of South Africa, and United Arab Republic, respectively, have done research at the Observatory using data obtained through the satellite tracking network.

During 1961, The Observatory issued special reports numbers 56 through 82 inclusive in its series Research in Space Science: and members of the scientific staff

published a score of papers in professional journals.

ORBITING ASTRONOMICAL OBSERVATORY

Project CELESCOPE, which is part of NASA's Orbiting Astronomical Observatory, will place three telescopes and a slitless spectroscopy in orbit to extend stellar observations to the far ultraviolet and X-ray region of the spectrum. The immediate objective of the program is to map about 200,000 stars and record their brightness.

During 1961, CELESCOPE negotiated a contract for the construction of the satellite payload and the ground station for receiving data from the satellite. In addition, two contracts have been concluded for the manufacture of the special television-type tubes sensitive only in the ultraviolet regions to 1000 angstroms.

In March, 1962, a prototype of the satellite instrumentation is scheduled to be launched in an Aerobee-Hi rocket. This experiment will test the capabilities of the data handling equipment and provide a rough idea of the sensitivity that will be required of the final satellite instruments. In late 1963 or early 1964, the satellite will be placed in orbit.

ORBITING SOLAR OBSERVATORY

For NASA's Orbiting Solar Observatory Program to make ultraviolet studies of the sun, the Smithsonian Astrophysical Observatory, in cooperation with Harvard College Observatory, is directing the design and construction of two scanning spectrometers. The combined spectral range of the spectrometers will be 75 to 1500 angstroms, and the resolving power will vary between 0.3 angstrom at the longer wavelengths and 1.0 angstrom at the shortest wavelengths. The design of these spectrometers was completed during the past year.

Chapter XI

Federal Aviation Agency

INTRODUCTION

The Federal Aviation Agency (FAA) is responsible for assuring the safety and efficiency of U.S. civil air operations and for fostering future development in a safe environment. During 1961, the Agency reviewed its first two years of operation in order to prepare to meet the increasing demands created by aviation's dynamic growth. Special task forces developed national aviation goals and made recommendations for modernizing the air traffic control system and for making rule-making and enforcement procedures fairer and more effective. At the same time, a concerted effort was begun to improve relations with the aviation community. The FAA also streamlined and decentralized its management organization.

NATIONAL AVIATION GOALS

Project Horizon

At Presidential direction, an FAA task force studied and defined national aviation goals for the next decade. The report calls for an integrated national aviation system designed to make a maximum contribution to the economic growth, security and culture of the United States, as well as to international commerce and world peace. Recommendations included in the report call for: development within five years of a common civil/military air traffic control system; supersonic aircraft development by early 1970 to maintain U.S. leadership in commercial aviation; economically efficient V/STOL aircraft; simplified air regulations; support of general aviation growth and an improved national airport system.

Supersonic Transport Aircraft

The FAA, in conjunction with the Department of Defense and National Aeronautics and Space Administration, has undertaken a long range program to work with the aviation industry in the development of an economically efficient Mach 3 transport aircraft. FAA, by virtue of its statutory authority and agreements with Defense and NASA, has basic responsibility for providing over-all leadership and management direction of the government role in the program. Congress appropriated \$11 million for contracted industry research in fiscal 1962.

Sonic Boom

A coordinated research program was begun by FAA, NASA, and the Air Force to determine methods of predicting and minimizing effect of the sonic boom. The projected development of a supersonic commercial airliner lends impetus to this project.

V/STOL Aircraft

For economical short-haul operations, more efficient helicopters and other vertical or short takeoff and landing aircraft are needed. To this end, a joint FAA/NASA/Defense report was prepared discussing these aircraft in detail.

FAA furnished technical assistance to the Army on standards necessary for certification of a tri-service V/STOL assault transport under development for operational service testing. Advance models will be made available to civil operators for recommendations to be incorporated into subsequent production models for possible civil use.

INTERNATIONAL AVIATION POLICY

The FAA Administrator, as Chairman of a committee appointed by the President to review U.S. international aviation policy, announced award of a \$300,000 industry contract to conduct a broad study of international aviation problems. The present system of granting international routes by bilateral agreements, and the operation of these agreements, were scheduled for review.

AIR SAFETY PROGRAMS

Project Beacon

A second study initiated by the President was based on a scientific and engineering review of the nation's air traffic control system and related research and development programs leading to safe and efficient use of the airspace.

The Beacon report recommended short and long-term changes in the existing air traffic control system to handle the forecast 44 percent increase in U.S. civil and military flying by 1975, and a corresponding 300 percent increase in air traffic control workload.

President Kennedy directed that the recommendations of the report be implemented, and work to that end has been undertaken.

Air Traffic Control

An intermediate airway system was established to provide express airways for long and medium haul aircraft flying between 14,500 and 24,000 feet. Navigation aids on these new airways are spaced farther apart than on the low altitude airways, with a resultant decrease in pilot position reporting workload.

Ceiling on the Chicago-Indianapolis positive control area was raised from 35,000 feet to 60,000 feet to provide positive control protection for civil and military aircraft conducting high altitude flight test and training operations at the higher altitudes. Plans for further expansion of the positive control area program await availability of additional radar equipment.

Standard Instrument Departure (SID) procedures, which simplify pilot-controller coordination of lengthy complicated departure instructions, were started at Indianapolis. SIDs are in the form of pictorial charts and are being developed for other

U.S. civil airports.

First national standards for conducting flight operations on and around all controlled airports were issued by the FAA. Aimed at flight safety and aircraft noise reduction, the new rule calls for limitation in airspeeds and requirements for two-way radio communications at all airports served by towers. There are 465 Federally-operated towers throughout the country, of which 234 are operated by the FAA and 231 by military services.

Progress was made in FAA efforts to furnish constant radar surveillance service, including direct radar hand-offs, at major terminals. Radar hand-offs are being accomplished on a full-time basis from 12 FAA Air Route Traffic Control Centers to 16 radar approach control facilities in airport towers. Fourteen other centers are providing radar hand-off service for inbound aircraft on a part-time basis. Limiting factor is availability of radar-trained controllers and special communications and radar equipment.

Joint use of long range radar by FAA and the Air Force has saved substantial sums in equipment costs and the units are adapted to serve both military and FAA functions. Fifteen radars are presently in joint use, with 33 scheduled for joint use by December 1963.

Federal Aviation Service

Looking toward a common civil/military air traffic control system, the FAA proposed to Congress the creation of a Federal Aviation Service which the President could have converted to military status in a national defense emergency to assure continued traffic control services.

During 1961, the Air Force transferred to the FAA its military flight service functions for all military aircraft operating within the continental United States and adjacent oceanic areas.

Plans for eventual transfer of a significant number of military air traffic control and air navigation facilities compatible with an integrated civil/military FAA control system are being developed.

Further civil/military cooperation was evident in an FAA prototype program of air traffic control training for USAF personnel.

Project Scan

Flight Safety Foundation was awarded an FAA contract to develop a pilot reporting program to obtain data on incidents in which mid-air collisions have nearly occurred. These reports are analysed by the Agency in its continuing campaign to improve air safety.

Airspace

A total of 3,790 square miles of restricted airspace was returned to general use in 1961, making a total return of 28,901 square miles since May 1959. Additional uncontrolled airspace was made available to pilots operating under Visual Flight Rules when flight visibility is less than three miles. This was done by generally raising the floor of the control area from the 700 feet to at least 1,200 feet above the surface, providing an additional 500 feet or more of uncontrolled space.

Safety

New FAA procedures for emergency operation of certain jet hydraulic systems were issued and, after extensive investigation by the FAA and industry, hydraulic system changes were ordered to correct similar problems with all large jet transports.

A special Civil Air Regulation was issued making it mandatory for pilots in command of aircraft operating in controlled airspace under Instrument Flight Rules to report immediately to FAA air traffic control any in-flight malfunctions of navigational or air/ground communications equipment.

Weather accounts for approximately 35% of the fatalities incurred in general aviation accidents. Incentive for raising private and commercial pilot skill was instituted in October 1961, with inauguration of the FAA's Blue Seal program. Private and commercial pilots who acquire enough instrument skill to fly out of any marginal visibility or weather conditions they might encounter and back to an area where visual flying is safe qualify for a Blue Seal on their pilot certificates.

Airports

FAA's 1961 National Airport Plan called for a total of 465 new airports to be built and improvements made to 2,834 existing airports during the next five years if the nation's civil aviation needs are to be met. Under the present Federal Airport Act, the FAA is authorized to allocate up to \$75 million to match local sponsors' funds during the fiscal year which ends June 30, 1962. Objective of the Federal Air Airport Program is the establishment of a nationwide system of public airports adequate to meet present and future needs of civil aviation.

Under a joint FAA/Civil Aeronautics Board policy statement regarding requests for airport aid funds, use of single airports serving adjacent communities -- which results in savings to the Federal Government, and to sponsoring communities, and improvement in air service to the area, -- is specified as a factor in allocating Federal funds for airport construction.

Dulles International Airport, under construction near Chantilly, Virginia, is scheduled to open in late 1962. Designed from the ground up for jet age needs, the new Washington airport features a new passenger handling concept, the mobile lounge, incorporated into the terminal design.

GENERAL AVIATION

Project Little Guy

To provide a greater margin of safety for the general aviation pilot, a study was initiated of simpler, more efficient cockpit instrumentation and layout for light aircraft.

Project Tightrope

Project Tightrope was initiated to review FAA's rule-making enforcement procedures to satisfy requirements of the Federal Aviation Act of 1958 and the Administrative Procedures Act of 1946. Published in November 1961, the Tightrope report recommended better management of the currently dispersed rule-making activities and authority of the Agency. It also urged establishment of a hearing officer system for enforcement cases. Based on these recommendations, FAA established an Agency Regulatory Council to provide a central forum for FAA's rule-making process, and it is actively considering other changes.

Safety Regulations

FAA's rules recodification, begun in 1961, will simplify and integrate all regulatory material into one code called the Federal Aviation Regulations. Purpose of the program is to simplify, combine and streamline the present complex of 123 regulations and considerable other materials into approximately 60 simplified, easily understood rules.

AGENCY REORGANIZATION

Reorganization of the FAA began in 1961. Authority for program development and policy-making remains in Washington, but operational responsibility has been delegated to the field, with the number of regions being increased from six to seven. Airport functions were removed from the Aviation Facilities Service and placed in a separate Airport Service to assure more effective administration of the Federal Aid Airport Program.

Chapter XII

Federal Communications Commission

SPACE COMMUNICATION

Radio communication, heretofore earthbound, except for reflecting layers extending to the outer limits of the atmosphere, is rapidly reaching thousand of miles into space. Man-made satellites transmit radio signals, and space objects are used to "bounce" other signals to test long-distance communication possibilities.

Although the Commission is not responsible for any over-all space program or any particular space vehicle launching project, space communications, as a new means of communication, obviously has great importance to it in view of the potential use of such means by non-government interests for telephone and telegraph communication, broad-band data transmission and intercontinental television. The Commission has obligations under the Communications Act to "study new uses for radio, provide for experimental uses of frequencies, and generally encourage the larger and more effective use of radio in the public interest," as well as to "make available, so far as possible, to all the people of the United States a rapid, efficient, nationwide, and worldwide wire and radio communication service."

The Commission's responsibilities include the allocation and assignment of frequencies for space communication and the authorization of research and experimentation looking toward the use of natural or man-made satellites to provide civil communication services on a regular basis. This development presents a new and complex array of technical problems, not the least of which is finding suitable and sufficient frequencies and insuring compatibility between space communication systems and surface systems in the public interest. Many regulatory problems will flow from adding space communication to radio's already manifold uses.

The achievement of these purposes involves both national and international considerations. Consequently, the Commission is working closely with the interests concerned.

This involves particularly close relationship with the National Aeronautics and Space Administration (NASA). On February 28, 1961, the FCC and NASA announced a joint memorandum of understanding for delineating and coordinating their respective responsibilities in this field.

The FCC also participated in other related interagency activities, including those of the Telecommunications Coordinating Committee (TCC) of the Department of State; the Telecommunications Planning Committee (TPC); the Office of Civil and Defense Mobilization (OCDM, later OEP); the Interdepartment Radio Advisory Committee (IRAC); the U. S. Committee for Study Groups IV and VIII of the International Radio Consultative Committee (CCIR) of the International Telecommunication Union (ITU); the Space Science Board (SSB); the International Radio Scientific Union (URSI); and the National Bureau of Standards Central Radio Propagation Laboratory.

Under the auspices of the National Aeronautics and Space Council, representatives of the FCC participated in the drafting of recommendations to the President on Communication Satellite policy and on draft legislation for organizing and regulating the commercial communication satellite business.

International Considerations

The International Administrative Radio Conference, held at Geneva in 1959 under the auspices of the ITU, adopted an international table of frequency allocations which, for the first time, opened bands of frequencies for space and earth-space services. These bands, however, are for research purposes only and are useful principally for research, tracking, control, and telemetry functions. Although no bands were allocated internationally for space satellite relay communication, an Extraordinary Administrative Radio Conference of the ITU is scheduled tentatively for late 1963 to deal specifically with world frequency problems for space communications on the basis of development as of that time. At the request of the Department of State, preparatory work toward formulating the U.S. position at that conference has been initiated jointly by the FCC and IRAC.

PROCEEDINGS

Space Frequency Allocation

As a result of developments in space communication during 1960, the Commission reopened its proceeding in the general inquiry relative to the allocation of frequencies above 890 Mc (docket 11866) to determine, in the light of evidence then available, whether the frequency requirements for communication via space satellites would require modification of the Commission's decision to permit some additional classes of users to establish communication systems on frequencies between 1,000 and 10,000 Mc. After a careful analysis of all the evidence then on hand, the Commission on September 28, 1960, concluded that its earlier decision need not be modified at that time.

However, in view of rapid developments in space communication, the Commission had, on the previous May 18, instituted an inquiry (docket 13522) as to space frequency needs on a longer range basis. This information will assist the Commission in its preparatory work leading to a U.S. position for future international conferences on space needs and usage. On December 21, 1960, the inquiry was expanded to include consideration of whether and what sparsely settled areas might be established and protected for future civil space communication earth terminals.

On May 17, 1961, the Commission adopted, for public comment, a second notice of inquiry in docket 13522 setting forth preliminary draft views of the United States concerning international frequency allocation requirements for coordinated domestic and foreign space programs. After consideration of the public comments and further study of the matter with IRAC, the Commission on August 1, 1961 adopted and

sent a document containing its preliminary views to the Secretary of State recommending that the Department disseminate these views abroad so that the United States can have the benefit of the reaction and comments of other administrations prior to the scheduled 1963 Conference. A similar document was also transmitted on about the same date to the Secretary of State by the Office of Civil and Defense Mobilization, which is now the Office of Emergency Planning for the President. The document has been distributed abroad by the Department of State for this purpose.

In summary, the proposals would provide frequencies for space communication, research, meteorological and aeronautical services, also for telemetry, command, guidance, and tracking functions associated with such space operations.

The U. S. draft estimates that a total of about 3,000 Mc of spectrum space for the communications satellite space service, in the range 3,700-8,400 Mc should be allocated to meet foreseeable requirements until about 1970. Of this, 2,000 Mc would be divided between earth-to-satellite and satellite-to-earth transmissions, 950 Mc in each case being shared with the fixed and mobile services, with two other bands reserved for adjustments as needed.

These allocations proposed for the communication satellite service lie in the range of 3,700-4,200 Mc (3.7-4.2 gigacycles) and 5,925 and 8,400 Mc (5.925-8.4 gigacycles) where it would share frequency bands with the existing fixed and mobile services. (A "gigacycle" is a short term for denoting 1,000 Mc.)

Administrative and Regulatory Problems

On March 29, 1961, the Commission to facilitate an early solution to administrative and regulatory problems relating to the authorization of a commercially operable space communications system, instituted an inquiry (docket 14024) into the matter. Specifically, on the assumption that only one or a related number of such systems would be feasible, and in view of the Commission's policy of fostering beneficial competition in the international communication field and within the antitrust laws, it solicited views from the public as to the best plan to ensure that international communications common carriers and others participate on an equitable and nondiscriminatory basis in a single or limited number of satellite systems. It also required views as to the consistency of such plan with antitrust and other laws and policy, the authority of the Commission to prescribe such plan, and the extent to which participants would be subject to its regulation.

After receiving comments the Commission, on May 24, issued a report stating that those replying generally favored a joint venture for the ownership and operation of such system but differed as to the composition of such venture. The Commission stated that a joint venture of international telephone and telegraph common carriers was deserving of consideration and exploration. After a conference was held with those carriers and other respondents, the Commission through a supplemental

notice of inquiry announced a plan of procedure to permit such carriers to meet jointly through an ad hoc committee for the purpose of formulating a plan of organization or joint venture with respect to such system. It set out public interest objectives which should be met by any joint venture, including the requirements that it be so structured or arranged to prevent any single carrier from being in the position to dominate such system, that it ensure that existing or future carriers, whether or not owners, have equitable access to a non-discriminatory use of the system under fair and reasonable terms, that it ensure, as through competitive bidding, that there would be no favoritism in the procurement of communications equipment required for the construction, operation, and maintenance of the system, and that opportunity would be fostered for continued research and development activity by all enterprises seeking to compete to furnishing such equipment for the satellite system. In connection with this last point, the Commission had previously announced that it intended to require that its approval be obtained with respect to the specifications for all equipment used in the system, including ground terminals, and that before approving any specifications it would examine into the relevant patent situation to ensure that an undesirable or dominant patent position would not hamper or frustrate its objectives in this regard.

Because of the prime importance given by the Commission to this undertaking it required the committee to report not later than October 13, 1961. On that date nine international carriers filed a plan which, together with all relevant information and proposals, was given careful study by the Commission.

Experimentation

The FCC encouraged experimentation by its licensees so that private industry might develop additional technical information to further the country's over-all space program. In this endeavor, NASA will cooperate by providing facilities at cost to launch satellites built by the communications industry.

Since January 1961, the Commission has granted authorizations to several private companies to conduct space communication experiments such as bouncing signals off the moon and "passive" earth satellites and also for testing earth terminal equipment and "active" satellites.

Monitoring

Another FCC activity is the continued monitoring of channels being used for space communication. This started with its long-range direction-finding work in tracing Sputnik I, before the Government established special installations to track space objects. Commission monitoring is to prevent unauthorized use by other stations of channels employed for space communication, and to identify and locate sources of interference on those channels. At a number of FCC monitoring stations, special equipment used for this purpose includes sensitive receivers, high-gain directional antennas, and automatic frequency scanning devices.

Chapter XIII

United States Information Agency

INTRODUCTION

In telling the story of our national space program during 1961, the United States Information Agency (USIA) made energetic use of its available resources. The Agency's five media divisions -- Press, Radio, Television, Motion Pictures, and Information Centers Service -- kept a continuing flow of materials enroute to U.S. Information Service posts in 98 countries for further dissemination, much of it in the local language. Because of restrictions on U.S. informational activities in the Communist bloc of nations, peoples in those countries were served primarily by Voice of America radio broadcasts, publications such as the Russian and Polish language America Illustrated circulated under reciprocal agreements with the USSR and Poland, and USIS exhibits carried out under cultural exchange agreements.

Space information was prepared for overseas audiences by USIA staff members, whose duties include originating some materials and processing those supplied by other Government agencies and private industry. Additional tailoring and translation were handled in the field by USIS officers and their locally employed staffs.

Because of the continuing heavy demand for space information, USIA took steps late in the year to set up a service, designed especially for foreign science writers, to supply materials on a wide range of U. S. scientific activities, including space. This service, already tested in Germany, promises fruitful returns in other areas.

THE MEDIA SERVICES

Press and Publications

News stories were carried via radioteletype Wireless File to 92 points in all areas, some of which are not serviced by U. S. commercial news agencies. A special Project MERCURY packet,* about our first manned space flight, furnished information on which news stories and articles in thousands of newspapers, magazines, and other publications throughout the world were based. The post in Bangkok, for example, reported that eight newspapers stopped their presses to handle the packet stories. Posts in Lahore, Warsaw, Caracas, Athens, and Buenos Aires told of similar results.

After the flight, Commander Shepard, assisted by a USIA editor, prepared a 2500-word by-line article that was sent around the world by Wireless File and received

*Whenever necessary, advance packets containing articles and photographs are dispatched for translation and preparation for distribution at launch time.

correspondingly wide usage.

During the year, materials prepared by USIA Washington appeared in 102 USIS periodicals in 29 languages ranging from Amharic to Vietnamese. USIS Paris dedicated an entire issue of its monthly Information et Documents to U.S. space achievements, as did USIS London with its monthly Science Horizons.

Twelve different pamphlets came out in such languages as French, Arabic, Greek, Chinese, Swahili, and Hausa. USIA's Regional Service Center in Beirut adapted a National Geographic article into a heavily illustrated pamphlet entitled "The Great Venture," and distributed it throughout Africa and the Near East. Other articles appeared in the Agency's America Illustrated in Russian and Polish; and Al Hayat in Arabic. A number of articles on space were selected from American periodicals, and after copyright clearance were offered to foreign journals for their use.

Wide photographic coverage in 1961 ranged from "TIROS-eye-views" of Africa and the Mediterranean to a serial "strip" on space that was published in book form by USIS Manila. Photographs acquired from NASA, the Department of Defense, and private industry, went out with news stories, picture stories, as illustrations for special features, and in plastic mat form to serve small newspapers lacking reproduction facilities. Sample usage: 19 Japanese newspapers and magazines used 111 pictures of our first manned space flight, covering 34 pages of photographic reproduction with 422 column inches of explanatory text.

Radio -- Voice of America

Throughout the year, Voice of America (VOA) covered all major space achievements as lead stories in world news roundups broadcast in 36 languages, including English, to all areas of the world. Space stories given top billing included: the Shepard and Grissom flights; the orbiting journey of a chimpanzee; the mid-air catches of DISCOVERER capsules in the Pacific; the use of TIROS weather satellites in spotting hurricanes; and defense spacecraft such as MIDAS.

In addition to the lead stories in 15-minute news roundups, separate, expanded accounts of each major U.S. space achievement were broadcast immediately after the news, to give additional details of the flight and the vehicle that made it. Other items broadcast included wrap-ups of editorial comment and press reaction, both at home and abroad, on significant U.S. space accomplishments.

More than 84 features and news analyses were broadcast world-wide throughout the year. Series of programs aired on space subjects included "Conquest of Space," "Project MERCURY," and "New Horizons in Science."

VOA reporters on the scene at Cape Canaveral provided bulletins and eye-witness accounts of the successful launchings of astronauts for the language services. Typical of the coverage was the Armenian broadcast on the first of such flights. Within one minute after launching, the newscast was interrupted with the first of four news bulletins. These special bulletins announced (1) the launching, (2) the first reports from the astronaut himself, (3) the sighting of the capsule, and (4) the recovery of the astronaut alive and well. The last scheduled feature of the program was replaced with a special interview, announced as having been pre-recorded at Cape Canaveral, featuring Shepard's own voice.

When Astronaut Grissom was launched into space, the world-wide English program then on the air interrupted its regular service to carry the story live with a feed from a VOA reporter on the scene in Florida. The story was carried, with updated news, as a special all during the day, to reach all areas.

During the International Meteorological Satellite workshop, VOA broadcast interviews with 15 of the delegates, in languages ranging from Chinese to Urdu. The Russian language service conducted interviews in French and English, then translated them into Russian for listeners in the Soviet Union.

In conjunction with the U.S. National Academy of Sciences, VOA transmitted the latest information on new satellite launchings, and up-to-the-minute revised statistics on satellites already in orbit. These broadcasts are a contribution to the international efforts of the Council on International Scientific Unions, COSPAR. While intended chiefly for tracking stations and scientific organizations in South America, the broadcasts can be received in other areas of the world, and are of interest to all listeners desiring the latest launching and orbital information on earth satellites.

Television

By distributing advance film clips and documentaries to the USIS posts serving the 54 countries which have television, USIA was able to capitalize immediately on the public interest in such major projects as MERCURY and SATURN at time of launch. These advance "visuals" served as background for news received by USIA's Wireless File and through commercial news agencies.

One such advance was Shadow of Infinity, a 15-minute documentary of the first U.S. manned space shot. Virtually all posts reported that the film was used extensively and received excellent reactions. USIS Manila reported: "Telecast was praised by viewers and received plaudits in the local press..." Similar reports were received from Caracas, Rio de Janeiro, Beirut, Damascus, Lagos, Wellington, Oslo and Lisbon. And USIS Rome reported that RAI, the Italian radio-television network, was able to go on the air the day of the flight with film, stills, and other background information sufficient to total 50 minutes of detailed and authoritative reports.

USIA's weekly Panorama Panamericana, a 15-minute TV newsreel in Spanish and Portuguese distributed to 47 stations (41 cities) in 17 Latin American countries, carried 22 reports on U.S. space progress and activities. Sample subjects: X-15 flights; TRANSIT; COURIER; ECHO; TIROS photos; MERCURY flights; and the International Meteorological Satellite Workshop. Similar subjects were covered in both regular and special reports for Europe, Africa, the Near East, and the Far East. U.S. scientific satellites were given special attention in the 13-film IGY series entitled Planet Earth, seven of which concerned outer space.

The USIA television branch assisted numerous teams from abroad -- particularly Western Europe and Japan -- in filming space subjects at major U.S. installations, and in procuring documentary footage from official sources. This service enabled foreign networks to give authoritative and well-rounded treatment of the U.S. space effort.

Motion Pictures

During 1961, the USIA motion picture service (IMS) distributed 10 documentary films on space topics. The following examples show typical language patterns and distributions: ATLAS (1 reel, black and white, 17 languages in 90 countries); TIROS EXPERIMENTAL WEATHER SATELLITE (2 reels, color, 14 languages in 75 countries); WORLD WATCHES EXPERIMENT IN SPACE (1 reel, black and white, 37 languages in 102 countries).

The last-named film was a factual, newsreel documentary, distributed soon after the historic space flight of May 5, and showed how the launch and recovery were carried out in full view of representatives of world news media. This policy of "openness," in marked contrast with the secrecy of the Soviet Union, was an impressive success. Typical of world press comment was this statement in Vienna's Neue Tageszeitung: "...A great technological achievement of the Communist world ...has been followed by an equally great one which has been reached in an entirely different social-political climate... We can only welcome this noble style which is rooted in the essence of free life."

Other newspapers throughout the world expressed similar reactions to the "open" policy and practice of the United States.

Film footage was also furnished to USIS posts for use in locally produced documentaries and newsreels.

Information Centers Service

The continuing requirements of overseas libraries (176 U.S. Information Service, 128 bi-national centers) for books and publications -- both in English and in translation -- official documents, exhibits, posters, prepared lectures, slides, etc., were met by the Information Centers Service (ICS) of USIA.

Drawing on the American publishing industry's prolific output on aeronautics and space subjects during 1961, the ICS Bibliographic division appraised more than 50 titles; of these, 33 (17 adult, 16 juvenile) were included in the lists of "Current Books Recommended for USIS" distributed to all posts. The books ranged from technical and industrial treatments to popular articles and books on space accomplishments and space potentials.

Fifteen titles fed into the book translation program came out in a variety of languages, including Bengali and Burmese, Tamil and Telugu, in editions ranging up to 10,000 copies. For example, one authoritative analysis appeared in Arabic, Burmese, Greek, Hindi, and Malayam; another was published in Japanese, Arabic, Chinese, Korean, Marathi, Malay, Telugu, Tamil, Malayalam, and Indonesian.

Numerous official Government publications, particularly those put out by NASA and the House and Senate Space Committees, were distributed to USIS libraries. Many of these documents were issued in translation by USIS posts overseas.

To assist USIS public affairs officers in giving factually accurate and authoritative talks on space subjects, ICS distributed a special packet containing background materials and a lecture, in layman's language, written by an official of the National Academy of Sciences.

Exhibits

Working in close cooperation with NASA's Office of Technical Information and Education, the USIA Exhibits Division circulated to overseas posts these NASA-produced exhibits:

TIROS Weather Satellite

Eight copies shown in 18 countries in all areas, including the USSR.

Project MERCURY

Seven 1/3-scale models of the MERCURY capsule with back-up panels were sent to as many important posts. Two full-scale models were circulated in Europe and Latin America. Two thousand copies of an eight-panel color poster on manned orbital flight were distributed world-wide for use at the proper time.

PIONEER V Space Probe

Eight copies shown in 17 countries.

In addition to the above, the following USIA-produced exhibits were shown:

X-15 Research Airplane

One hundred copies, scale model and explanatory panel, were shown world-wide.

Space Unlimited

Fifteen copies of an old standby still being used effectively in 15 countries.

Outer Space -- A New Frontier

Eighty-six thousand copies of a full color poster, shown world-wide.

By far the most impressive single exhibit activity was the showing of Freedom-7 spacecraft at the International Air Show in Paris (600,000 visitors) May 25-June 4, and at the Electronic and Nuclear Fair in Rome (1,200,000 visitors) June 13-25. In both shows it became a fetish for the viewers to touch the capsule for "luck." The genuine public interest reflected in all public information media led one Italian paper to comment editorially: "The psychosis of American failure after Gagarin's flight has now disappeared."

SUMMARY

The policy of "openness" observed in both U.S. manned space flights during the year dramatized the basic difference between the American open society and the Soviet closed society, and drew widespread approval from commentators

throughout the free world. The availability of full information about the events through all news media, together with the presence of foreign correspondents -- who gave first-hand, on-the-spot coverage -- enabled overseas audiences to achieve a high degree of self-identification with one of the greatest adventures of our time. USIA fostered and promoted this sense of participation by every means at its disposal through all of its informational media.

SUCCESSFUL U. S. LAUNCHES -- 1961

Launch Date Name Designation Vehicle	Payload Data	Apogee and Perigee (in statute miles) Period (minutes) Inclination to Equator	Remarks
Jan. 31, 1961 SAMOS II 1961 Alpha 1 Atlas-Agena	Total weight: 4100 lbs., including 2d-stage casing. Objective: determine capabilities for making observations of space, the atmosphere, and the nature of the globe from satellites. Payload: Photographic and related test equipment.	340 295 94.9 97.40*	Near-circular polar orbit achieved. * The listed inclination in excess of 90° means the orbit was retrograde, i.e. pointed slightly westward instead of in the favored direction.
Feb. 16, 1961 EXPLORER IX 1961 Delta 1 Scout	Total weight: 80 lbs., including 15-lb. sphere and 65 lbs. of ejection, inflation, telemetry, and other equipment. Objective: Study performance of Scout research rocket; orbit inflatable sphere to measure atmospheric density. Payload: 3.65 meter inflatable sphere of mylar and aluminum foil; radio beacon, 280 solar cells, and miniature batteries.	1605 395 118.3 38.63°	First satellite orbited by all-solid-fuel rocket; first satellite orbited from Wallops Station. Radio beacon on balloon satellite never operated, requiring optical tracking. Early results: at 700 kms., atmospheric density was measured at 3×10^{-17} gram per cubic cm.
Feb. 17, 1961 DISCOVERER XX 1961 Epsilon 1 Thor-Agena B	Total weight: 2450 lbs., including 2d-stage casing and 300-lb. re-entry capsule, retro-rocket, and recovery aids. Objective: Evaluation of Agena B satellite and of modified satellite stabilization system. Payload: As above, plus four silicon samples to test effects of high-energy protons on silicon used on transistors and solar cells.	486 177 95.4 80.43°	Near polar orbit achieved; capsule could not be recovered because of equipment malfunction in satellite. Still in orbit, 1/2/61.

Feb. 18, 1961 DISCOVERER XXI 1961 Zeta 1 Thor-Agena B	Total weight: 2200 lbs. (approx.) Objective: Collect data on atmospheric phenomena and infrared radiation in support of USAF early warning satellites. Payload: Not disclosed.	659 149 93.8 97.8 after restart 80.74°	Near polar orbit achieved; first successful restart of Agena engine in space was made while satellite was in orbit. Satellite still in orbit.
Feb. 21, 1961 TRANSIT III-B and LOFTI 1961 Eta 1 Thor-Able-Star	Total weight: 250 lbs. Objective: Test of all-weather global navigational satellite system for ships and aircraft. Payload: 36-inch sphere ringed with 6600 solar cells and containing 2 transmitters, command system, memory system, telemetry system, despersion system, SECOR experiment.	511 117 94.5 28.36°	Orbit achieved was elliptical instead of near circular as intended and hampered quality of TRANSIT data; the two satellites failed to separate as planned but both transmitters functioned. Decayed on 3/30/61.
(LOFTI)	Total weight: 57 lbs. Objective: measure intensity of VLF signals coming through the ionosphere. Payload: 20-inch sphere containing telemetry and transmitting equipment and 2 VLF receivers.		
March 25, 1961 EXPLORER X 1961 Kappa 1 Thor-Delta	Total weight: 79 lbs. Objective: Gather definitive data on interplanetary and earth's magnetic fields and their interplay with solar plasma. Payload: 13-inch cylinder; magnetometer, 2 fluxgate magnetometers, plasma probe, optical aspect sensor, transmitter, and chemical batteries.	145,000 100 112 hours 32°	Orbit achieved, transmitters functioned continuously for 60 hours; data supported theory that interplanetary magnetic field near earth is mainly extension of sun's magnetic field.
April 8, 1961 DISCOVERER XXIII 1961 Lambda 1 Thor-Agena B	Total weight: 2100 lbs., including 2d-stage casing and 300-lb. re-entry capsule, retro-rocket, and recovery aids. Objective: Test of Agena B satellite, especially changes in guidance, stabilization, and propulsion for improved control of orbital period. Payload: Re-entry capsule with retrorockets and recovery aids; external lights for tracking experiment.	349 (768 capsule) 183 (126 capsule) 101.2 81° 94'	Orbit achieved, capsule separated from Agena in orbit; capsule failed to return to earth because of stabilization problems.

April 27, 1961 EXPLORER XI 1961 Nu 1 Juno II (4 stages)	Total weight: 82 lbs. Objective: orbiting a gamma-ray telescope to detect high-energy gamma rays from cosmic sources and map their distribution. Payload: 12" x 23 1/2" octagonal satellite mounted on 6" x 20 1/2" instrument column; gamma-ray telescope, sun and earth sensors, micrometeorite shield, temperature sensor, damping mechanism; 2 radio transmitters, solar cells, and batteries.	1,113.2 304 108.1 28.8°	Orbit achieved, with all equipment functioning normally. Preliminary analysis of data from gamma-ray telescope measuring intensity of gamma radiation rules out one version of steady-state cosmology in which matter and antimatter were held to be created simultaneously. If this were correct the intensity of gamma radiation would have been 1,000 times greater than it measured.
May 5, 1961 FREEDOM 7 (MR-3) Mercury- Redstone	Total weight: 2,100 lbs. (approx.), including man Objective: putting a man into suborbital flight and recovering man and spacecraft. Payload: in addition to man, life-support systems, radio and telemetry equipment to report on condition of man.	—————	Suborbital flight achieved; Astronaut Alan B. Shepard, Jr. went to 115 miles altitude, landed 297 miles downrange, demonstrated pilot control during weightlessness; astronaut and capsule recovered by helicopter after 5 minutes in water and transferred to USS Champlain.
June 16, 1961 DISCOVERER XXV 1961 Xi 1 Thor-Agena B	Total weight: 2,100 lbs. (approx.), including 2d-stage casing and 300-lb. re-entry capsule with retrorockets and recovery aids. Objective: testing of recently changed components in Agena B; improving control of orbital period. Payload: rare and common metals for study of effects of space environment; radiation and micrometeorite measuring instruments.	251.6 139.1 90.87 82.11°	Orbit achieved, capsule ejected from orbit and recovered from sea that same day north of Hawaii.

<p>June 29, 1961 (1) TRANSIT IV-A 1961 Omicron 1 and (2) GREB III (3) INJUN 1961 Omicron 2 Thor-Able-Star</p>	<p>Total weight: (1) 175 lbs.; (2) 55 lbs.; (3) 40 lbs. Objective: orbiting of 3 satellites, (1) to develop all-weather global navigation system (TRANSIT IV-A); (2) to measure solar X-ray radiation (GREB III); (3) to measure cosmic radiation and its intensity (INJUN) Payload: (1) memory system and electronic clock, 4 transmitters; (2) X-ray detectors, 1 transmitter; (3) 12 particle and proton detectors, 1 transmitter.</p>	<p>(1) 623 (2) and (3) 634 (1) 534 (2) and (3) 534 (1) 103.7 (2) and (3) 103.8 67°</p>	<p>Orbit achieved, but satellites 2 and 3 apparently failed to separate; this somewhat damaged the quality of trans- mission; TRANSIT IV-A was first satellite to use nuclear generator. TRANSIT IV-A data established that the earth's equator is elliptical rather than round, there being a 1000 ft. difference between the longest and shortest equatorial diameter. this difference, if not allow- ed for, would affect satellite orbits.</p>
<p>July 7, 1961 DISCOVERER XXVI 1961 Pi 1 Thor-Agena B</p>	<p>Total weight: 2100 lbs. (approx.) including 2d-stage casing and 300-lb. re-entry capsule with retro- rockets and recovery aids. Objective: evaluating of Agena B and new changes in components; improving of control of orbital period; ejection and recovery of capsule. Payload: chemical elements, including silicon, iron, bismuth, yttrium, to be tested for effects of space en- vironment; erosion gauge; micrometeorite detector.</p>	<p>503 146 95 82.93°</p>	<p>Orbit achieved, capsule ejected some 3 days later, recovered in mid-air north- west of Hawaii after 32 orbits.</p>
<p>July 12, 1961 TIROS III 1961 Rho 1 Thor-Delta</p>	<p>Total weight: 285 lbs. Objective: further development of satellite weather observation system; photographing earth's cloud cover and transmitting it to earth for analysis; measuring solar energy absorbed, reflected, and emitted by the earth. Payload: 42" x 19" cylinder, containing 2 wide-angle cameras, 2 tape recorders and electronic clocks, infra- red cameras, 5 transmitters, attitude sensors.</p>	<p>506.44 461.02 100.4 47.8°</p>	<p>Orbit achieved, cameras and infrared equipment trans- mitted good data.</p>

July 12, 1961 MIDAS III 1961 Sigma 1 Atlas-Agena B	Total weight: 3500 lbs. (approx.) including entire 2d stage. Objective: testing system for global detection of missile launchings. Payload: sensor, telemetry, and communications equipment; details not released.	2,197 2,084 160 N.A.	Orbit achieved, almost perfectly circular; highest orbit to date, heaviest U.S. satellite to date.
July 21, 1961 LIBERTY BELL 7 (MR-4) Mercury-Redstone	Total weight: 2100 lbs. Objective: further testing of Mercury capsule and life-support system in manned flight, preliminary to orbiting man. Payload: in addition to man, capsule and life-support system, radio and telemetry to report on condition of man.	_____	Flight successful, reaching altitude of 118 mi. and range of 303 mi. Astronaut Virgil L. Grissom recovered, capsule partially flooded and lost. This was the second successful manned suborbital flight.
Aug. 15, 1961 EXPLORER XII 1961 Upsilon 1 Thor-Delta	Total weight: 83 lbs. Objective: Investigating solar wind, interplanetary magnetic fields, distant parts of the earth's magnetic field, energetic particles in interplanetary space and in the Van Allen radiation belts. Payload: 27" x 19" cone with magnetometer boom and 4 solar-cell paddles; 10 particle detection systems measuring proton and electron activity and its relationship to magnetic fields; optical attitude sensor; 1 transmitter.	47,800 180 26 hrs. 25 min. 33,3 ⁰	Ceased transmitting 12/6/61 after sending 1.6 billion bits of data. Preliminary analysis of 10 percent of data indicated Van Allen belts really one zone of charged particles trapped in earth's magnetic field; extends from 400 to 30,000 or 40,000 mi. out, with abrupt outer boundary topped by 12,000-mi. electromagnetic turbulence. Zone's outer portion is mostly low-energy protons, its electrons having less intensity than previously indicated; lower portion still dominated by high-energy protons.

Aug. 23, 1961 RANGER I 1961 Phi 1 Atlas-Agena B	<p>Total weight: 675 lbs.</p> <p>Objective: Developing systems for lunar and interplanetary exploration; measuring cosmic rays, radiation, dust; checking on whether earth is followed by comet-like trail of hydrogen gas.</p> <p>Payload: 5" x 11" cone containing equipment for measuring solar radiation, energetic particles, cosmic rays, magnetic fields, solar X-rays, neutral hydrogen geocorona, cosmic dust, and friction; 2 transmitters, 8680 solar cells, 1 silver zinc battery.</p>	174 108 91.1 32.9°	Orbit achieved was low, oval earth orbit rather than deep space probe as planned; test of spacecraft achieved, but many of the desired interplanetary measurements could not be made. Re-entered 8/29/61.
Aug. 25, 1961 EXPLORER XIII 1961 Chi 1 Scout	<p>Total weight: 187 lbs., including spent 50-lb. 4th stage and 12-lb. transition section.</p> <p>Objective: Testing performance of Scout vehicle and guidance; investigating the nature and effects on space flight of micrometeoroids.</p> <p>Payload: 76" x 24" cylinder, almost covered by 5 types of micrometeoroid impact detectors; 2 transmitters, solar cells, and nickel cadmium batteries.</p>	722 74 97.5 37.5°	Orbit achieved was lower than planned: re-entered on 8/27/61.
Aug. 30, 1961 DISCOVERER XXIX 1961 Psi 1 Thor-Agena B	<p>Total weight: 2,100 lbs. (approx.), including 2d-stage casing and 300-lb. re-entry capsule with retrorockets and recovery aids.</p> <p>Objective: Testing reliability of Agena B; improving control of orbital period; ejecting and recovering capsule.</p> <p>Payload: Test instruments to check on adjustments made as result of previous flights.</p>	345 140 91 82.14°	Orbit achieved, capsule ejected on 33d orbit and recovered from sea north of Hawaii, 9/4/61.

<p>Sept. 12, 1961 DISCOVERER XXX 1961 Omega 1 Thor-Agena B</p>	<p>Total weight: 2100 lbs. (approx.), including 2d-stage casing and 300-lb. re-entry capsule with retrorockets and recovery aids. Objective: testing reliability of Agena B; improving control of orbit; ejection and precision recovery of capsule. Payload: biological samples, solar cells, and radiation-sensitive materials for testing of effects of exposure to radiation.</p>	<p>345 154 92.4 82.58^o</p>	<p>Orbit achieved, capsule ejected on 33d orbit and recovered in mid-air near Hawaii, 9/14/61.</p>
<p>Sept. 13, 1961 MERCURY - ATLAS IV 1961 Alpha-Alpha Mercury-Atlas D (MA-4)</p>	<p>Total weight: 2700 in orbit (3900 at liftoff, 2200 at recovery). Objective: orbiting the unmanned Mercury capsule to test systems and ability to return capsule to predetermined recovery area after one orbit; testing of global Mercury tracking network. Payload: simulator of pilot, to test invironmental control; 2 voice tapes to check tracking network; life-support system; 3 cameras, tape recorder, telemetry.</p>	<p>158.6 100 88.6 32.57^o</p>	<p>Orbit achieved, re-entry made automatically on program after one orbit; capsule recovered within programmed area, 161 mi. east of Bermuda; all test objectives met.</p>
<p>Sept. 17, 1961 DISCOVERER XXXI 1961 Alpha-Beta 1 Thor-Agena B</p>	<p>Total weight: 2100 lbs. (approx.), including 2d-stage casing and 300-lb. re-entry capsule with retrorockets and recovery aids. Objective: testing reliability of Agena B; improving control of orbital period; ejecting capsule for precision recovery. Payload: test instruments to check on adjustments made as a result of previous flights.</p>	<p>255 152 91 82.7^o</p>	<p>Orbit achieved, but 2d stage and capsule failed to separate; capsule did not re-enter as programed; decayed 10/26/61.</p>

<p>Oct. 13, 1961 DISCOVERER XXXII 1961 Alpha- Gamma 1 Thor-Agena B</p>	<p>Total weight: 2100 lbs. (approx.) including 2d-stage casing and 300-lb. re-entry capsule with retrorockets and recovery aids. Objective: testing reliability of Agena B; improving control of orbital period; ejection and recovery of capsule investigating radiation effects.</p>	<p>246.06 147.07 90.84 81.69°</p>	<p>Orbit achieved; capsule ejected on 18th orbit and recovered in mid-air north of Hawaii, 10/14/61.</p>
<p>Oct. 19, 1961 P-21 Probe Scout</p>	<p>Total weight: 94 lbs. Objective: testing Scout vehicle and guidance system, measuring ionospheric electron density profile, and testing new Doppler velocity and position facility at Wallops Station. Payload: 15' x 33' 8-sided frustrum containing electron sensor, 2 transmitters, nickel cadmium batteries.</p>	<p>4,261</p>	<p>Attained planned altitude and transmitted good data. Confirmed EXPLORER VIII data on helium layer, provided structure of ionosphere: at 120 km, a mixture of nitrogen and oxygen molecules; from 120 to 1,000 km, predominately atomic oxygen; from 1,000 to 2,500 km, helium; above 2,500 km, hydrogen.</p>
<p>Oct. 21, 1961 MIDAS IV 1961 Alpha- Delta 1 and WEST FORD Atlas-Agena B</p>	<p>Total weight: 3500 lbs. (approx.), including 2d stage. Objective: place experimental satellite in orbit and eject the piggyback WEST FORD dipoles. Payload: in addition to Midas equipment, 75-lb. package of 350,000,000 copper dipoles to form radio-reflection belt.</p>	<p>NA NA 172 NA</p>	<p>Orbit achieved; Project WEST FORD piggyback capsule ejected in orbit but fate uncertain; no definite radar sighting.</p>

<p>Nov. 5, 1961 DISCOVERER XXXIV 1961 Alpha-Epsilon 1 Thor-Agena B</p>	<p>Total weight: 2100 lbs. (approx.), including 2d-stage casing and 300-lb. re-entry capsule with retrorockets and recovery aids. Objective: testing reliability of Agena B; improving control of orbital period; ejection and recovery of capsule. Payload: unidentified instruments plus re-entry capsule.</p>	<p>614 140 96.9 82.52^o</p>	<p>Orbit achieved; capsule was ejected in orbit but failed to re-enter because of in-orbit malfunction.</p>
<p>Nov. 15, 1961 TRANSIT IV-B 1961 Alpha Eta 1 Thor-Able-Star and</p>	<p>Total weight: 200 lbs. Objective: testing of all-weather global navigation satellite for use by ships, aircraft. Payload: 43' x 31' drum carrying stable oscillators, continuous transmitters, phase modulators, memory systems, clock, SNAP auxiliary power system for transmitters.</p>	<p>700 582 105.6 32.42^o</p>	<p>Orbit achieved.</p>
<p>TRAAC 1961 Alpha-Eta 2</p>	<p>Total weight: 200 lbs. Objective: testing a gravity orientation system for satellites; gaining data on Van Allen belts. Payload: 43' x 16' door-knob containing gravity gradient stabilization equipment particle detectors.</p>	<p>720 562 105.6 32.43^o</p>	<p>Orbit achieved.</p>
<p>Nov. 15, 1961 DISCOVERER XXXV 1961 Alpha-Zeta 1 Thor-Agena B</p>	<p>Total weight: 2100 lbs. (approx.), including 2d-stage casing and 300-lb. re-entry capsule with retrorockets and recovery aids. Objective: testing design changes; obtain radiation data; obtain data on future spacecraft design; orbit, eject, and recover capsule. Payload: instruments to measure effects of design changes; experiments on future design; radiation measuring equipment.</p>	<p>173.4 147.2 89.76 81.63^o</p>	<p>Orbit achieved; capsule ejected and retrieved in mid-air by a C-130 some 500 miles NW of Honolulu on 11/16/61.</p>

Nov. 18, 1961 RANGER II 1961 Alpha-Theta 1 Atlas-Agena B	<p>Total weight: 675 lbs.</p> <p>Objective: Test spacecraft systems for future lunar and interplanetary missions; obtain data on cosmic rays, radiation, and dust particles and on whether the earth is trailed by comet-like tail of hydrogen gas.</p> <p>Payload: 5' x 11' cone with hexagonal base, containing experiments on solar radiation, particle detection, cosmic rays, magnetic fields, solar X-rays, neutral hydrogen geocorona, cosmic dust, and space friction; 2 transmitters, 8680 solar cells.</p>	<p>145.7</p> <p>94.9</p> <p>88.3</p> <p>33.3^o</p>	<p>Orbit achieved was low earth orbit rather than the deep elliptical one planned so data was not obtained on some of the test items. Primary objective of testing the system was achieved. The satellite re-entered on 11/18/61, somewhere between 6th and 13th orbit.</p>
Nov. 29, 1961 MERCURY- ATLAS V {MA-5} 1961 Alpha-Iota 1 Mercury-Atlas D	<p>Total weight: 4,100 lbs., liftoff; 2,900 lbs., orbit; 2,400 lbs., recovery.</p> <p>Objectives: Orbit MERCURY spacecraft with chimpanzee aboard in test of all MERCURY systems preparatory to manned orbital flight.</p> <p>Payload: In addition to chimpanzee, 4 cameras, 6 radiation measurement packs, 78 temperature measurement instruments, 2 playback tape recorders.</p>	<p>147.5</p> <p>99.6</p> <p>88.5</p> <p>32.5^o</p>	<p>Orbit achieved; on 2d of 3 planned orbits, MERCURY capsule was programed into re-entry because of minor difficulties with attitude jets and electrical system; capsule landed in the recovery area near Puerto Rico about 1:28 PM, 12/29/61, was picked up by <u>USS Stormes</u> about 2:53 PM the same day; chimpanzee Enos performed satisfactorily in flight and was in good condition on recovery. Flight was considered successful; no additional primate flights were felt necessary to prepare for the manned orbital flight.</p>

Dec. 12, 1961
DISCOVERER XXXVI
1961 Alpha-Kappa 1
Thor-Agena B
and
OSCAR
1961 Alpha-Kappa 2

Total weight: 2100 lbs. (approx.), including 300-lb. re-entry capsule with retrorockets and recovery aids.

Objective: To conduct radiation and radio experiments; to orbit Agena stage, DISCOVERER capsule, and OSCAR satellite; to eject from orbit and recover the DISCOVERER capsule.

Payload: Capsule contained radiation experiments including biopack of human and animal tissues, spores, molds, and algae; nuclear track plate; dosimeters and samples of silicon, bismuth, magnesium, gold, titanium, and nickel; radiation instruments including ones measuring the time history of radiation and radiation shielding properties of materials. Agena stage (to remain in orbit) contained radiation-measuring instruments relating to ARPA's Vela Hotel program, cosmic monitors, impedance probe, and radio propagation experiment. Also 10-lb. OSCAR (Orbiting Satellite Carrying Amateur Radio) experiment.

280
148
91.5
81.21^o

Orbit achieved; OSCAR was ejected into separate orbit and transmitted to worldwide "ham" radio network; DISCOVERER capsule was ejected from orbit 12/18/61, landed in the Pacific near Hawaii, was kept afloat by 3 USAF pararescue men until picked up by USS Renshaw.

N A S A L A U N C H V E H I C L E S

Vehicle	Stages	Propellant	Thrust (in Thousands of pounds)	Max. Dia. (Feet)	Height Less Spacecraft (Feet)	Payload (Lbs.)			First NASA Launch
						345 mile orbit	Escape	Planetary	
Redstone	1. Redstone	LOX/ALCH*****	78	5.9	83	Ballistic	---	---	1960
Scout	1. Algol (Aerojet Senior) 2. Castor (XN-33-20) 3. Antares (X-254) 4. Altair (X-248)	Solid Solid Solid Solid	98 48 13.6 2.8	3.3	65	150	---	---	7/1/60
Delta	1. Thor (DM-19) 2. AJ10-118 (Improved AJ10-42) 3. Altair (X248)	LOX/RP* WIFNA/UDMH** Solid	150 7.7 2.8	8.8	77	500	60	---	5/13/60
Thor-Agena B	1. Thor 2. Agena B	LOX/RP* IRFNA/UDMH***	165 16	8	80	1,600	---	---	1962
Atlas D	1. Atlas D	LOX/RP*	367	10	72	2,700	---	---	1960
Atlas-Agena B	1. Atlas D 2. Atlas D Sustainer 3. Agena B	LOX/RP* LOX/RP* IRFNA/UDMH**	367 80 16	10	98	5,000	750	400	1961
Titan II	1. LR-87 2. LR-91	Storable Liquids Storable Liquids	430 100	10	90	N/A	N/A	N/A	1963
Centaur	1. Atlas D 2. Atlas D Sustainer 3. Centaur	LOX/RP* LOX/RP* LOX/H ₂ ****	367 80 30	10	105	8,500	2,300	1,300	1961
Saturn C-1	1. S-I (8 Cluster H-1) 2. S-IV (6 Cluster A-3)	LOX/RP* LOX/H ₂ ****	1,500 90	21.6	125	20,000	---	---	1 stage 1961 2 stage 1963
Advanced Saturn	1. S-IB (5 Cluster F-1) 2. S-II (5 Cluster J-2) 3. S-IVB (One J-2)	LOX/RP* LOX/H ₂ **** LOX/H ₂ ****	7,500 1,000 200	33	275	200,000	85,000	60,000	1965
Nova	1. N-I (8 Cluster F-1) 2. N-II (4 Cluster M-1) 3. N-III (One J-2)	LOX/RP* LOX/H ₂ **** LOX/H ₂ ****	12,000 4,800 200	50	280	350,000	150,000	100,000	---

*Liquid Oxygen/Kerosene-like Hydrocarbon
 **White Fuming Nitric Acid/Unsymmetrical Dimethylhydrazine
 ***Inhibited Red Fuming Nitric Acid/Unsymmetrical Dimethylhydrazine
 ****Liquid Oxygen/Liquid Hydrogen
 *****Liquid Oxygen/Alcohol
 N/A Not Available

APPENDIX C

July 24, 1961

THE PRESIDENT'S POLICY STATEMENT ON COMMUNICATION SATELLITES

Science and technology have progressed to such a degree that communication through the use of space satellites has become possible. Through this country's leadership, this competence should be developed for global benefit at the earliest practicable time.

To accomplish this practical objective, increased resources must be devoted to the task and a coordinated national policy should guide the use of those resources in the public interest. Consequently, on May 25, 1961, I asked the Congress for additional funds to accelerate the use of space satellites for worldwide communications. Also, on June 15, I asked the Vice President to have the Space Council make the necessary studies and policy recommendations for the optimum development and operation of such system. This has been done. The primary guideline for the preparation of such recommendations was that public interest objectives be given the highest priority.

I again invite all nations to participate in a communication satellite system, in the interest of world peace and closer brotherhood among peoples throughout the world.

The present status of the communication satellite programs, both civil and military, is that of research and development. To date, no arrangements between the government and private industry contain any commitments as to an operational system.

A. Policy of Ownership and Operation

Private ownership and operation of the U. S. portion of the system is favored, provided that such ownership and operation meet the following policy requirements:

1. New and expanded international communications services be made available at the earliest practicable date;
2. Make the system global in coverage so as to provide efficient communication service throughout the whole world as soon as technically feasible, including service where individual portions of the coverage are not profitable;
3. Provide opportunities for foreign participation through ownership or otherwise, in the communications satellite system;
4. Non-discriminatory use of and equitable access to the system by present and future authorized communications carriers;
5. Effective competition, such as competitive bidding, in the acquisition of equipment used in the system.

6. Structure of ownership or control which will assure maximum possible competition;
7. Full compliance with antitrust legislation and with the regulatory controls of the government;
8. Development of an economical system, the benefits of which will be reflected in overseas communication rates.

B. Policy of Government Responsibility

In addition to its regulatory responsibilities, the U. S. Government will:

1. Conduct and encourage research and development to advance the state of the art and to give maximum assurance of rapid and continuous scientific and technological progress;
2. Conduct or maintain supervision of international agreements and negotiations;
3. Control all launching of U. S. spacecraft;
4. Make use of the commercial system for general governmental purposes and establish separate communications satellite systems when required to meet unique government needs which cannot, in the national interest, be met by the commercial system;
5. Assure the effective use of the radio-frequency spectrum;
6. Assure the ability to discontinue the electronic functioning of satellites when required in the interest of communication efficiency and effectiveness;
7. Provide technical assistance to newly developing countries in order to help attain an effective global system as soon as practicable;
8. Examine with other countries the most constructive role for the United Nations, including the ITU, in international space communications.

C. Coordination

I have asked the full cooperation of all agencies of the government in the vigorous implementation of the policies stated herein. The National Aeronautics and Space Council will provide continuing policy coordination and will also have responsibility for recommending to me any actions needed to achieve full and prompt compliance with the policy. With the guidelines provided here, I am anxious that development of this new technology to bring the farthest corner of the globe within reach by voice and visual communication, fairly and equitably available for use, proceed with all possible promptness.

APPENDIX D

SPACE ACTIVITIES OF THE UNITED STATES GOVERNMENT
New Obligational Authority/Program Basis - in millions

Historical Summary and FY 1963 Budget Recommendations

	<u>NASA</u> ^{1/}	<u>Defense</u> ^{2/}	<u>AEC</u> ^{3/}	<u>NSF</u> ^{4/}	<u>WB</u> ^{5/}	<u>Total</u>
FY 1955	\$56.9	\$3.0	-	-	-	\$59.9
FY 1956	72.7	30.3	\$7.0	\$7.3	-	117.3
FY 1957	78.2	71.0	21.3	8.4	-	178.9
FY 1958	117.3	205.6	21.3	3.3	-	347.5
FY 1959	338.9	489.5	34.3	-	-	862.7
FY 1960	523.6	560.9	43.3	.1	-	1,127.9
FY 1961*	926.2	793.8	63.2	.6	-	1,783.8
FY 1962	1,630.3	1,147.2	120.1	1.6	50.2	2,949.4
Recommended supplemental .	156.0	-	-	-	-	156.0
Total 1962*	<u>1,786.3</u>	<u>1,147.2</u>	<u>120.1</u>	<u>1.6</u>	<u>50.2</u>	<u>3,105.4</u>
FY 1963 budget*	3,732.9**	1,517.7	192.9	1.7	47.2	5,492.4

1/ National Aeronautics and Space Administration amounts for 1961 and subsequent years exclude amounts for aircraft and missile technology. Amounts for 1960 and prior years are totals for all activities of NASA and include totals for NACA prior to establishment of NASA.

2/ The Department of Defense amounts include identifiable Defense funding for space and space-related programs, but exclude the cost of developing missiles and related equipment which are also used in the space programs, military personnel costs, and certain operating and supporting costs which it is not feasible to separate from other military expenses. Amounts for 1960 and prior years also exclude construction and operating costs of the national missile ranges and certain supporting research and development applicable both to space and other programs.

3/ Atomic Energy Commission amounts are those identified with Rover nuclear rocket, the SNAP atomic power source project, and related activities.

4/ National Science Foundation amounts are those identified with Vanguard and with the NSF space telescope project.

5/ Weather Bureau amounts are those identified with the meteorological satellite program.

* These amounts used in table on "New Obligational Authority for Federal Space Programs" on page 329 of the 1963 budget.

** Rounded to \$3.8 billion on Bureau of the Budget chart.

Bureau of the Budget
January 19, 1962