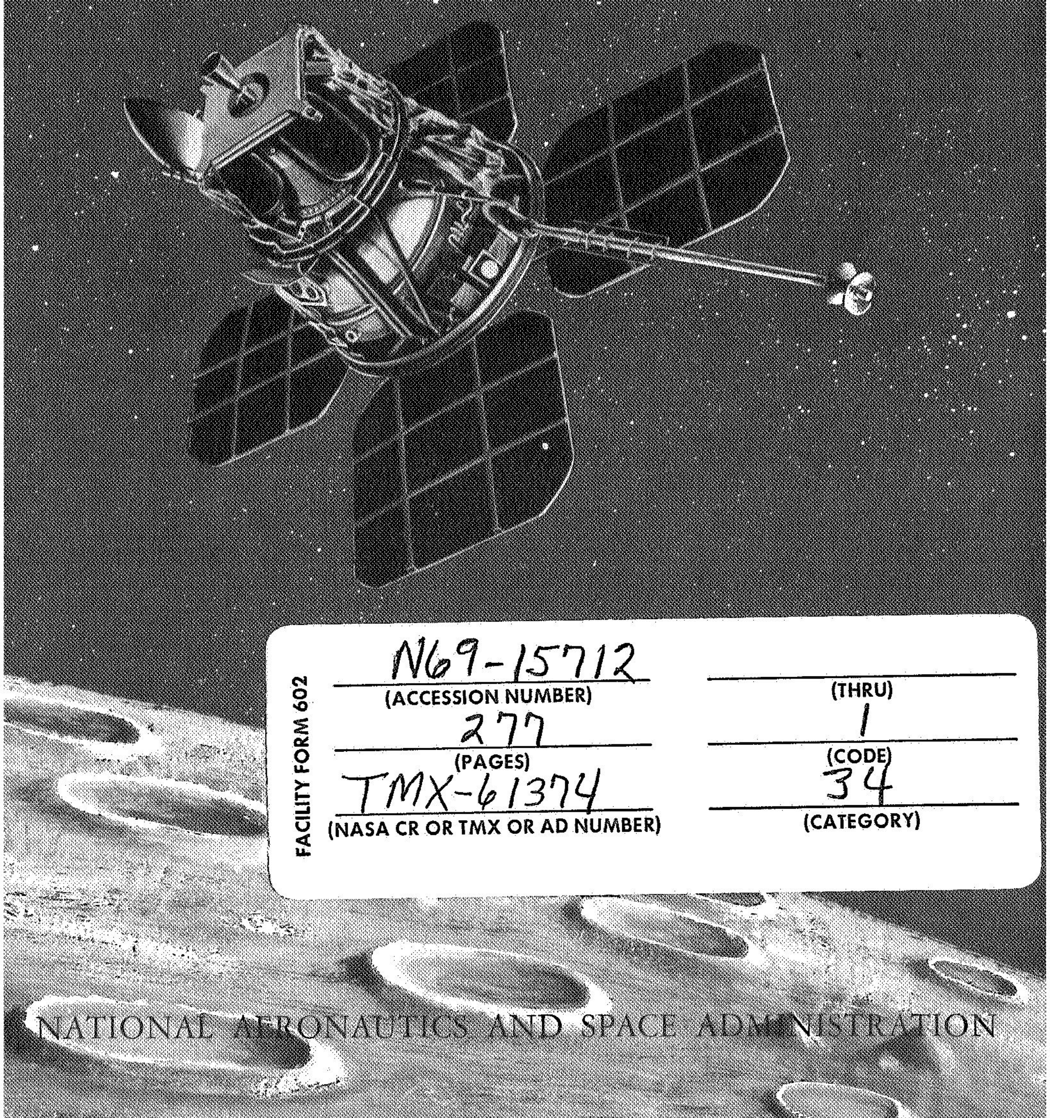
17TH

SEMIANNUAL REPORT TO CONGRESS

JANUARY 1 - JUNE 30, 1967



TO THE CONGRESS OF THE UNITED STATES:

I am transmitting today the Sixteenth, Seventeenth, and Eighteenth Semi-Annual Reports of the National Aeronautics and Space Administration covering the period between July 1, 1966 and December 31, 1967.

The events recorded here are both tragic and encouraging; sobering and inspiring.

The eighteen-month period saw success and failure and then success again as a proud agency moved forward with renewed determination.

The Gemini missions were completed; Lunar Orbiters I and II transmitted thousands of clear pictures of the moon; new communications and meteorological satellites were orbited.

Then came tragedy. Three brave American astronauts were killed in the Apollo fire.

Initially stunned, NASA then went to work to overcome the flaws in the Apollo system. Soon, impetus was restored to this crucial part of our space effort. Other great space achievements followed such as the Apollo 4 flight.

I commend these reports to your attention. They contain, I believe, concrete evidence that NASA is moving forward, and that America is contributing mightily in the worldwide effort to conquer space for the benefit of all mankind.

Lyndon B. Johnson

THE WHITE HOUSE,

Oct. 11, 1968.

Seventeenth

SEMIANNUAL REPORT TO CONGRESS

JANUARY 1 - JUNE 30, 1967

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D. C. 20546

Cover: Artist's sketch of Lunar Orbiter.

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THE PRESIDENT
The White House

October 7, 1968

DEAR MR. PRESIDENT:

The Seventeenth Semiannual Report of the National Aeronautics and Space Administration, covering the period January 1 through June 30, 1967, is submitted herewith for transmittal to Congress in accordance with section 206(a) of the National Aeronautics and Space Act of 1958.

This period was overshadowed by the Apollo fire which took the lives of three of our astronauts. The thorough investigation of the accident and the steps that were initiated to improve safety by changes in design and procedures have previously been made matters of public record. This report shows that the same period was also one of progress in aeronautics and space as evidenced, for example, by the successful flights of Surveyor, Lunar Orbiter, and many other spacecraft. It was a difficult time for NASA, but one in which the agency showed, I believe, that it could react maturely to failure as well as success, and continue to deserve the confidence and support of the nation.

Respectfully yours,

JAMES E. WEBB
Administrator

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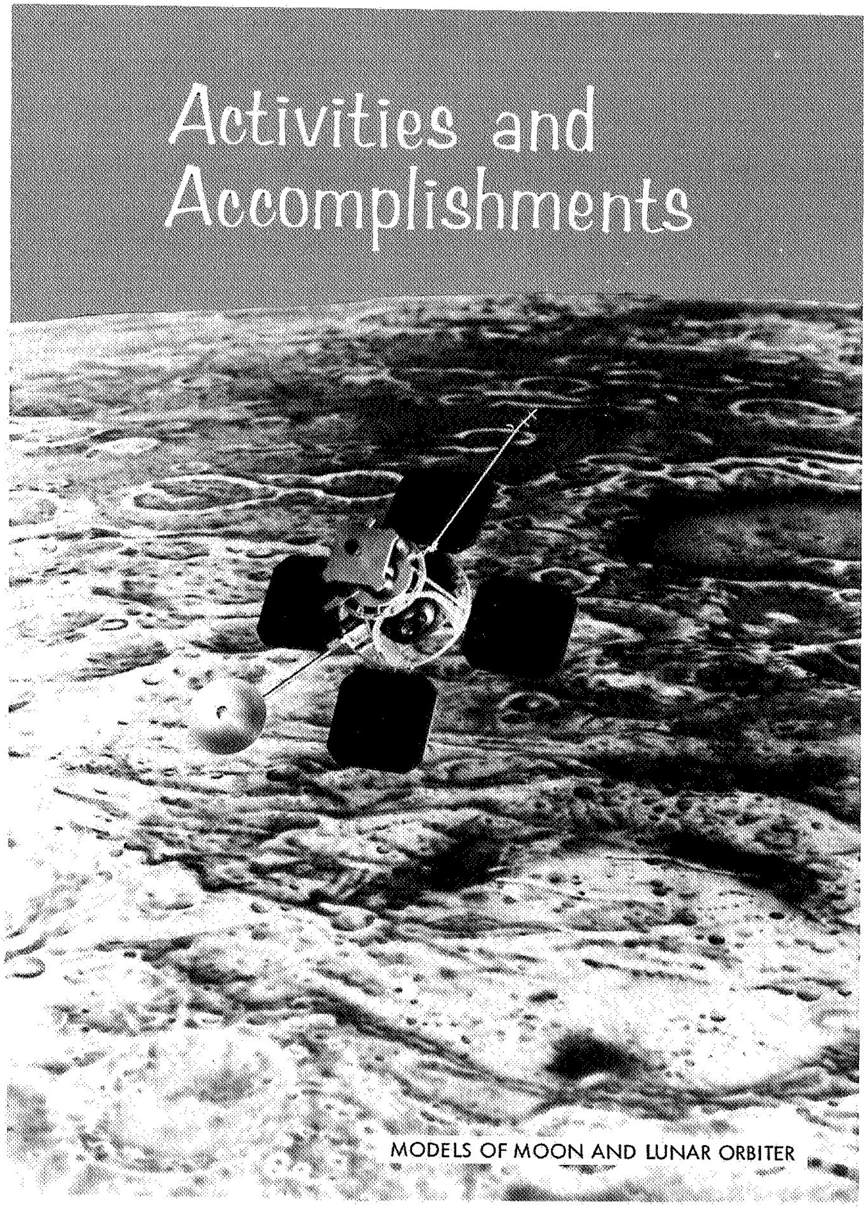
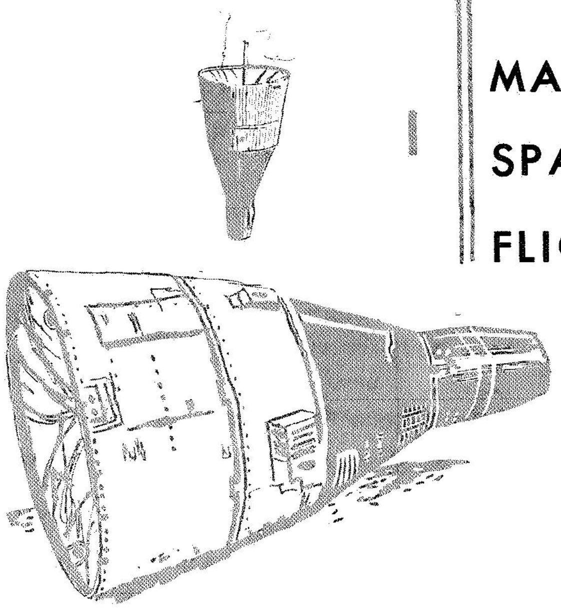


MODELS OF MOON AND LUNAR ORBITER



MANNED SPACE FLIGHT

This period involved intensive development efforts on the Apollo spacecraft and the Saturn V launch vehicle, and was marked by a fire during a ground test of this spacecraft which claimed the lives of three astronauts. The Gemini program was closed out.

The Gemini Program

Gemini Program activity consisted primarily of property disposition and final reporting. At the end of the period, approximately 95 percent of all remaining property had been transferred to on-going government development programs or to the Smithsonian Institution as artifacts. The Manned Orbiting Laboratory Program received about $103 million worth of Gemini property (new cost prices), not including the cost of spacecraft II, III, III-A and VIII, which were also transferred. Nine programs in the Department of Defense, other than MOL, received Gemini equipment.

Within NASA, the Apollo Program, the Apollo Applications Program, and several unmanned satellite programs were using Gemini equipment. Seven NASA centers received Gemini surplus test equipment suitable for laboratory use. Gemini Spacecraft XI was transferred to the Electronics Research Center as a guidance and control research tool and will be released to the Smithsonian when no longer needed. The remaining spacecraft were being transferred as artifacts to the Smithsonian, which will place three on exhibit, one at KSC, one at MSC, and one at MSFC.

Program documentation progressed routinely, with completion expected by year's end. A summary report on Gemini extravehicular activity, a catalog of Gemini anomalies, and supplements to mission reports were distributed. The proceedings of the Gemini Summary Conference were expected to be published in January, 1968. A publication containing earth photographs from Gemini III, IV, and V (SP-129, described in Appendix L of this report) was distributed, and a companion book including earth photographs from subsequent missions was being prepared.

All costing against Gemini contracts was completed, and all contracts were either closed out or in final process of termination.

The Apollo Program

The goal of the Apollo Program is to develop the capability for exploration of space out to 250,000 miles from earth. This capability will be demonstrated by a mission to land men on the moon for limited observation and exploration and to return them safely to earth. Such a mission will climax a series of sub-orbital and orbital missions, each with specific objectives. However, all are to be flown primarily to advance the state-of-the-art and to qualify systems for the ultimate lunar landing mission.

The Apollo Program was preparing for the resumption of the flight phase at period's end. Both NASA and industrial management continued to identify and solve problems which would impair the schedule, increase the costs, jeopardize the safety of astronauts or otherwise hinder the performance of the Apollo team. Apollo flight program planning is based on providing not only the capability to capitalize on success but also the capacity to respond to problems.

Flight missions were assigned and planned to assure flexibility in manning the uprated Saturn I (Saturn IB) and Saturn V series and in providing for the orderly transition between the two flight series. NASA intends to transfer manned flights from the uprated Saturn I to the Saturn V vehicle as soon as the latter is ready for manning, with the earliest transfer point occurring after the first manned uprated Saturn I mission, AS-205/CSM-101. Such planning will allow the Apollo Program to proceed in a deliberate manner despite the impact of the AS-204 accident which required extensive redesign of flight hardware.

The Apollo flights were rescheduled to accommodate the many program changes that were made following the accident. These changes reduced the number of flights available to achieve a lunar landing by the end of 1969.

One unmanned Apollo flight is scheduled for the second half of 1967. It is to be the first launch of a Saturn V, AS-501 (Apollo 4 mission), placing in orbit an unmanned Command and Service Module. It will be a launch vehicle development mission, including a demonstration of the spacecraft heat shield at lunar return velocities and flight testing the sealing technique of the redesigned hatch.

Apollo Management

The fundamental soundness of the Manned Space Flight Programs' management structure and process were demonstrated by the success of the Mercury and Gemini Programs and by the first thirteen successful missions of the Saturn I vehicle in the Apollo Program. The management review carried out by the Apollo Program Office since the accident noted no areas requiring major organizational change. However, the review did identify the need for greater centralization and clarification in documenting and updating the specific responsibilities of the organizations within the Apollo Program.

Possible ambiguities in the assignment of program responsibilities were removed, and control of waivers and deviations was reinforced. Specific management directives were prepared to replace or consolidate previous directives concerning preparation of test and checkout plans and procedures at KSC; responsibilities in the Apollo Program at Marshall Space Center; and functions and authority of the Apollo Program Office at NASA Headquarters.

To further strengthen program management, NASA contracted with The Boeing Company to assist and support the NASA Apollo organization in performing specific technical integration and evaluation functions, with NASA maintaining the final technical decision responsibility. The Boeing Company established and began maintaining organizations within the geographical locations of each of the Manned Space Flight Field Centers and the Apollo Program Office for this purpose.

Apollo management techniques and reporting systems were being further strengthened to meet the needs of the program, and a system was being established to provide a continuous flow of information to all Centers, to the Apollo Program Office and top officials in NASA headquarters, and to the various contractor organizations.

Apollo 204 Accident

On January 27, 1967, a tragedy occurred at Cape Kennedy when fire erupted inside the Apollo spacecraft during ground testing. The fire resulted in the deaths of Lt. Colonel Virgil I. Grissom, Lt. Colonel Edward H. White, II, and Lt. Commander Roger B. Chaffee.

The Apollo-204 Review Board, comprised of NASA officials as well as representatives of other government agencies and private organizations, determined after 2½ months of investigation that the most likely cause of the fire was electrical arcing from certain spacecraft wiring.

(The "Report of Apollo 204 Review Board to the Administrator, National Aeronautics and Space Administration," was printed as Volume II, Parts 1, 2, and 3, Hearings, Subcommittee on NASA Oversight, Committee on Science and Astronautics, U.S. House of Representatives, April 10, 1967.)

Many changes were made in the Apollo hardware following the accident, with design changes in the more advanced Block II Apollo spacecraft reflected on the contractor manufacturing lines. Other changes, not resulting from the accident investigation, were also being made in the Apollo spacecraft.

Spacecraft crew compartment material was a key consideration in the post-accident review. Knowledge gained as a result of the fire and in subsequent testing led to alterations both in the selection of spacecraft materials and in their placement within the vehicle. This was probably the most significant single technical change resulting from the accident investigation. An account of changes in Apollo design, construction, and procedures made during the report period follows.

Materials Selection and Substitution.—An improved spacecraft material selection and substitution program was established to reduce the risk of fire in all manned spacecraft operations both on the ground and in flight.

Hatch Redesign.—Before the Apollo 204 accident, improvements were being made in the Apollo Command Module hatch, following the extravehicular experience in the Gemini missions. The original hatch opened inward. Effort on hatch redesign was intensified as a result of the accident, with emphasis on preflight and postflight crew egress. (Fig. 1–1.) The new design, which opens outward, offers operational improvement in normal preflight, spaceflight, and post-landing use. It also provides the fastest emergency crew egress capability.

Emergency egress considerations were also applied to the facilities for Apollo launches. The launch umbilical tower and access arm were being altered by (1) modifying the access-arm mechanism and changing the "park" position to shorten reposition time; (2) eliminating steps and protuberances in the egress path; and (3) providing positive ventilation, improved lighting, and fire-resistant materials in the white room.

Ground Communications.—The operation of the ground communications system was improved by reducing the number of stations on critical loops. Access to the system is to be limited to stations that will be essential for an operation.

Steps being taken to assure the reliability of the present system included design changes, improved operational procedures, controlling circuit configuration, and adding intercommunication equipment. These modifications and additions will permit full duplex operation on critical

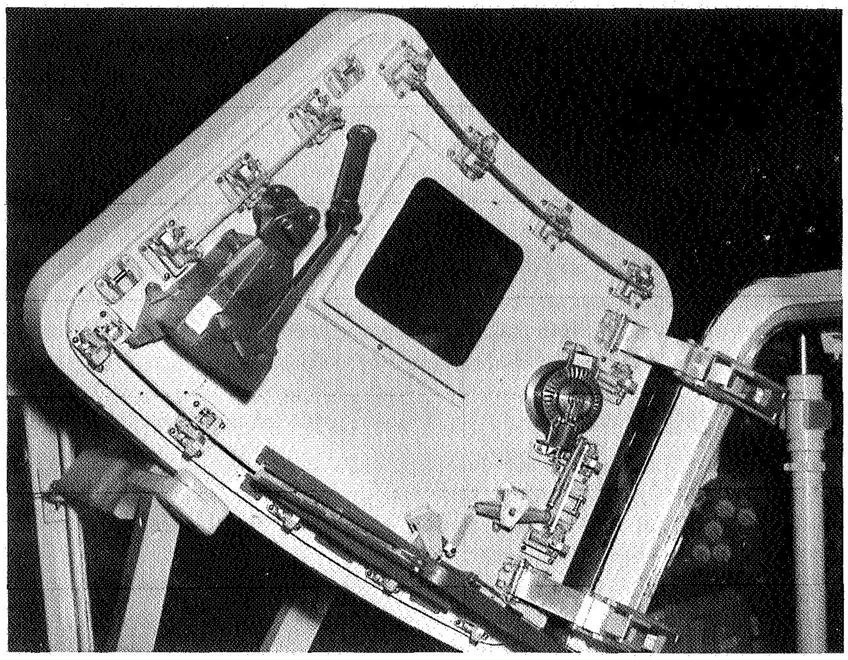


Figure 1–1. Redesigned hatch on Command Module mockup 28.

circuits off the pad at Kennedy Space Center (KSC) and to other key places such as the Mission Control Center at the Manned Spacecraft Center, Houston. The changes are to be made before the next manned spacecraft tests at KSC.

Spacecraft Communications.—Problems associated with spacecraft communication in the Block I spacecraft were solved and corrections were made in the Block II spacecraft design; therefore, minimal spacecraft changes were required.

Environmental Control System.—After intensive study of the Apollo Environmental Control System, NASA determined that 100 percent oxygen at 5 psi will be used during space flight, including reentry. This requires no changes in the spacecraft hardware. However, changes were considered for the cabin atmosphere while the spacecraft is on the ground and during launch. For manned test operations on the ground, NASA will continue to use the 16.5 psi pure oxygen atmosphere unless the boilerplate fire-safety tests conducted with the new materials indicate that another system would be preferable. As an option, NASA will be able to use either air or 100 percent oxygen during ground tests, prelaunch, and launch.

Alterations were also being made in the oxygen plumbing within the cabin. The aluminum oxygen lines with solder joints were being changed to stainless steel, and protective covers are to be added to exposed oxygen lines. Materials in the Environmental Control System which constitute a fire hazard will be replaced, although the water-glycol coolant, which has some inflammable properties, is to be retained. It is essential that an inhibitor be used in the coolant to prevent corrosion, and the present inhibitor was selected as the best possible one for the system. The principal effort is to provide a leakproof coolant system and to minimize fire hazard to prevent spills. Leaking and spillage were being substantially reduced or eliminated by using soft-metal washers, by employing improved torquing procedures, and by adding quick disconnects with fluid check valves to prevent water-glycol spillage during normal maintenance.

It was determined that solder joints are acceptable if properly made and not abused. However, the number of solder joints is to be reduced, armor is to be added to the water-glycol system joints exposed to structural abuse, and protective covers are to be added over all exposed plumbing.

Materials and procedures were developed to clean up any spills which do occur without leaving a residue, and improved test procedures to verify proper clean up were worked out.

Fire Protection.—Provisions for increased fire protection included an emergency breathing mask system to permit crew operations if fire occurs during the shirtsleeve mode of operation, (Fig. 1–2.) an enlarged

Figure I–2. Prototype emergency oxygen mask stowed in cabin.

pressure relief valve so the cabin can be depressurized rapidly, additional oxygen surge tank capacity and associated plumbing so that the cabin can be repressurized rapidly, and a newly developed portable crew-operated fire extinguisher for the Command Module.

Electrical System.—In a major review of the spacecraft electrical system, the Block I and Block II spacecraft were examined to determine if any of the components or subsystems were possible ignition sources, and then the design of the Block II spacecraft electrical system and the adequacy of manufacturing, installation, and testing practices were scrutinized. In general, the Block II spacecraft electrical system design appeared to be satisfactory and the plan of implementation conformed to acceptable practices. The improvements previously incorporated in the Block II spacecraft solved most of the problems revealed in the investigation of the Block I spacecraft involved in the fire.

Changes were being made to ensure compliance with the proper criteria for circuit breakers, protective covers were being added over exposed wiring to prevent damage during installation and test, and the wiring on spacecraft already built was being inspected. Additional mandatory inspection is now called for during the manufacturing and testing of new spacecraft.

Launch Complex Emergency Equipment.—Adequate provisions for fire-fighting and other emergencies were also made by installing additional launch-complex equipment.

Safety Organization.—NASA placed renewed emphasis on all aspects of its safety program. Kennedy Space Center established new criteria to determine which additional test-team personnel require emergency and pad rescue training (Fig. 1–3.), new safety training standards for all personnel and an individual certification program were being developed, and an Apollo spacecraft mockup containing new hatch provisions will be used at KSC for training rescue and operational personnel. It is to be movable so that it can be installed in the altitude test chamber for training exercises.

Steps Toward the First Manned Apollo Mission.—A number of steps must be completed before the next manned flight. One—a ground test program (aircraft-drop, propulsion, structural, and crew-compatibility tests) for the Block II Command and Service Module to qualify the spacecraft—was underway. Vibration and thermal-vacuum tests will be conducted on the ground, and the new hatch design will be tested on the unmanned Saturn V missions. Also required is the Command Module fire test in the boilerplate spacecraft and requalification of the various units and systems being changed. Finally, all approved changes and modifications must be incorporated into the flight spacecraft, which must then be tested at both the Downey (California) plant and the Manned Spacecraft Center.

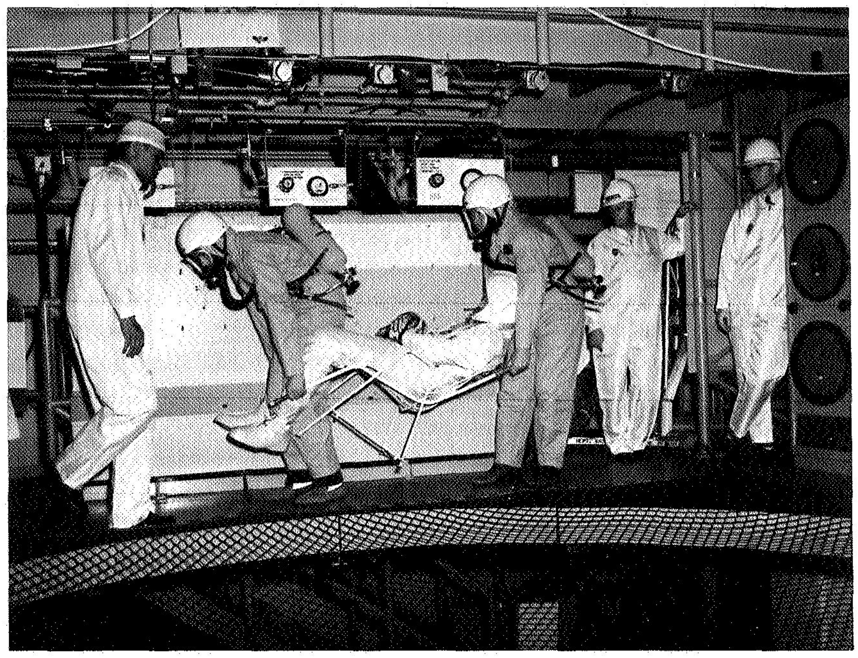


Figure I—3. Simulated evacuation procedure (training).

During the necessary three- to five-month checkout period at the Cape, the Command and Service Modules are to be mated, and combined systems tests are to be run. Following the first manned test at sea-level conditions, there will be an unmanned test in the altitude chamber. The last of the vacuum chamber tests is to be conducted with the spacecraft manned and the chamber simulating the changing environmental conditions from launch to orbit. The spacecraft is then to be moved to the Launch Complex 34 pad and mated with the launch vehicle for further testing. Finally, the manned "plugs in" and "plugs out" tests and the countdown demonstration tests will be carried out.

In 1968, NASA expects to be prepared to fly the Block II spacecraft, the first of the manned Apollo series, in an open-ended mission of up to two weeks in earth orbit. The goal will be to verify the combined performance of the spacecraft and the crew.

Design Status

During the first half of 1967, the Apollo hardware design program progressed as major portions of the Saturn V Launch Vehicle Dynamic Test Program and various other test programs were completed.

Following the investigation of the 204 accident, extensive redesign and modification of the Command Module was made. Major areas of change include the hatch, materials, the earth landing system, cabin repressurization, and protective coverings for exposed plumbing and electrical harnesses. Redesign and modifications of the Lunar Module were not as extensive as those on the Command Module and primarily involved material changes. Scheduled deliveries of both spacecraft were delayed to permit additional testing, retesting, and requalification of modified hardware.

Hardware Status

Because of the 204 accident, the Apollo Program underwent extensive replanning to accommodate the changes to Block II Command Service Modules and Lunar Modules necessary for manned flight. Consequently, Apollo launches originally scheduled for the first half of 1967 had to be deferred.

Apollo 4 Mission.—The unmanned Apollo 4 mission's objectives are to qualify the Saturn V Launch Vehicle facilities and procedures, to test the S-IVB restart-in-space capability, to test the Block II spacecraft heat shield under lunar return velocities, and to test the new hatch seal. The launch vehicle for the Apollo 4 Mission will be SA-501 and the Command Service Module will be CSM 017. A Lunar Module Test Article, LTA-10R, will be used in place of the LM. This mission has been delayed by the Command Module CM 017 wiring rework, inspection, and validation; and by problems associated with the S-II-1 stage.

The S-IC-1 first stage of SA-501 was delivered to KSC on September 17, 1966, and erected on the launch umbilical tower. The S-IVB-501 and S-IU-501 arrived at KSC on August 14 and 25 (1966), respectively. Because of the unavailability of the S-II-1 second stage, an S-II spacer was employed to allow complete stacking of the launch vehicle. The CSM 017 was erected on the launch vehicle on January 11, 1967. Partial launch schedule integrated testing with the S-II spacer was completed early in February. The S-II-1 stage arrived at KSC on January 24. After completion of low bay activity in mid-February, the S-II spacer was replaced by the S-II-1 late in February.

In early June, as a result of weldment discrepancies identified on the S-II-6 liquid hydrogen tank, the launch vehicle was disassembled so the S-II-1 stage could be inspected. The inspection was completed in mid-June and no serious problems were found. The launch vehicle was being prepared for electric mate. During this time, extensive progress was made in the checkout of launch Complex 39 and Pad A facilities and equipment including swing arm validation of Launch Umbilical Tower No. 1 (LUT-1). As a result of the 204 accident investigation, the Command Service Module 017 was moved to the Manned Spacecraft Operations Building for wiring inspection, modification, and validation during April and May.

Apollo 5 Mission.—The unmanned Apollo 5 mission objective is to verify the operation of the Lunar Module ascent and descent propulsion systems and the Lunar Module structure.

The launch vehicle for the Apollo 5 mission will be the SA-204, and the payload will be the Lunar Module LM-1 and a nose cone. The launch vehicle was delivered to KSC during 1966, and LM-1 arrived on June 23, 1967. Early in April, the SA-204 launch vehicle was moved from Launch Complex-34 to Launch Complex-37B. Launch Ccmplex-37B was modified to accommodate the additional instrumentation on SA-204 launch vehicle.

LTA-8 (Thermal Vacuum Test Article) underwent modification and systems validation in preparation for shipment to MSC for thermal vacuum testing. (Fig. 1–4.) Testing of the Structural Test Vehicle, LTA-3, the descent Propulsion test vehicles, LTA-5D and PD-2, and the Ascent Propulsion Test Vehicle, PA-1, continued through this period. All tests delaying the LM-1 mission were completed except the LTA-3

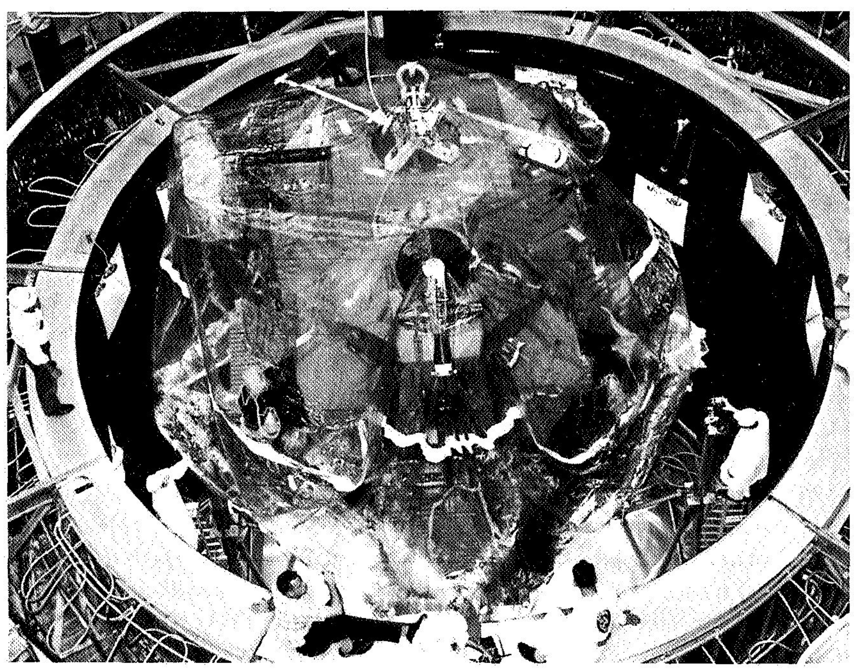


Figure 1–4. LTA–8 being put in space simulation chamber for manned thermovacuum tests.

vibration acoustic test and the PD-2 malfunction and start tests, and these were scheduled for September and October, 1967. The launch schedule was delayed by LM-1 propulsion plumbing system leak problems and a helium heat exchanger failure which occurred during LTA-5D testing. The LM-1 helium heat exchanger was being replaced and leak problem solutions were being developed.

Apollo 6 Mission.—The mission objective of the unmanned Apollo 6 is to qualify the Saturn V launch vehicle facilities and procedures and the Block II CM heat shield, and to test the new Block II hatch design. The launch vehicle for the Apollo 6 mission is the SA-502; the Command Service Module is CSM 020.

In February, the S-IVB-502 and the LTA-2R (Lunar Test Article) were delivered to KSC, in March the S-IC-2 stage and the Instrument Unit (S-IU-502) were delivered and in May the S-II-2 was delivered. CSM 020 was being modified as a result of changes called for following the 204 accident, with delivery planned for November.

Program Software.—The launch vehicle and spacecraft flight programs, and the Saturn launch computer complex software required to support the Apollo 4, 5, and 6 missions were on schedule.

Spacecraft Status and Development Problems.—As stated earlier, wiring inspection, rework, and modifications were delaying delivery of Block II ground and flight test Command and Service Modules. Lunar Module production was also delayed during the first half of 1967 because of the fire-related changes.

Both the Command Module and Lunar Module were made heavier by the changes, and the increased weight caused three basic problems. First, the changes reduced the safety factor of the Earth Landing System, which was designed for an 11,000-pound Command Module. An intensive effort was undertaken to reduce the growth in Command Module weight. Also under investigation was a modification to the Earth Landing System to increase the factor of safety by providing two-stage reefing main parachutes, and by using larger drogue chutes.

Second, because of the additional weight, the Command Module rate of descent during earth landing increased from 35 feet per second to 39½ feet per second for the design case. Structural adequacy of the Command Module in a launch pad abort condition was under study. A safe land landing could occur at the higher descent rate, however. Steps were taken to modify the astronaut couches to increase crew protection to withstand a 40G impact load. Additionally, increased testing was being planned to determine spacecraft structural capability under the worst possible pad abort land landing condition.

Third, the Service Module and Lunar Module propellant tank capacities were being severely taxed because of increased propellant requirements. The additional propellant is required to maintain the spacecraft at necessary delta velocities which are most sensitive to decreases in the propellant weight/hardware ratios. Necessary corrective actions being taken included examining the Lift/Drag ratio at re-entry to allow a reduction in ballast requirements. Operational changes (such as restricting lunar landing to pre-selected sites) which would minimize increased hardware weight by reducing overall propellant requirements were also being considered.

Lunar Module Structural Test Problem.—In February, during launch boost load testing of the Structural Test Vehicle, LTA-3, two descent stage upper deck skin panels failed at about 100 percent limit load. The failure occurred during the first stage end-boost static test condition. Other tests not affected by this failure continued to be conducted. It was determined to be more economical to replace the LTA-3 descent stage with the LM-6 descent stage than to repair it. The LM-6 descent stage was prepared for structural tests and shipped to MSC in May. The LM-1 mission constraint was removed when the end-boost static test was successfully accomplished in June 1967. (Completion of the LTA-3 Acoustic Vibration Tests in September should remove the last LTA-3/LM-1 mission constraint.) Structural fixes were incorporate in LM-1 and subsequent vehicles.

Launch Escape Systems.—The delivery of Launch Escape Systems to support Apollo launches was on schedule, with no development problems apparent. (Fig. 1–5.)

Uprated Saturn I Launch Vehicles.—Apollo Saturn launch vehicles 205–212 were proceeding on schedule. The AS-205 launch was being paced by the availability of CSM-101, the first manned Block II CSM, with the remainder being paced accordingly. If required, the additional uprated Saturn I missions will be dual launches involving both the CSM and the LM.

Saturn V.—The Saturn V consists of three stages—the S-IC (first), the S-II (second), and the S-IVB (third). The second S-IC stage, the S-IC-2, was delivered to KSC in March and was undergoing checkout in preparation for the Apollo 6 mission. The S-IC-3 was successfully static fired at MSFC in late 1966 and was in storage at Michoud at the end of this period. It is to be delivered to KSC during the fourth quarter of 1967. The S-IC-T was fired at MTF in March 1967, marking the completion of checkout of Position I of the S-IC acceptance test stand. The S-IC-4 completed its static firing test program at MTF in May. S-IC vehicles 5 through 15 were in various stages of fabrication, assembly, and checkout at the Michoud operation near New Orleans.

The first and second S-II stages, S-II-1 and -2, were delivered to KSC during the period, after acceptance testing in the S-II test stand A-2 at

Figure I–5. Launch Escape System being hoisted to top of service tower.

MTF. The S-II-3 was in transit to MTF for acceptance testing at the close of the period. The S-II-4 through 15 were in various stages of fabrication, assembly, and test at Seal Beach, California.

On April 15, the S-II-2 was static fired at the MTF for a full duration of 367 seconds. This was the second static firing for the S-II-2 stage and was a major milestone in the Confidence Program that was initiated in 1966 after the S-II-T failure. The Confidence Program consisted primarily of five battleship captive firings and two successful consecutive firings on each of the S-II-1 and S-II-2 stages.

Two major problems paced the S-II Program. They were the weld defects in the propellant and pressurization lines and in the liquid hydrogen and liquid oxygen tanks. The problem with welded lines became apparent early in May when the final S-II-3 inspection revealed ten defective lines that had to be replaced. Subsequent inspection of S-II-1, -4, and -5 stages resulted in returning 43 welded lines to the vendor for rework. Manufacturing procedures and inspections were being upgraded to eliminate weld defects of this type. The tanks of the S-II-4 and all subsequent S-II's were inspected with dye penetrant and ultraviolet light. Through this technique, inspectors discovered 104 surface flaws on the S-II-6 liquid hydrogen and liquid oxygen tanks. Although only five of these flaws required rewelding, reinspection of S-II-1, -2, and -3 was directed to insure the integrity of the welds on all these stages. No serious flaws were detected in these stages. Similar tests and inspections were carried out on the S-IC and S-IVB stages, with no discrepancies being found. Investigation of the causes of the high defect rate in the S-II-6 was still underway at the end of this period.

The S-IVB-502 was received at KSC in February 1967, and numbers 503 (new) through 515 (new) were in various stages of fabrication, assembly, and test. On January 20, 1967, the S-IVB-503 stage exploded on the Beta 3 test stand in California during countdown for static firing. The stage was completely destroyed and heavy test stand damage resulted. Investigation showed that the S-IVB-503 helium tanks were fabricated with welding rods of pure titanium instead of the required titanium/aluminum/vanadium alloy. Subsequent inspection of all helium tanks indicated that this problem was confined to the S-IVB-503 stage.

The Instrument Unit 502 (S-IU-502) was received at KSC during March. The S-IU-503 was available for shipment to KSC during the reporting period but was placed in storage until required at KSC. S-IU-504 through 515 were in various stages of fabrication, assembly, and test.

The F-1 engine production program remained on schedule in support of the S-IC stage program. Eleven F-1 engines were delivered during the report period.

The J-2 engine production program also remained on schedule in support of the S-II and S-IVB stage programs. Nineteen J-2 engines were delivered during the report period.

During the first half of 1967, stability and chamber erosion problems showed up in the LM ascent engine. (Fig. 1–6.) At period's end, the

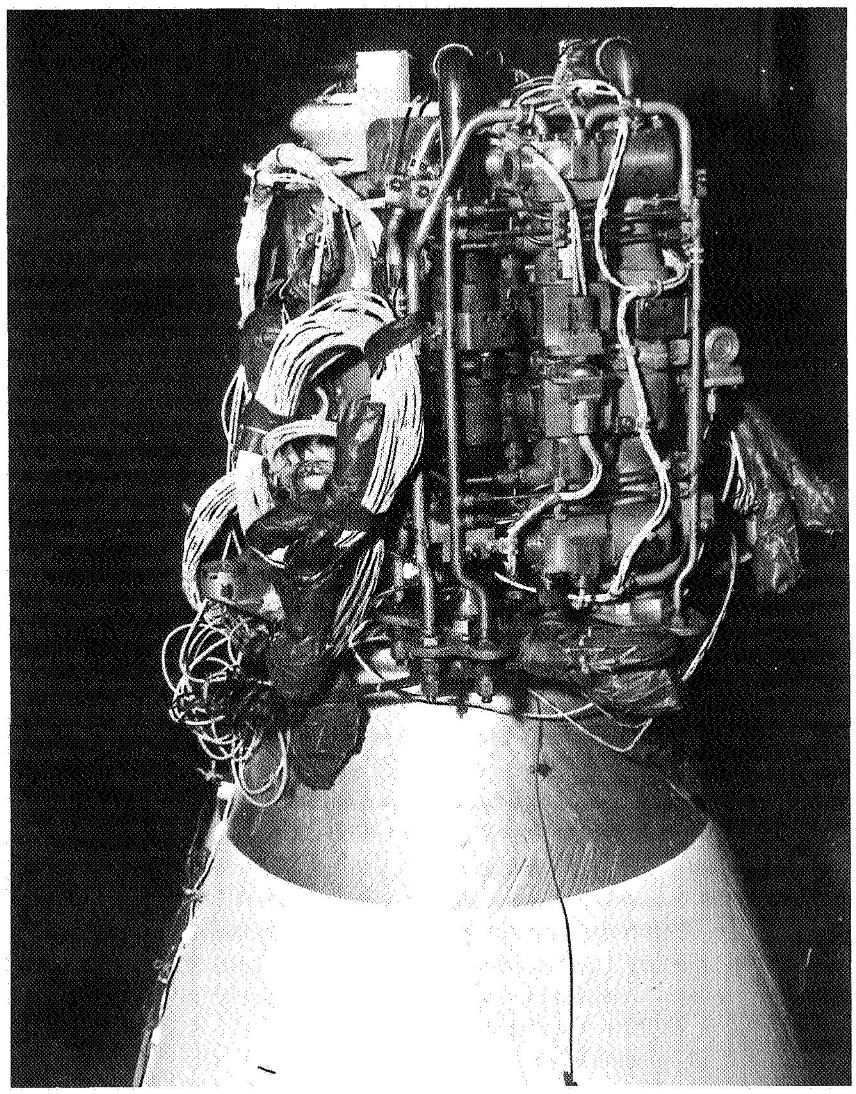


Figure 1–6. Lunar Module ascent engine.

subcontractor had not been able to produce a stable injector compatible with the combustion chamber. A NASA evaluation team went to the plant to determine the basic problems and to aid in their solution. Actions were initiated to select another manufacturer to develop an injector as a backup.

Extensive qualification testing of the LM descent engine continued; plans call for the work to be completed during the third quarter of the year.

Dynamic Test Vehicle Test Program.—The objective of the Dynamic Test Vehicle (DTV) test program is to verify the mathematical techniques by comparing the dynamic characteristics derived from tests of a full scale prototype with characteristics derived mathematically. These characteristics, when updated to the flight configuration, are used as input parameters in flight control and structural loads analyses, which are then verified (flight control and structural) on the Saturn/Apollo vehicles.

The testing concept required simulating various conditions of flight using a Dynamic Test Vehicle erected in a test stand. The stages of the vehicle were ballasted to simulate the vehicle at a specific point in the trajectory.

The Configuration I dynamic testing program was initiated and completed at MSFC. Configuration I consists of all stages of the launch vehicle and all elements of the Command and Service Module, Lunar Module, and Launch Escape System. Correlation with analysis for center line modes and frequencies was achieved. However, the analysis did not accurately predict the response at the Flight Control Gyro location. Considerable local deformation was experienced at the Instrument Unit, resulting in slopes at the Control Gyro location that were considerably greater than center line slopes of the vehicle. Because of this local activity, flight control stability margins were below design objectives for several lateral Configuration I modes. To solve this problem, engineers relocated the Control Gyro to the bottom of the cold plate III, and redesigned the filter networks. Configuration I testing was then extended to verify dynamic characteristics at the new location of the Control Gyro and also to identify a possible alternate location for it. Stability margins were substantially improved as a result of the design change. With the redesign, all modes demonstrated stability margins above design objectives, and the SA-501 margin restraint was removed.

After undergoing the complete Configuration I testing, the Dynamic Test Vehicle was disassembled so the test tower could be modified for Configuration II tests. Configuration II consists of the S-II and S-IVB stages and all elements of the Apollo Spacecraft. Configuration II testing began in May and was in progress at the end of the period, with completion expected in the third quarter of 1967. (Fig. 1–7.) Initial

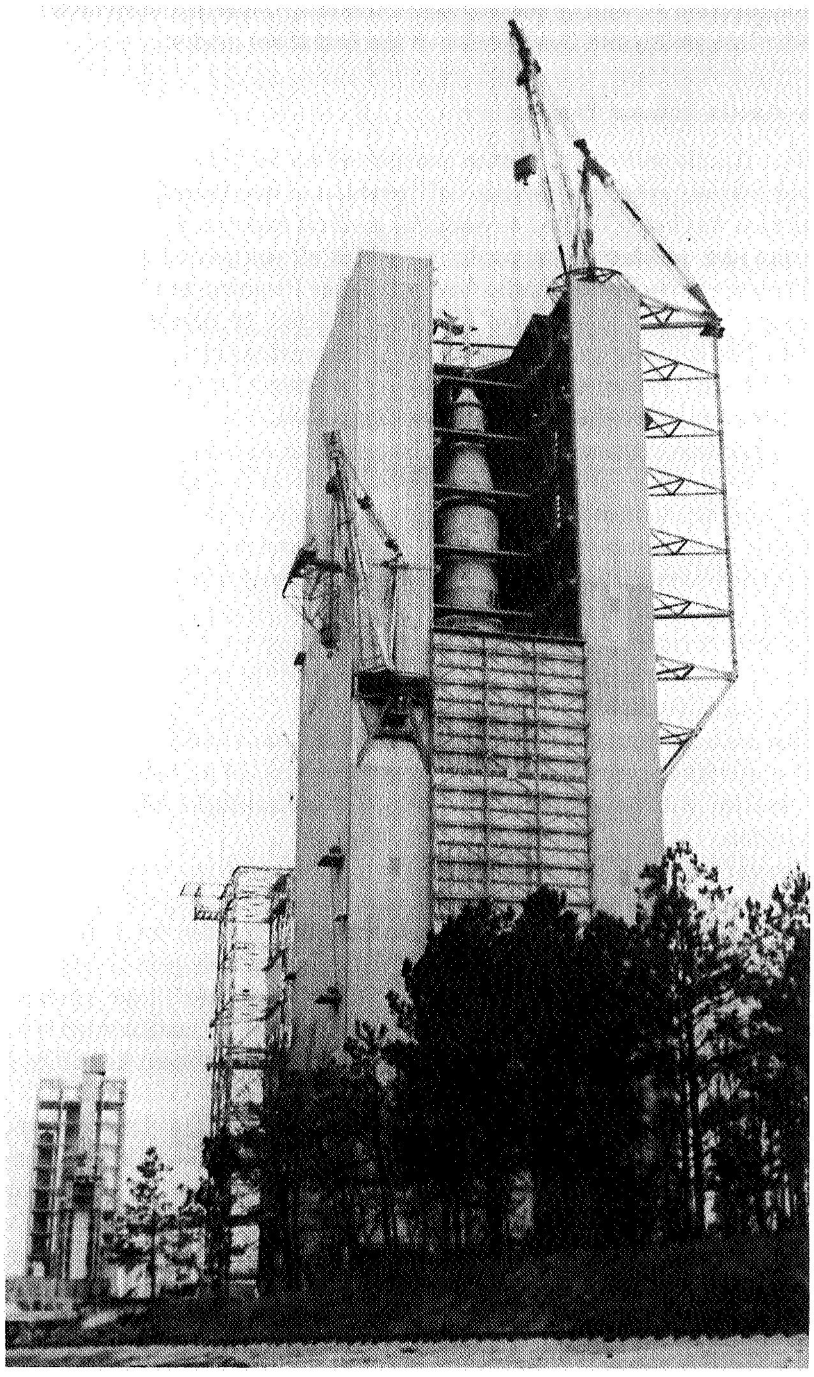


Figure I–7. Saturn V in Dynamic Test Stand for Configuration II testing.

Configuration II testing results were indicating excellent correlation for center line modes and frequencies on the first three modes.

The Apollo Science Program

The Apollo Science program consists of an in-flight program and a lunar science program. Because of operational constraints, the in-flight program was being limited to essential medical experiments and synoptic terrain and weather photography for which all equipment was available.

The objectives of the Apollo Lunar Science Program are to investigate the structure and processes of the lunar interior, to determine the composition of and the processes modifying the surface of the moon, and to establish the historical or evolutionary sequence of events by which the moon has arrived at its present configuration.

For the first missions, four scientific activities were being programmed for the astronauts: making observations to provide a qualitative description of lunar surface features; collecting samples to permit post-mission analysis in geochemistry, petrology, geology, and bioscience; deploying the Apollo Lunar Surface Experiments Package (ALSEP) which will remain and obtain continued measurements of geophysical parameters for a year or more; and performing field geology experiments to obtain information on the geologic structure as it may be revealed by surface features and formations.

The ALSEP system acts as a scientific station capable of accepting and supporting a variety of different experiments. (Fig. 1–8.) Power for the system will be supplied by a Pu 238 radioistopic thermoelectric generator.

The initial ALSEP experiments are a passive seismometer, a lunar surface magnetometer, a solar wind spectrometer, a suprathermal ion detector, and a cold cathode gauge. Experiments for later missions include an active seismic experiment with pyrotechnic seismic sources, a lunar heat flow experiment, and a charged particle lunar environment experiment. A lunar surface drill is to be used in conjunction with the heat flow experiment and will also be used to obtain lunar core samples.

Geology tools and a tool carrier developed for the Lunar Field Geology experiment are to be incorporated into the Scientific Equipment Bay (SEQ) with ALSEP. Included with the tools are core tubes and aseptic samplers. Two Apollo Lunar Sample Return Containers and a Hasselblad camera are part of the Lunar Field Geology experiment but are stowed separately.

Qualification testing for ALSEP I is to be started by early October, 1967, with flight hardware planned for delivery in the summer of 1968.

The following sections briefly describe the initial ALSEP experi-

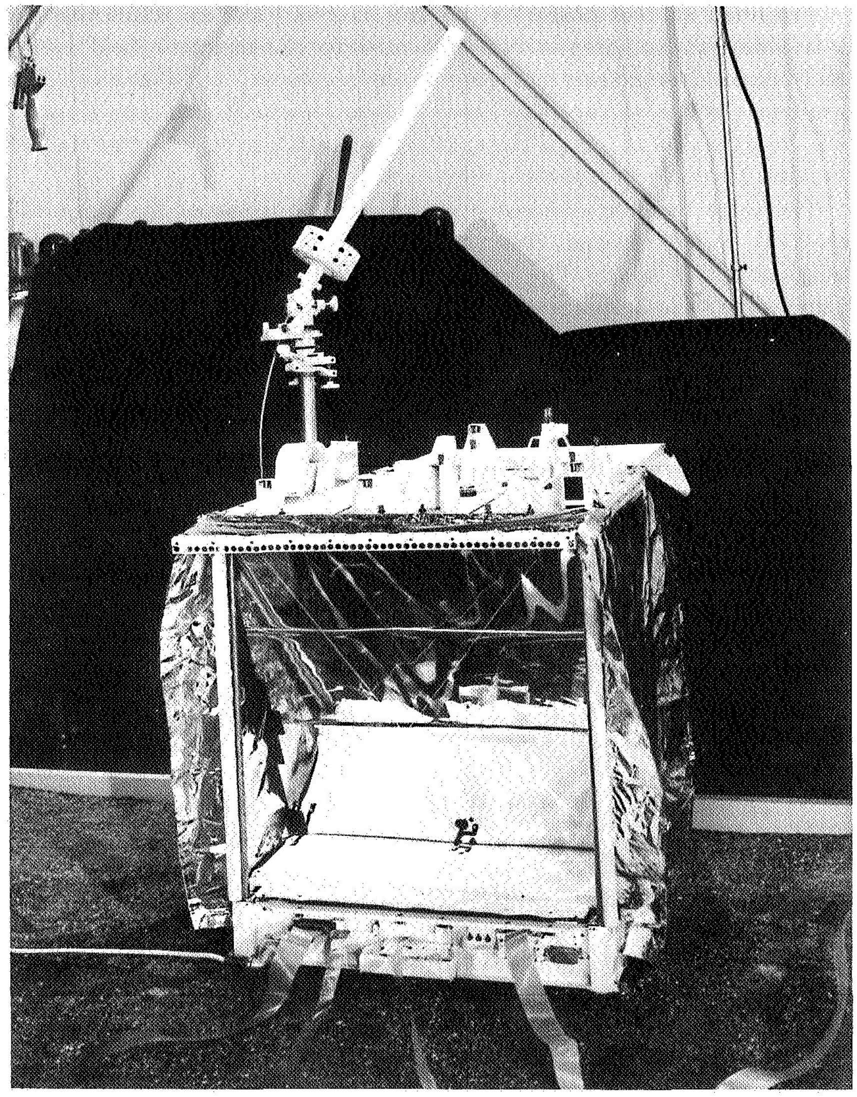


Figure I–8. ALSEP central station crew engineering model in deployed configuration.

ments. The passive seismometer is designed to determine the natural seismicity of the moon, and to provide data on the physical properties of the lunar interior. Data is to be obtained by using a 10 to 15 second, three-axis orthogonal seismometer for long-period, low-frequency, seismic energy and a short-period (½ to one second) seismometer for the high frequency portion of the seismicity signal spectrum.

The lunar surface magnetometer is a magnetic station which will use a tri-axis flux-gate magnetometer to measure the magnetic field vector and temporal variations at the lunar surface as well as to measure field gradients at the sensor site. Three booms, each with flux-gate sensors, will be separated to form a rectangular coordinate system and gimballed to allow parallel or orthogonal alignment.

The solar wind spectrometer is designed to measure the temporal, spectral, and directional characteristics of the interaction of the solar wind and the moon. The experiment will measure the number of charged particles impinging upon it, and their energy (electrons to 1376 electron volts, protons to 9600 ev). Directional origin of the particles will be determined by observing which of the seven oriented sensors indicates their flow. Energy selection is made by modulating the flow of particles in the energy interval being measured.

The suprathermal ion detector (SIDE) is designed to measure the flux, energy, and velocity of positive ions in the lunar ionosphere. (Fig. 1–9.) The instrument has a velocity selector composed of crossed electric and magnetic fields followed by a curved plate analyzer. Velocity and

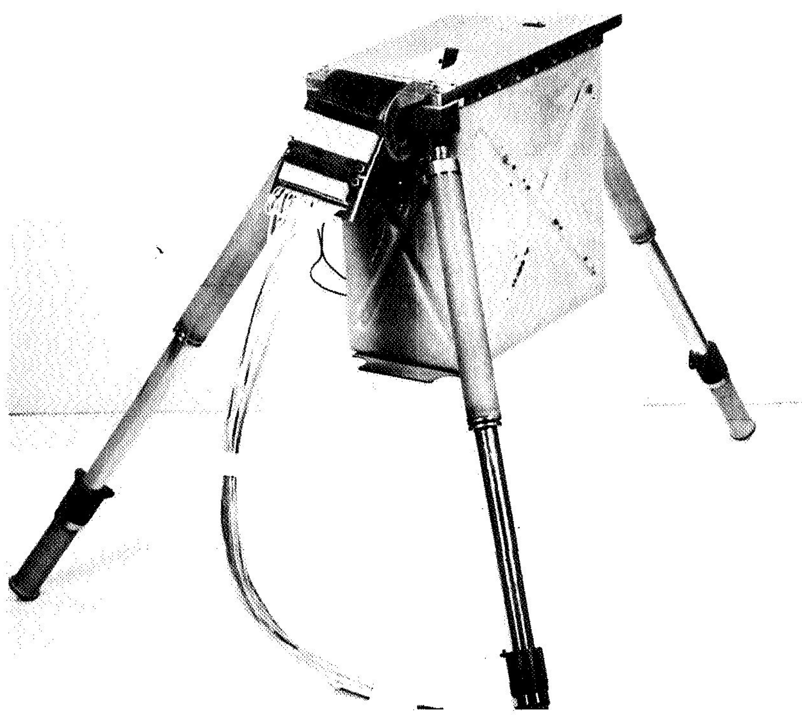


Figure 1–9. The suprathermal ion detector (SIDE) deployed.

energy sorting of the particles entering these detectors covers ions in the range from one to four AMU per unit charge, from 2×10^2 to 2×10^7 cm/sec., and from 0–2 KEV. A second curved plate analyzer without a velocity filter detects solar wind particles. Associated with the SIDE is a cold cathode gauge to determine the pressure of neutral particles by measuring the density of the ambient lunar atmosphere.

Apollo Applications

Through its Apollo Applications Program (AAP), NASA continued to refine program objectives, plan program and flight missions, develop hardware concepts and designs, identify experiments to be used, and establish its program management structure.

Program Objectives

The program has four primary objectives: to conduct long duration manned space missions (up to one year); to conduct extended lunar exploration; to carry out scientific investigations in earth orbit; and to make space applications in earth orbit.

Long duration space flights will include evaluation of habitability, systems development, and usefulness of man. Space applications in earth orbit will include experiments in meteorology; communications and navigation; and earth resources. The last-named will apply to agriculture and forestry, geology and minerals, geography, cartography, man-made resources, hydrology and water, and oceanography. Scientific investigations in earth orbit are to include solar astronomy, earth observations, and stellar astronomy.

Program and Flight Mission Planning

The AAP missions were being planned to gain experience, test theories, perform experiments, and collect data. Multiple objectives were being established for each flight mission in order to obtain maximum results at a relatively low cost.

Key elements in this planning include the decision to use, modify, and expand present Apollo systems capabilities rather than initiate whole new developments; the concept of reusing basic hardware for many missions by storing it in orbit and returning later with fresh crews and a resupply of expendables; the approach of designing experiments that will gather important data while simultaneously testing the experimental concepts themselves; and the anticipated use of the open-ended mission philosophy of allowing each mission to proceed as far as it is capable.

The first three missions were more clearly defined. The first mission (AAP-1A) is to be manned and is to carry out science, meteorology, and earth resources experiments. This one should last up to 14 days. The second (AAP-1 and AAP-2) is to be a manned dual launch mission of up to 28 days' duration which will demonstrate the feasibility of orbital workshop operations. This mission is also expected to conduct biomedical, science, and technology experiments. The third mission (AAP-3 and AAP-4) is also to be a manned dual launch mission but should last up to 56 days. It is to carry out ATM operations, demonstrate the feasibility of reuse of the workshop, and conduct biomedical, science, and technology experiments. Detailed mission planning was in progress at period's end.

The Agency issued a formal version of the AAP flight mission assignment document for the early flights. This document, which authorizes the missions, describes in general terms the primary objectives of each flight, the flight profiles, the space vehicle configurations, the identity of experiments to be carried, and the space operations to be conducted.

Following issuance of the flight mission assignment document, NASA issued flight mission directives for the early flights. These define in more detail the mission's purpose and objectives, the general flight plan, the flight hardware configuration, the experiments, the ground tests, the reliability and quality assurance requirements, and the organizational responsibilities.

Additionally, a configuration definition document was issued. This provides detailed descriptions of the flight hardware for the early missions. For later flights, studies were started, or continued, to define the requirements and problems associated with attaining AAP one-year missions.

Flight Hardware

NASA continued its efforts to develop or modify major flight hardware required for the early missions. This hardware includes the orbital workshop, the airlock, the Apollo Telescope Mount (ATM), the launch vehicles, and the command and service modules.

The orbital workshop, for use in AAP-1 and 2, will permit astronauts to outfit, inhabit, work, and perform experiments in the empty hydrogen tank (Workshop) of a spent S-IVB stage by means of a 65-inch diameter airlock between the spacecraft and the hydrogen tank. A hatch in the airlock will permit egress into space without depressurization of the workshop or the spacecraft. In orbital flight, the command and service modules will dock with the airlock, and the crew will activate systems to pressurize the spent hydrogen tank for habitation.

Preliminary design of the orbital workshop was completed, and a full-scale mockup was delivered to MSFC. A thorough and well documented astronaut walk-through was conducted, followed by a preliminary design review. Plans were approved to provide an additional work area for the installation of more experiments and habitability equipment for future revisits after the initial use.

An Airlock Development Plan was prepared. A contractor defined the airlock and multiple docking adapter interfaces and began design analyses for incorporating a two-gas (nitrogen and oxygen) orbital workshop environmental control system. Reviews indicated that the airlock design was proceeding satisfactorily.

The Apollo Telescope Mount (ATM) provides a new capability for a variety of solar scientific experiments to be performed above the earth's atmosphere. It has a stabilized platform to accommodate experiment instruments requiring finely controlled pointing and scientific instruments and supporting systems mounted in a structural rack attached to the ascent stage of an Apollo lunar module (LM). The ATM rack will have a pointing control system consisting of control moment gyroscopes, fine control vernier gimbals, electronic control circuitry, and appropriate astronaut controls and displays. A thermal control system and a communications and data handling system are also to be included. Electrical power is to be furnished by a solar array mounted to the ATM rack, with rechargeable batteries to maintain system loads during darkness.

ATM systems contracts were awarded for a three-axis simulator, for control moment gyroscope systems, for thermal and contamination studies, for an ATM neutral buoyancy trainer test article, and for the vernier pointing control system.

The full-scale ATM mockup was completed as was the ATM spar test unit. (Fig. 1–10.) The ATM structural design was released for fabrication. Astronauts performed one-G walk-through tests for evaluation of the Lunar Module (LM) and the film was retrieved for evaluation. The ATM installation and interface requirements were established for modifying the LM to suit the LM-ATM configuration. Initial thermal stability tests of the ATM spar were performed, and preliminary results indicated no apparent problems concerning the spar deflection.

The Command and Service Module contractor completed preliminary studies of the modifications that would be required to give the CSM the capability for a space mission lasting up to 56 days. These modifications would adapt the CSM to a two-gas system (nitrogen and oxygen), would enable it to carry cryogenics for longer fuel cell operation and sufficient oxygen for the astronauts, would provide more stabilization thruster propellant for the increased stabilization demands of experiments and

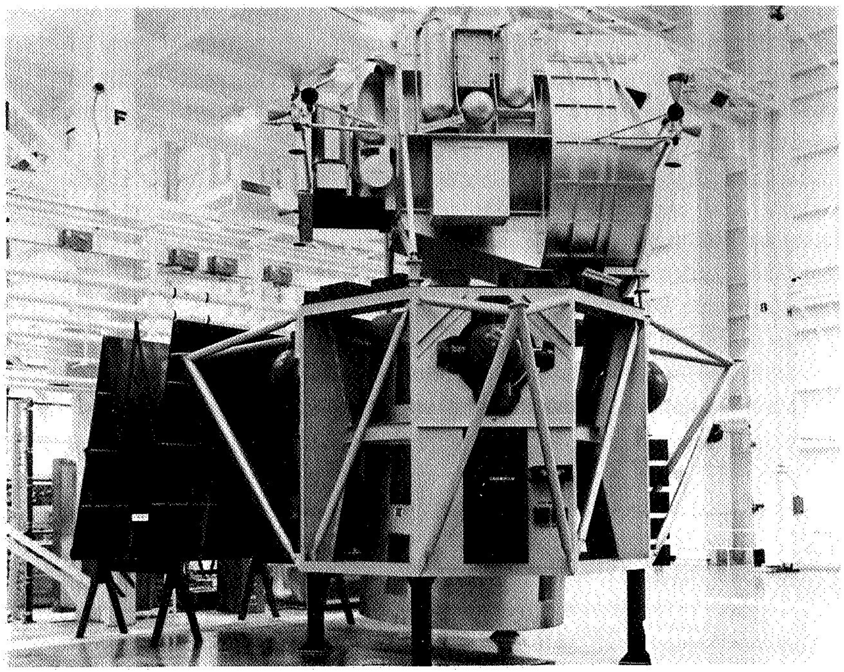


Figure 1–10. Overall view, left side, of ATM.

long-duration flight, and would add solid retro engines to provide a backup re-entry capability.

Long-lead procurement was initiated for those items required to keep open the option of buying additional uprated Saturn I and Saturn V launch vehicles.

Experiments

By the end of the period, 62 experiments had been reviewed by the Manned Space Flight Experiments Board, approved by the Associate Administrator for Manned Space Flight, and assigned to AAP for implementation. Twenty-five additional experiments were identified and were under consideration for assignment. Contracts were awarded or were in the process of being awarded for development of approved experiments. Most of this experiment hardware is in either the design or the development phase. The payload integration centers (MSFC and MSC) were actively working with the principal investigators and were in the process of integrating experiments into the spacecraft modules. This integration includes such items as the necessary support provisions, electrical power, coolants, storage locations, and mounting brackets.

Mission operations requirements were being established, including such items as the required crew training and in-flight time allocation.

The majority of the approved experiments were assigned to the first five AAP flights. Fourteen experiments were being considered for use on mission AAP-1A, including science experiments previously assigned to the Apollo Program, earth resources experiments, and meteorology experiments. Payload integration and compatibility studies were being conducted to define the mission payload.

Representative of the experiments to be carried is one for making measurements in X-ray astronomy, and one for photographing selected ground sites using a variety of films and filters. These experiments would provide early data for use in determining the feasibility and applicability of conducting earth resource surveys from space.

The second and third AAP flights, AAP-1 and AAP-2, are being planned as a dual launch mission, one manned, and one unmanned but carrying the Orbital Workshop experiment. Thirty-five experiments are being considered for these flights—eight medical, ten engineering, six Department of Defense, six advanced technology, and five scientific experiments.

The medical experiments for AAP-1 and AAP-2 would be aimed primarily at determining the effects on man of a flight of up to 28 days' duration. The significant engineering experiment, involving the orbital workshop, would be to evaluate crew quarters, a food management system, and a waste management system. Also, the crew quarters would be evaluated to determine suitability for a mission duration of up to 56 days, as planned for the AAP-3 and AAP-4 mission, and possible suitability for a crew member remaining in orbit up to 90 days, as is planned in future AAP missions.

Department of Defense selected experiments would be aimed at obtaining early information useful to the Manned Orbital Laboratory Program. Other DOD experiments would obtain advanced technical data needed to design advanced systems.

Typical advanced technology experiments would be those to further define the micrometeorite phenomena and the associated effect on the spacecraft. Scientific experiments would be aimed at gathering additional astronomy data which will be more advanced than the astronomy data from AAP-1A.

The fourth and fifth flights, AAP-3 and AAP-4, were also being planned as a dual launch, one manned and one unmanned, carrying the Apollo Telescope Mount (ATM). The mission would have two prime objectives—one to conduct solar astronomy experiments, and the other to conduct additional medical experiments.

The medical experiments would try to determine the effects on man of up to 56 days in space, a major duration extension over the planned 28-day mission of AAP-1 and AAP-2. In addition, evaluation of the orbital workshop quarters would be continued because the orbital workshop from the AAP-1 and AAP-2 mission would be revisited and reactivated.

The ATM is expected to carry five major solar astronomy experiments: a white light coronograph, UV coronal spectrographs, an X-ray spectrographic telescope, UV spectrometers, and dual X-ray telescopes. These experiments are expected to obtain high resolution images of the sun and detailed views of selected portions of it, primarily in the ultraviolet and X-ray portions of the light spectrum. This research is important to the scientific community because the 1969–1971 period of peak solar activity will not be duplicated for 11 years.

Preliminary design was completed for most ATM experiment equipment. Preliminary design and interface reviews were conducted to verify the experiment design and performance specifications and to define experiment interface requirements of the ATM supporting subsystems. Long-lead time procurement was authorized for the ATM experiment equipment, and the thermal-mechanical units were being fabricated. Breadboard testing to verify the design concept of all ATM experiments was completed. (Fig. 1–11.)

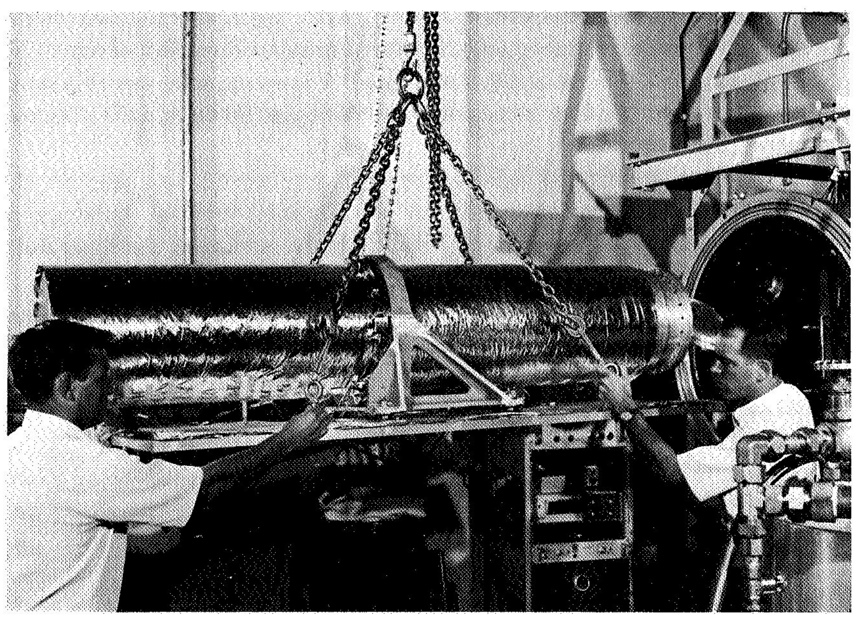


Figure 1–11. ATM X-ray telescope being removed from thermal/vacuum chamber.

Program Management

Refinements continued to be made in the definition of program responsibilities. Assignments were made to the field centers for the integration of experiments, support systems, and experiment carriers, and responsibility interfaces were clarified among MSC, MSFC, and the prime contractor.

Coordination activities also continued. Intercenter coordination panels were established to identify and define technical and management problems that may arise among the three MSF field centers. Meetings were conducted with the Department of Defense to exchange information on AAP plans, manned space flight experience, and MOL program plans and experience. To assure closer working relationships at Headquarters on the ATM project, personnel were assigned to AAP from both the Office of Space Science and Applications and the Office of Advanced Research and Technology.

The payload integration contractor was selected. His primary tasks will be to assure compatibility between the space vehicles and the payloads, including experiments, experiment operational and support equipment, and expendables; and to make certain that experiment requirements and plans will be compatible with mission plans.

The preparation of AAP management plans continued. The Reliability and Quality Assurance plan was published and distributed. A version of the Test Requirements Document was circulated for final comments from project organizations at the field centers. The AAP project office at KSC completed plans for AAP KSC operations for the early missions. These plans provided a baseline for launch facilities modifications, launch operations requirements, and the joint AAP and Apollo use of launch facilities.

Progress was also made in scheduling and control. A formal set of schedules with associated review procedures was started between the centers and Headquarters. These management tools are expected to assist management in the day-to-day process of investigation, assessment, corrective action, and program adjustment.

Advanced Manned Missions

The Advanced Manned Missions Program continued studies aimed at identifying mission requirements, investigating modes for mission accomplishment, determining hardware design concepts, and identifying required resources and technology. Studies were also underway to design integrated manned space flight programs that would accomplish more ambitious national goals than those set for Apollo and Apollo Applications.

The studies showed that the accumulation of systems design and operating experience in preceding programs will make it feasible to launch Earth-orbiting space stations in the 1970's. These stations could be designed for five years of continuous operation, accommodating a crew of nine to twelve men. Several space station concepts identified in the studies could be reasonable follow-ons to the Earth-orbiting missions of the Apollo Applications Program. The concepts differ in cost, sophistication, and ability to accommodate conflicting requirements. Some configurations could provide artificial gravity should that be necessary or desirable, and all could be launched by Saturn V vehicles. All of these concepts are to be analyzed and refined so that a realistic set of options will be available when the time comes to initiate space station development.

Operating a long life-time space station requires an efficient and versatile logistics system for rotating the crews, replenishing expendables, delivering experimental equipment, and returning data. Systems being studied would meet these demands and use Gemini and Apollo hardware and subsystems. The logistics spacecraft would consist of a crew module accommodating six to nine men and a combined cargo/propulsion module.

Advanced manned studies conducted to date indicate that the space station is the key to future exploration and exploitation of space. It is here that Earth-oriented applications in the fields of communications, meteorology, oceanography, and land resources can be made and subsystem refinement take place. Basic research in bioscience, medicine, geoscience, and astronomy will benefit from the enlarged and more sophisticated facilities which will become available for the first time. The five-year space station anticipated for the 1970's will enable the nation to make the technological and operational advances required for planetary exploration, lunar orbiting stations, and even more sophisticated Earth-orbiting space stations.

Apollo and Apollo Applications missions should provide for limited exploration of the lunar surface in the vicinity of the landing sites. Results from these early missions may indicate that more extensive operational and scientific capabilities are needed. Such extensions would include provisions for longer staytime and greater mobility on the lunar surface. In anticipation of such requirements, conceptual designs of shelter-laboratories and extended mobility vehicles were being studied along with the improved transportation systems required for their delivery to the moon.

Manned planetary studies have considered Mars and Venus reconnaissance missions with the potential of retrieving samples of atmosphere and soil. Missions studied use an encounter (fly-by) trajectory profile and combine the unique capabilities of both manned and unmanned systems to carry out the desired scientific experiments. Samples would be retrieved by an automated spacecraft deployed from the manned vehicle as it swings by the planet. The spacecraft would be flown into the atmosphere to take samples. In the case of Mars, a soft landing would be made on the surface and soil samples would also be taken. Sampling completed, the automated spacecraft would return to the manned craft as it departs the planet. Other orbiting, landing, and impact probes would also be deployed.

Advanced lunar and planetary mission studies, as well as space station logistics studies, also indicated the need for uprating Saturn launch vehicles. Various methods of uprating were therefore being investigated. Methods being considered would employ strap-on solid motors, uprated engines, advanced engines, and increased propellant capacity. Such techniques, used either singly or in combination, would provide the increased capability needed to meet the requirements of missions under study.

Construction of Facilities

During the first half of 1967 construction and activation continued on schedule in providing the nation with the basic plant which will not only support the lunar mission but establish the facilities foundation for future programs. Most key facilities needed for the lunar landing and return mission are complete and operational. At the Kennedy Space Center elements of Launch Complex 39 required for first launch became operational; construction of the Lunar Receiving Laboratory at the Manned Spacecraft Center, Houston, Texas, approached completion; and at the Mississippi Test Facility the second static test stand for the S-II stage became operational.

Kennedy Space Center

At Kennedy Space Center, final operational readiness for the first Saturn V launch was achieved through the activation of Launch Area A, the Mobile Service Structure, and Launch Umbilical Tower number two. Work was continuing on schedule for outfitting the high bay #2 of the Vehicle Assembly Building (VAB), Launch Complex 39, and Launch Area B. Contracts were awarded for the construction of an addition to the KSC Headquarters Building and the Visitors Information Center.

Manned Spacecraft Center

At the Manned Spacecraft Center, construction of the Lunar Receiving Laboratory, begun in August, 1966, neared completion. (Fig. 1–12.)

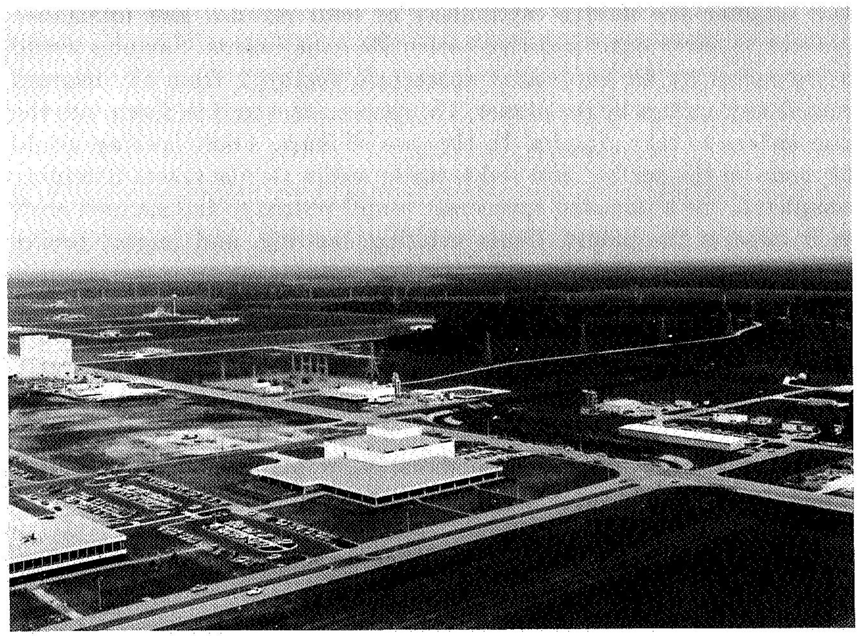


Figure 1–12. Aerial view of Lunar Receiving Laboratory, MSC.

All remaining work is scheduled to be completed during 1967. Construction of the Flight Crew Training Facility began. This facility will house an Apollo Procedures Development Trainer for support of the astronaut training program.

Mississippi Test Facility

At the Mississippi Test Facility, the second stand for the Saturn V second stage testing became operational in March. (Fig. 1–13.) The second S-II flight stage was successfully tested and delivered to KSC, and the fourth S-IC flight stage was fired and accepted on the first position of the dual S-IC test stand.

Supporting Systems and Operations

Efforts were continued to make certain that the supporting systems and operations were kept abreast of the programs which they augmented. These systems and operations included the Launch Information Systems, the Mission Control Systems, operational support activities, and flight crew efforts.

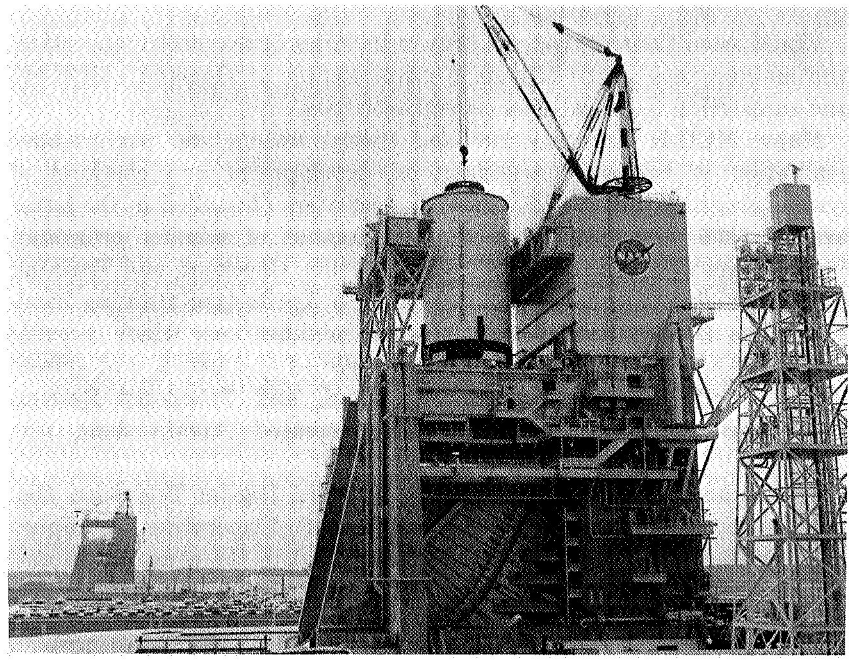


Figure I—13. S-II stage being lowered into second S-II test stand.

Launch Information Systems

The Launch Information Systems (*16th Semiannual Report*, p. 72) is the name of the manned space flight project which develops, implements, and operates ground instrumentation systems at the Kennedy Space Center during countdown, launch, and the initial phases of flight. The Apollo Launch Data System supplies spacecraft vehicle data in real time to the Manned Spacecraft Center, Mission Control Center. The Launch Information Exchange Facility (LIEF) supplies launch vehicle data to the Marshall Space Flight Center, also in real time, during major preflight tests and launch. Both were being used to support uprated Saturn I and Saturn V prelaunch checkouts.

Checkout of equipment for support of the first Saturn V launch, AS-501 (Apollo 4), including large-screen display equipment, hazard monitoring systems, and geophysical measuring systems, was completed. Also, during the period, the Central Instrumentation Facility (expanded in December, 1966) was completely checked out and became operational.

Mission Control Systems

The Mission Control Systems project includes development, operation, and maintenance of the Mission Control Center at Houston (MCC-H) and supporting technical systems and activities.

Major MCC-H activities included system testing and performance evaluation of hardware modifications, development and checkout of system programs for the IBM 360–75 computers (installed in the latter half of 1966), and development and checkout of mission programs. System tests were completed on the Simulation, Checkout, and Training System which was updated in late 1966 with Apollo-type training hardware. The Display and Control System modifications which provide dual mission support capability were completed and tested, and system testing of the Communications, Command, and Telemetry System, which was modified to accommodate increased Apollo data, was initiated.

System acceptance testing of the breadboard Digital Television Display System was completed, and development of operating techniques was initiated. This system will significantly aid in the preparation and real-time display of mission operational data in the MCC-H. The development of a prototype spacecraft television scan converter was also completed and system testing started.

Compatibility and performance evaluation tests, which will verify the operational capability of the Spacecraft Communication System and associated ground station equipment, were being conducted on various subsystems of the Apollo Unified S-Band Communication System. This activity is to continue until all operational modes and system configurations have been tested and the results analyzed.

Operations Support Requirements

The joint NASA/DOD MSF Support Requirements Documents System was refined by improving the reporting formats. In addition, a new Support Discrepancies Reporting System was coordinated; it is to be implemented beginning with the Apollo 4 (AS–501) mission.

The Launch Support Team and Flight Support Team operational procedures were modified, resulting in an expansion of both operational authority and activation time. This modification is expected to expedite handling of last minute changes to mission requirements.

NASA continued as an associate member to the DOD Range Commanders' Counsel Inter-range Documentation Group (IRDG). This group developed a Program Introduction Requirements Documentation System which is compatible with the organization of the present Manned Space Flight Support Requirements Documentation System.

Flight Crew Operations

Eleven scientists were selected for astronaut training and assignment to the astronaut force. (Fig. 1–14.) The selectees were chosen from a list of 69 candidates nominated by the National Academy of Sciences. During the first eighteen months with NASA, they will assist in planning and implementing the Apollo Applications Program as they complete general training.

The loss of spacecraft 012 and the AS–204 crew led to a reorientation of the astronauts' program. All of the astronauts, and particularly those with flight experience, became heavily involved in spacecraft modification and redesign activities. A minimum of training time was lost, however, since crew participation in spacecraft design and testing has always been an invaluable part of crew preparation for flight.

Spacecraft changes necessarily lead to changes in simulators and trainers. As changes were made to the Apollo spacecraft following the AS–204 accident, additional work was necessary to update Apollo training equipment. Even though the workload increased, all major

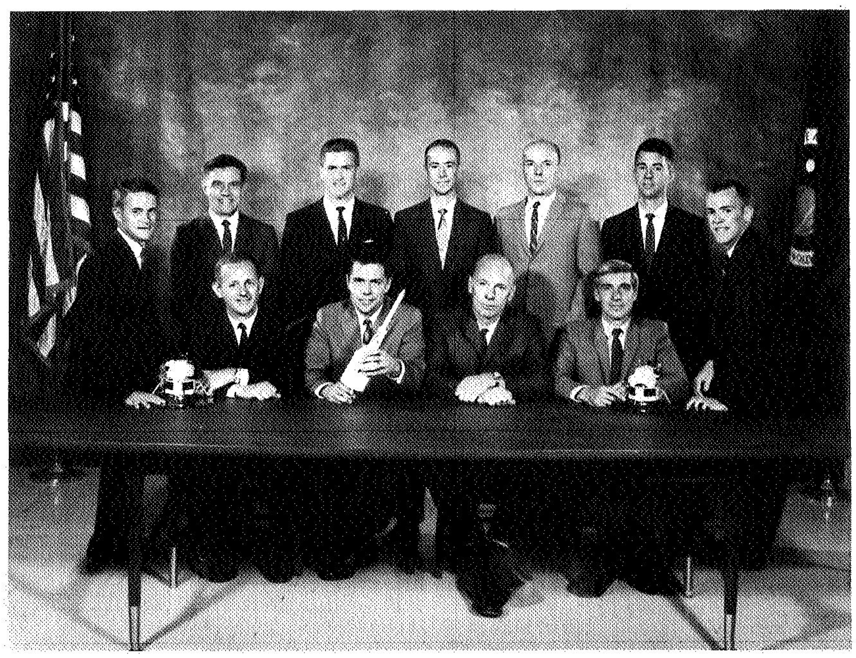


Figure 1–14. Eleven new astronauts: (seated left to right) Phillip K. Chapman, Robert A. Parker, William E. Thornton, and John A. Llewellyn; (standing left to right) Joseph P. Allen, Karl G. Henize, Anthony W. England, Donald L. Holmquest, Franklin S. Musgrave, William B. Lenoir, and Brian T. O'Leary.

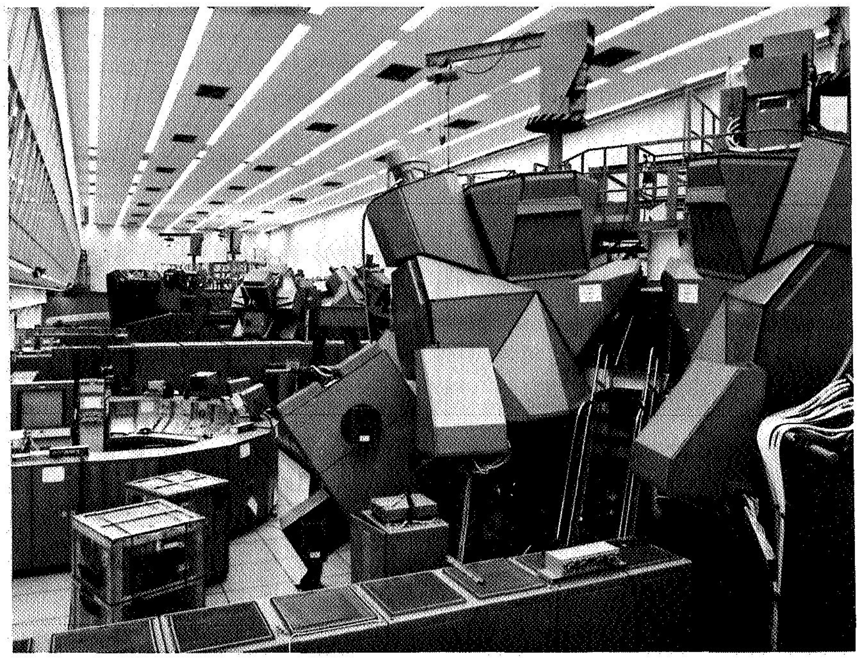


Figure 1–15. Apollo simulator room, KSC. Foreground: Apollo Mission Simulator No. 2; center: Lunar Module Mission Simulator No. 2.

items of Apollo training hardware except three lunar landing training vehicles were in place by the end of June. The last of the three Apollo simulators and the second LEM simulator were delivered; a procedures development simulator was operational and in use by the Apollo crews; and the lunar landing research vehicles were flown by astronauts at the new Ellington Air Force Base (Texas) site in March. (Fig. 1–15.)

Space Medicine

During the period, the space medicine program continued to be concerned with such matters as back contamination, medical and behavioral laboratory measurements, the US/USSR space biology and medicine foundations project, and biomathematical studies.

Interagency Committee on Back Contamination

In 1966, NASA and other government agencies established the committee on back contamination to plan those projects that would prevent contamination of earth life by lunar samples. The committee is also concerned with protecting the integrity of the lunar samples, themselves, as well as the related scientific equipment.

By the end of the period, the committee had developed an interagency agreement related to the protection of the earth's biosphere from lunar sources of contamination and was in the process of obtaining agency signatures to it. The committee also prepared or approved a series of recommendations and policy documents. These actions included a recommendation for a microbiological training prospectus for astronauts and one for control of contamination within the lunar and command modules.

The Lunar Receiving Laboratory at the Manned Spacecraft Center was nearing completion, and steps were begun to certify the facility as a containment-type laboratory.

Integrated Medical and Behavioral Laboratory Requirement System

An Integrated Medical and Behavioral Laboratory Measurement System (IMBLMS) is being planned for flight use, beginning with the Apollo Applications missions of 1970. This system is to perform medical and behavioral measurements on flight crew members. It is also being planned to accommodate experiments proposed by the scientific community. During this period, the procurement plan was approved, requests for procurement were issued, proposals were received and evaluated, and the Source Evaluation Board action was completed. Two Phase B (Definition) contractors were selected.

Additionally, through the space medicine program, certain definition studies related to making valid measurements of man in space were completed. Subjects of these studies were: collection and preservation of biological specimens during space flight for post-flight analysis; feasibility of the utilization of physical methods of biochemical analyses in space flight; definition of microbiological test requirements for manned space flight; and feasibility of noninvasive venous pressure measurement.

Medical Information Analysis

NASA renewed for one year a major space medicine contract—one which has provided in-depth studies and a "quick response" capability since 1962. A 1964 publication stemming from this contract, *Fire and Blast Hazards,* Part II of the series *Space Cabin Atmospheres,* was a basic document used by the Congress and NASA in the investigation of the Apollo fire. The services of the principal investigator (Dr. E. M. Roth) were extensively used to provide additional information required in the course of that investigation.

Publications under this contract during the period included *Human Water Exchange in Space Suits and Capsules* and *Storage of Biological Samples*. In addition, other studies were completed and were either in press or being reviewed prior to publication. There were (1) *Clinical Space Medicine: A Prospective Look at Medical Problems from Hazards of Space Operations;* (2) *Biomagnetics—Considerations Relevant to Manned Space Flight;* (3) *Biomedical Techniques for Use in Manned Space Laboratories*, Parts I, II and III; and (4) *The Intangibles of Habitability During Long Duration Space Missions.*

Three studies were in progress under this contract: (1) a survey of manned environmental test and simulation facilities; (2) development of human standards for space flight; and (3) an analysis of the problem of developing a method for a noninvasive means of measuring peripheral and venous blood pressure.

US/USSR Project: Foundations of Space Biology and Medicine

Both space medicine staff members and representatives of a NASA contractor participated in the editorial aspects of the joint United States and Soviet effort, *The Foundations of Space Biology and Medicine*. Primary responsibility for this activity is in the Bioscience Directorate of the Office of Space Science and Applications.

Two other significant reports were published. *A Review of the Medical Results of Gemini 7 and Related Flights* documented a symposium on Gemini medical experiments and operational data, held at KSC on August 23, 1966. *The Effects of Confinement on Long Duration Manned Space Flights*, Parts I and II, documented the proceedings of a NASA symposium sponsored by Space Medicine on November 17, 1966.

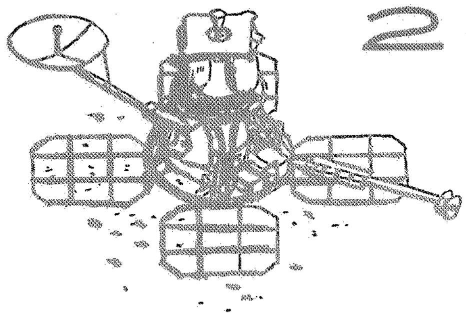
Biomathematical Studies

Action was underway to develop a computerized system for storing and retrieving astronaut medical data. This system will make relevant astronaut data easily and quickly available to medical monitors and qualified medical and paramedical researchers. The development of the system was essentially completed during this period, and plans were made to demonstrate its capability at the Manned Spacecraft Center.

Another research endeavor was concerned with continuous monitoring and interpreting electrocardiographic data by digital computer. This research offers NASA the possibility of real-time or near real-time analysis and diagnosis of possible adverse functioning of heart action in the astronauts aboard spacecraft. It is possible, using the system under study, to receive EKG data directly from a spacecraft or from a patient in Europe via satellite, feed the data into a computer, play it against the appropriate computer program, and arrive at a presumptive diagnosis based on the EKG within a matter of minutes or less. Its value to the general medical community is obvious when one considers the occasions when the patient and the expert cardiologists are separated by considerable distances and when speed and accuracy of diagnosis are essential.

Still another research effort is that of evaluating cardiovascular deconditioning resulting from true or simulated space flight. The results of this research will provide medical monitors as well as research personnel with an additional tool in dealing with the problem of cardiac deconditioning during prolonged space flight. The research is concerned with the variables important in evaluating deconditioning and the method of arriving at an integrated score which would reflect a significant change in one or more of the variables.

Two in-service papers have been written covering the effort to date. The first of these, *Development of an Integrated Score for Multiple Biomedical Measurements,* suggests a statistical method for combining scores through what is known as the Z-score method. The second paper, *Evaluation of Cardiovascular Deconditioning Due to True or Simulated Space Flight,* treats the physiological basis of deconditioning; the selection of pertinent variables for integration; and the development, applications, and limitations of the integrated scoring method proposed.



2 SCIENTIFIC INVESTIGATIONS IN SPACE

The several regions of the space environment must be understood, if man is to travel through this medium with confidence. Already Orbiting Solar Observatories monitoring processes taking place within the sun, and Orbiting Geophysical Observatories measuring the earth's magnetosphere and its upper atmosphere, have provided some insight into the more subtle, fundamental secrets of this strange environment. The Lunar Orbiter and Surveyor spacecraft have paved the way for exploration of the moon by pinpointing possible landing sites for astronauts and by sampling its surface; while Mariner spacecraft have furnished data on Mars and Venus. To prepare for prolonged manned flights beyond the earth, bioscientists have begun to determine how man can survive in this hostile environment by investigating the effects of space on various life forms in orbiting biological laboratories.

Physics and Astronomy Programs

Orbiting Observatories

On March 8 OSO-III was placed into an orbit ranging between 335 and 355 miles. Carrying instruments for nine experiments of scientists from universities, NASA, and other governmental laboratories, the satellite weighs 627 pounds and its instruments can be pointed at the sun with an accuracy of 1 minute of arc. Instruments for two experiments are in OSO-III's sail and those for seven others in its spinning wheel (Fig. 2–1). These provide additional data on solar disturbances, the effects of solar ultraviolet radiation on the earth's atmosphere, and information on the radiation environment between the earth and the moon. Such data should also be helpful in understanding the solar flare hazard for Project Apollo astronauts.

For the first time, OSO-III obtained detailed data on the absorption of extreme ultraviolet solar radiation in the earth's atmosphere during sunrise and sunset. (Readings were made at altitudes between 75 and

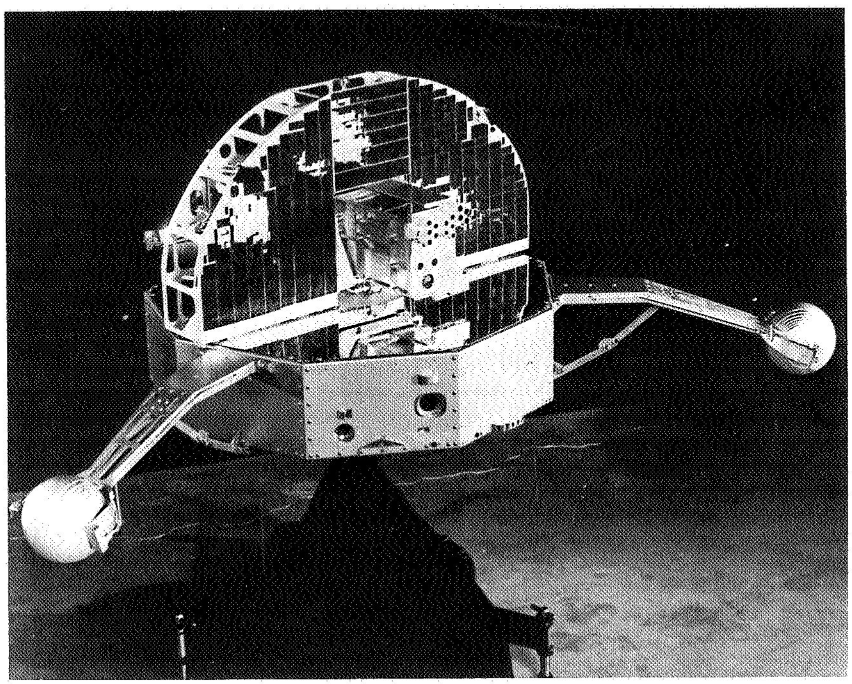


Figure 2–1. Orbiting Solar Observatory (OSO-III).

300 miles, in latitudes between 33°S and 33°N.) The orbiting observatory also observed the most energetic X-radiation coming from the sun yet detected. These X-rays occurred simultaneously with heightened activity on the sun's surface. Other measurements of X- and ultraviolet radiation were made (not possible from the earth) showing previously unobserved spectral lines present during flares only. Spectral line intensities were found to be four or more times greater than those observed earlier during the sun's quiet period.

The satellite also measured radiation coming from the direction of the earth. Larger amounts of radiation in the near ultraviolet (near the visible wavelengths) were found than expected, along with a decrease in the intensity of the ultraviolet of shorter wavelengths (farther from the visible wavelengths). Infrared measurements showed higher intensities than those computed from the earth's heat balance and supported previous measurements made by OSO-I and OSO-II using different techniques. (OSO-I was launched in March 1962; OSO-II in February 1965). In addition, higher intensities for gamma rays with energies above 100 million electron volts were measured when the instrument aboard OSO-III was pointed toward the earth than when pointed in other directions. The next OSO, OSO-D, was being made ready for launch in the second half of 1967.

The three Orbiting Geophysical Observatories, OGO-I, II, and III, still transmit useful information upon command when they are in the sunlight and able to generate sufficient power. They were orbited in 1964, 1965, and 1966. OGO-D was being prepared for launch in July 1967. The next Orbiting Astronomical Observatory (OAO-A2) was undergoing extensive changes to prepare it for flight.

Pioneer

Measurements of the magnetosphere and interplanetary magnetic fields made by Pioneer VI and VII, while flying almost 200 million miles in solar orbits, indicate that the tail of earth's magnetosphere, greatly elongated and weakened, extends away from the sun and may reach as far as 3.5 million miles from the earth. The spacecraft (launched in 1965 and 1966) noted over 30 bursts of cosmic ray particles generated by solar flares during 1966—a year marked by a minimum of solar activity. They also measured temperatures of electrons in interplanetary space for the first time, and found that on the average electron temperatures in the solar wind were about twice as high as positive particle temperatures.

Russian scientists compared data on solar wind velocities, ion concentrations, and energy spectra provided by Pioneer VI with information supplied by their Venus 3 probe and concluded that the results obtained by the two spacecraft were essentially in agreement.

Explorer Satellites

Explorer XXXIV (IMP-F), fifth in the Interplanetary Monitoring Platform series, was launched on May 24. The 163-pound spacecraft operated as designed in its planned orbit ranging between 154 and 131,187 miles from the earth (fig. 2–2).

The spacecraft's 11 experiments measure solar and galactic cosmic rays within and at the boundary of earth's magnetosphere and in interplanetary space. These data will be used in studying sun-earth relationships, particularly the effects of solar events on the earth environment during the present period of increasing solar activity. Explorer XXXIV is more complex and carries more experimental equipment than have earlier Explorers of the IMP class. For example, Explorer XXXIII (orbited in July 1966) carries equipment for just 7 experiments. The next IMP, to be placed into an anchored orbit about the moon, was scheduled for a July 1967 launch.

The most distant correction of a malfunction in spacecraft equip-

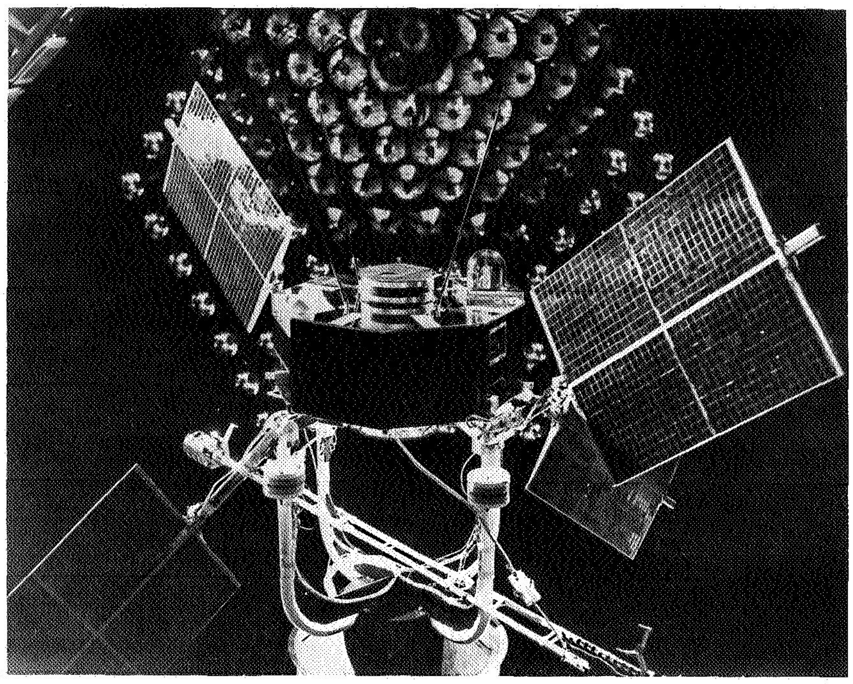


Figure 2–2. Explorer XXXIV undergoes thermal-vacuum tests.

ment known was made with Explorer XXXIII early this year. When this spacecraft was about 253,000 miles from the earth, signals received indicated a low power voltage supply. The power drain was cured by turning off the spacecraft transmitter for 40 minutes by radio command and then sending a power surge through the other equipment aboard.

In a noteworthy "first," Explorer XXXIII established that earth's magnetosphere extends beyond the moon.

San Marco and Ariel Satellites

International cooperation in space (ch. 7) continued with the launchings of the San Marco II and Ariel III scientific satellites. The San Marco II Italian satellite was put in orbit off the coast of Kenya, Africa on April 26—the first launching from a mobile launch platform and the first made from near the equator. The platform was floated to the launch site in the Indian Ocean and secured by extending moveable legs into the seabed. The satellite is a 26-inch 285-pound sphere equipped to determine air density at the satellite's height of several hundred miles and to investigate ionospheric disturbances to radio transmissions.

The British Ariel III was launched on May 5 into a nearly circular orbit 306 to 373 miles above the earth (fig. 2–3). This 198-pound spacecraft carries 5 experiments in electron density and temperature, radio noise, and the distribution of molecular oxygen. All of its experiments were working as planned.

Sounding Rockets and Balloons

Fifty physics and astronomy sounding rockets were launched during the first six months of this year carrying experiments to study auroral, particle, and electromagnetic radiations, solar physics, and ionospheric phenomena. Twenty-three of these were in Brazil, Canada, India, Norway, and Sweden. Two were flights of four-stage Argo D-4 Javelins from near Natal, Brazil to test instruments being developed for a German research satellite scheduled to investigate the Van Allen radiation belts of the earth in 1969. Two experiments of OSO-III were calibrated by rocket flights soon after the orbiting observatory's launch.

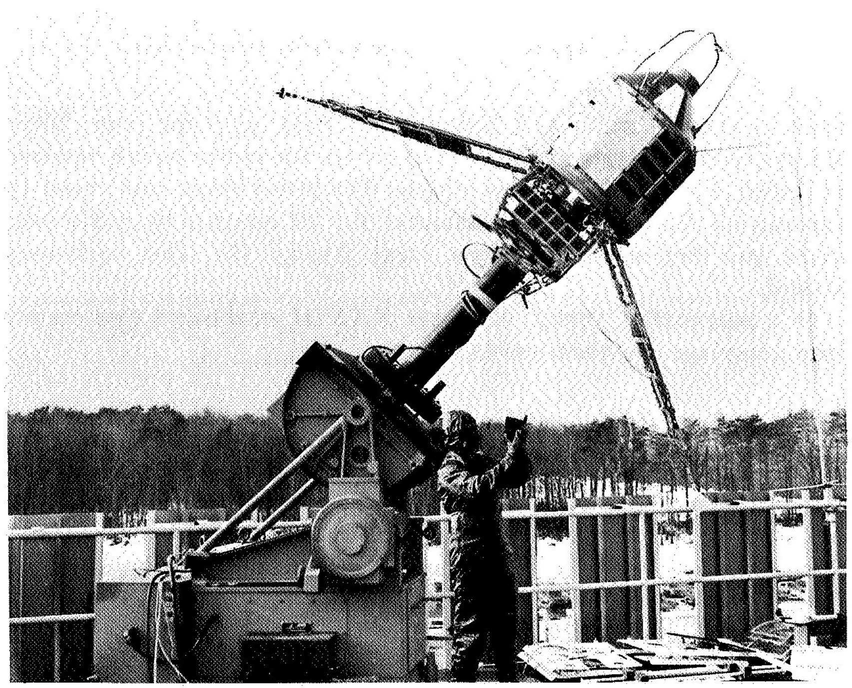


Figure 2–3. The British Ariel III.

Also, 36 meteorological research rockets were launched during this period.

Twenty-one balloons (operating at lower altitudes than rockets but able to remain in space longer and carry more experiments) investigated particle or electromagnetic radiation absorbed in the earth's atmosphere, and tested satellite and observatory instruments.

Lunar and Planetary Programs

Surveyor

Surveyor III, NASA's second spacecraft to make a soft landing on the moon, landed inside a crater in the Sea of Storms (Oceanus Procellarum) on April 20. The vernier engines continued to burn after initial touchdown because of a problem with the landing radar, causing the spacecraft to lift off twice before finally settling down. The spacecraft operated for 14 earth days until lunar sunset, transmitting 6,315 TV pictures, some in color. Included were views of the surrounding lunar landscape, photos of the spacecraft's surface sampler manipulating the lunar soil, a solar eclipse, and photographs of the earth.

A surface sampler instrument was included for the first time to allow Surveyor III to dig trenches and otherwise manipulate the lunar soil. The spacecraft's TV camera shows the surface sampler at work in a 6-inch deep trench. (Fig. 2–4). From landing gear strain gages and surface sampler data, the surface bearing strength was calculated to be 3 to 8 pounds per square inch, very similar to that measured by Surveyor I (*16th Semiannual Report*, p. 75).

Surveyor D, scheduled to be launched this summer, will carry a payload identical to that of Surveyor III. But instead of a surface sampler, the next two Surveyors will carry an alpha-scatter instrument to measure the relative abundance of chemical elements in the lunar surface along with the TV and other instruments of Surveyors III and IV. The seventh and last Surveyor will carry an alpha-scatter instrument, a surface sampler, a television camera, and the other standard instruments.

Lunar Orbiter

Lunar Orbiters III and IV were placed in close-in orbits about the moon during the first six months of this year. Each spacecraft (one remains to be launched in this series of 5) carried a moderate- and high-resolution roll film camera, a film processor, and a scanning light beam film readout unit. There were also sensors to measure the micrometeoroid flux and radiation levels in the near lunar environment.

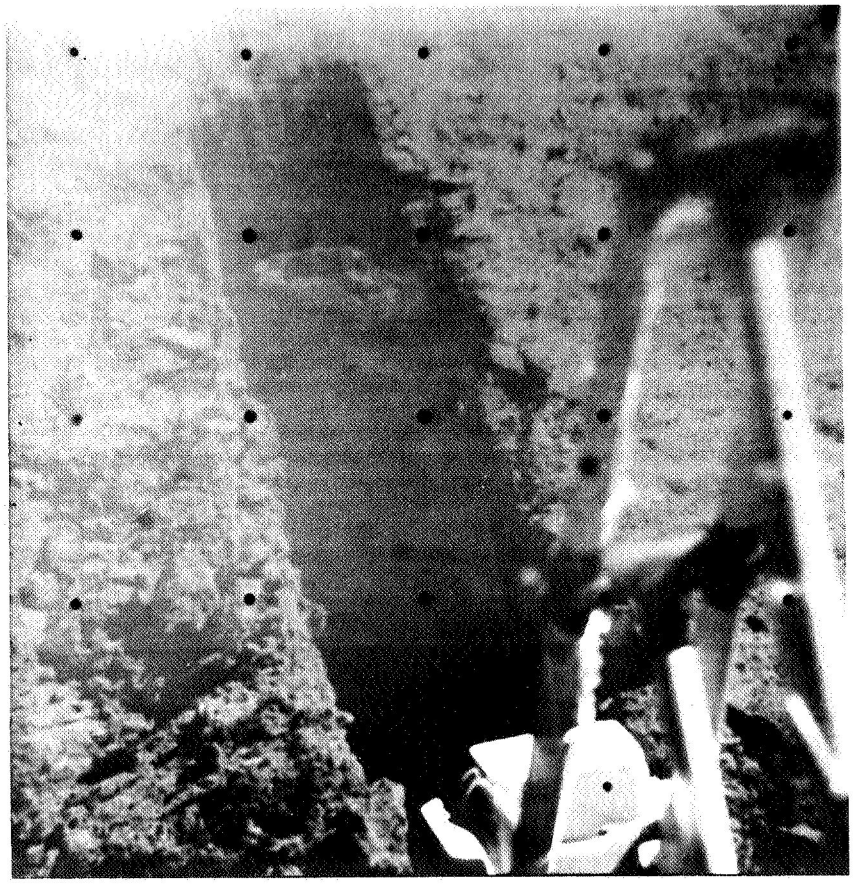


Figure 2–4. Surveyor III digs a trench on the moon.

Lunar Orbiter III's primary objective was to obtain additional detailed photography to confirm the suitability of promising landing sites for Surveyor spacecraft and Project Apollo astronauts identified by Lunar Orbiter I and II pictures. Its secondary objectives were to measure meteoroid flux and high energy radiation in the near lunar environment and gather radio tracking data to add to scientists' knowledge of the moon's gravitational field. Launched on February 4, Lunar Orbiter III photographed 12 primary potential Apollo and Surveyor landing sites and provided pictures of other areas on the front and far sides of the moon. It also achieved the other objectives of its mission.

Lunar Orbiter IV (fig. 2–5) was orbited on May 4 to make a systematic photographic survey of the entire front surface of the moon. The spacecraft has provided detailed pictures of 99 percent of its front

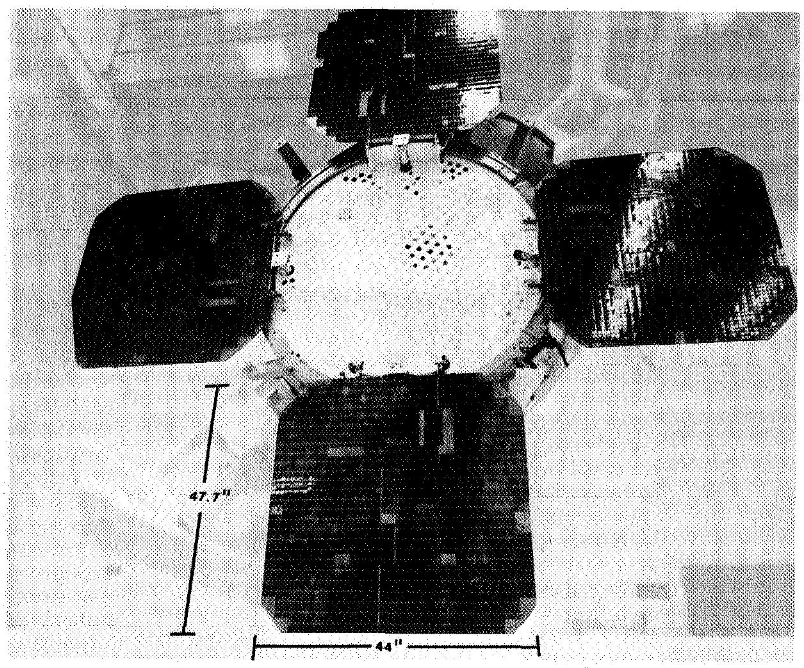


Figure 2–5. Lunar Orbiter IV with solar panels unfolded.

face more than ten times clearer than any ever made from the earth. Other photographs were taken of the moon's hidden side. (To date the four Lunar Orbiters have photographed about 75 percent of this side.)

Lunar Orbiters II, III, and IV continued to orbit the moon. Although functioning normally, they were unable to take more pictures. They are tracked regularly and contribute substantially to equipment checkout and training of personnel of the Manned Space Flight Network. Tracking data from them were being analyzed to provide further information on the lunar gravitational field. Data from their micrometeoroid detectors indicated that micrometeoroid flux in the immediate vicinity of the moon is about the same as that near the earth. Instruments monitoring radiation dose levels near the moon found this radiation to be insignificant, except during major solar flares.

Mariner

Mariner IV telemetry data indicated that the spacecraft was functioning normally. On May 12 when a series of commands was transmitted to update its attitude control system to prepare for joint operation with Mariner V during August and September, the spacecraft responded saisfactorily. Since its launching 31 months ago Mariner IV has traveled over 1.28 billion miles in more than 1.5 revolutions around the sun. As of June 30 it was about 57.5 million miles from the earth and 136 million miles from the sun.

Mariner V was launched on June 14 and injected into a transfer trajectory to Venus (fig. 2–6). Attitude stabilization was achieved

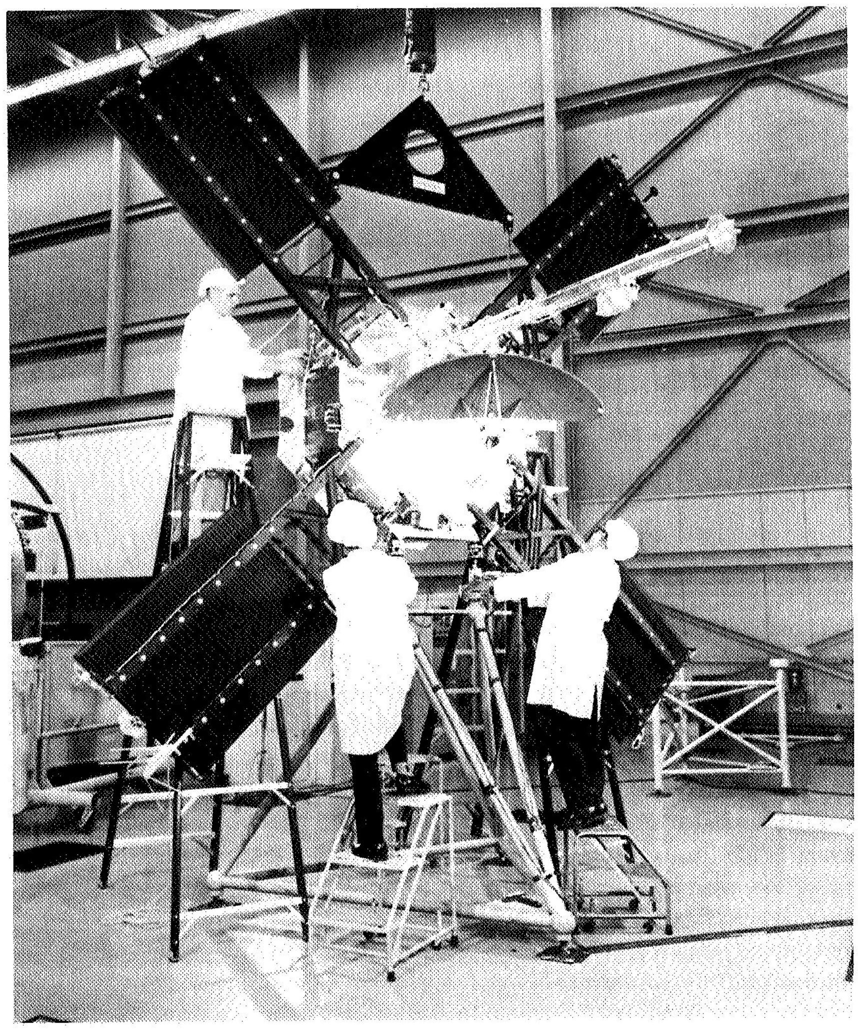


Figure 2–6. The Mariner V spacecraft.

by using the sun and the star Canopus as reference points. Its instruments were turned on and transmitted scientific and spacecraft performance data immediately. All systems were operating as planned. The spacecraft will pass by Venus on October 19. Its closest approach should be about 2,500 miles from the planet's surface—very close to the desired distance.

Two identical Mariner spacecraft will be launched to flyby close to Mars during the August 1–19, 1969 period when the planet is closest to the earth. The spacecraft are based on the Mariner IV design and will provide data on the physical, chemical, and thermal properties of the Martian atmosphere and surface (*16th Semiannual Report*, p. 79). All spacecraft subsystem contractors began preliminary and detail design and preliminary design reviews were held. Prototype hardware was being delivered and was undergoing engineering evaluation.

A communications breakthrough was made in the radio and telemetry subsystems. Through a more efficient spacecraft antenna, modifying the telemetry electronics on board the spacecraft and at the ground receiving stations, and by using the 210-foot Deep Space Network tracking antenna at Goldstone, Calif., the telemetry playback data rate was increased to 16,200 bits a second. The playback data rate of Mariner IV was $33\frac{1}{3}$ bits a second. This progress in communications will contribute to the more advanced missions such as Voyager which will have data rate requirements far beyond those of these Mariner missions.

Voyager

Voyager spacecraft, whose flights to Mars are planned for 1973, will orbit the planet supplying data on its environment and helping to determine suitable landing sites. The spacecraft will also transmit information on the physical and chemical characteristics of the planet's surface and its ability to support life forms.

To assure the best possible use of NASA's resources, the Voyager Project was reorganized during the first six months of this year and a Voyager Interim Project Office set up. The Marshall Space Flight Center was assigned the spacecraft and launch vehicle systems; Langley Research Center, the capsule bus system; Jet Propulsion Laboratory, the surface laboratory, mission operations, and tracking and data systems; and the Kennedy Space Center the launch operations system. Preliminary design work was begun by three contractors on one phase of the spacecraft system, and preliminary design by two other contractors of one phase of the capsule. Also, the preliminary mission description was completed.

Advanced Programs and Technology

Lunar and Planetary Studies

A study to determine the feasibility of a Mariner Venus flyby-probe during 1970 when the planet is nearest to the earth, indicated that the mission could be carried out through reasonable modifications of the Mariner Mars 1969 spacecraft and by adapting the Mars 1971 probe designs. An Atlas-Centaur could be the launch vehicle. However, the mission was not recommended since available resources are needed for the Mariner 1969 and the proposed Mariner 1971 programs.

Another study revealed the need for unmanned surface roving vehicles to explore the moon during Surveyor, Lunar Orbiter, Apollo, and post-Apollo lunar missions.

Little is known of the orbits of comets and asteroids and their motions are not well understood. To study them a spacecraft should pass within about 620 to 6,200 miles of their surface. Recent studies showed that by observing a typical comet from the time it appears until a week before the spacecraft is launched it is possible to flyby as close as about 4,340 miles. Continued observations after its launching can bring the spacecraft even closer to the comet or asteroid being investigated.

Advanced Technical Development and Sterilization Program

The advanced technical development and sterilization program has expanded to cover all phases of spacecraft and capsule system development. For example, significant progress was made in life testing electronic piece parts and materials (primarily plastics) for use in designing a sterilizable planetary capsule. Results of these tests were published. There were also noteworthy advances in developing and testing a series of sterilizable solid propellant rocket motors. A new saturethane propellant was developed, which when loaded into a two-pound motor, successfully fired after six sterilization cycles. This propellant will be test fired next in a 60- to 100-pound rocket motor.

In addition, substantial progress was made in developing the optical planetary approach guidance system for spacecraft, increasing its accuracy. The prime contractor initiated the fabrication of prototype hardware for this development and it should be completed by the fourth quarter of 1968.

A new concept for sterile assembly and testing of capsule hardware would allow last minute repairs of a planetary capsule without disturbing its sterile condition. Detailed design of a full-scale laboratory simulation facility was begun at the Langley Research Center.

Further, improved methods were developed for screening electronic piece parts used in spacecraft assemblies. These methods will provide procurement guidelines for an approved parts list to assure more reliable electronic components for long-life planetary spacecraft.

Bioscience Programs

Exobiology

Studies of organic matter in ancient sediments in the earth have uncovered evidence of amino acids in 3.1 billion-year-old rocks—the oldest amino acids so far known. The discovery suggests that life arose early in earth's history, perhaps within its first billion years.

New techniques were being devised to extract and identify these amino acids and carbohydrates from rocks and fossils in analyzing terrestrial rocks and in future investigations of lunar, planetary, and interplanetary samples returned to the earth. A prototype of a more sensitive micro-amino acid analyzer was being built with automatic reaction steps including acid hydrolyses of samples, and separation of the resulting amino acids from contaminating metal compounds. Also, an instrument combining a gas chromatograph and a compact, relatively simple, low-cost mass spectrometer was being devised for analyzing traces of organic substances.

Various techniques were under development which, when automated and combined, will be used to detect life on extraterrestrial bodies. Automated probes will be first, perhaps, followed later by manned probes. These techniques include the search for certain basic characteristics of living systems—chemistry, metabolism, and growth—requiring the development of breadboard and flight instruments. An example of such a technique would be using the gas chromatograph-mass spectrometer combination for organic analysis, which was being studied and miniaturized for pre-flight testing.

The technique of combining a mass spectrometer and a gas chromatograph was developed to analyze mixtures of organic substances of very high molecular weights. This could be the most sensitive, versatile and accurate system for making organic lunar sample analyses. Other devices for metabolic and growth detection were progressing toward flight systems. Visual imaging systems were also being developed for both macro- and microscopic applications.

Planetary Quarantine

Planetary quarantine and sterilization are planned to control the transfer of life forms from the earth to the moon and the planets. This inevitable contamination of the planets by terrestrial life must be delayed as long as possible in order not to endanger the search for extraterrestrial life on these bodies, or complicate the problem of quarantining returning astronauts. Studies of biological contamination control and dry heat sterilization have further advanced knowledge of clean assembly and sterilization of spacecraft—consistent with maintaining spacecraft reliability. Recent studies indicated that the organism's resistance to dry heat sterilization is directly proportional to the water activity (roughly the relative humidity) of the cell. This finding may be of considerable value in reducing the heat required to sterilize space flight hardware. Other studies on the integration of heat-up and cool-down time in the sterilization cycle suggest that advantage can be taken of the lethality of this portion of the cycle to reduce total sterilization time.

A full-scale mock-up of a planetary landing capsule at the Jet Propulsion Laboratory's new sterilization assembly development laboratory will be used in tests of the feasibility of this heat-up and cool-down lethality method. The laboratory will also attempt to solve engineering problems resulting from the heating of full-scale and complex capsule systems.

Improved methods of reducing the number of microorganisms borne by spacecraft resulted in record low levels in the assembly and decontamination of the Anchored Interplanetary Monitoring Platform "E" satellite (Explorer XXXV). This satellite, launched on July 19, had a final total surface load of only 2200 organisms after assembly—the lowest level of contamination of any spacecraft so far built in this country.

Environmental Biology

Depressed Metabolism.—Bioscientists have announced a breakthrough in the study of depressed metabolism. In their experiments hamsters exposed to 5°C in normal air did not become hypothermic (have abnormally low body temperatures). However, after 5 to 8 hours of exposure to an atmosphere of 80 percent helium and 20 percent oxygen at 5°C, their body temperatures also became 5°C. The hamsters remained hypothermic for 2 to 3 days, but returned to normal when exposed to room temperature. Hypothermic hamsters showed an increased resistance to radiation damage. They survived 1000 roentgens for more than 90 days, while the nonhypothermic, irradiated controls died within a few days after exposure to the same radiation dose.

Intravascular Catheters.—A method was developed for implanting and maintaining intravascular catheters for over 360 days. The procedure allows three major blood vessels and one heart chamber to be catheterized. The implants permit experimenters to observe mechanisms of the body adapting to chronically applied stress without any disturbance to the animal other than that caused by the particular stress being studied.

Clinical Microanalysis.—A self-contained mobile laboratory for clinical microanalysis, *Cosmolab,* was developed for use in areas of inadequate power or water supply. Able to perform a wide range of chemical analyses in a simplified manner, it is portable, compact, complete, and ready for immediate use anywhere.

Acceleration-Radiation; Vibration-Radiation Effects.—Acceleration and radiation combined, as well as vibration and radiation combined, were thought to cause greater cellular and genetic damage together than when acting alone. However, just the opposite happened in experiments with brine shrimp. In these experiments vibration and radiation antagonized each other, producing a lesser effect in combination than either did alone. Acceleration and radiation produced the same results.

Biosatellites

Biosatellite I was launched successfully on December 14, 1966 (*16th Semiannual Report,* p. 83). The first of NASA's recoverable biological satellites for use in determining the effects of the space environment on various life processes, it operated satisfactorily for three days in an orbit with an initial perigee of 159 miles and an apogee of 178 miles. During this time about 50 tasks associated with the biological experiments were carried out automatically as scheduled. The attitude control system maintained near-weightless conditions for over 95 percent of the flight, and capsule temperatures, pressure, and relative humidity were as planned.

The satellite's deorbit sequence began on December 17, as scheduled, but tracking data showed that the capsule continued in orbit. On February 15, 1967, tracking data indicated that the capsule would probably land in the sea east of Australia, but it was not recovered.

Biosatellite I carried 13 experiments designed to study the effects of weightlessness on certain organisms and the effects of weightlessness combined with an onboard radiation source. Non-irradiated experiments were of cell division, cell growth of a developing embryo, the effects on the basic structure of protoplasm, effects on enzymes, and the orientation of leaves, roots, and shoots of various plants to gravity. After recovery all biological material was to be examined for growth, changes in shape, changes in structure of tissue and cells, and for biochemical changes. Experiments had identical control versions on the ground, subjected to conditions close to those of the experiments aboard the satellite (except for weightlessness). Radiation experiments had non-irradiated replicas aboard the spacecraft to function as "controls," enabling experimenters to determine the effects of weightlessness only.

Necessary design changes were incorporated into Biosatellite B, the second recoverable biological satellite, scheduled for launch in September. Spacecraft and experiments for 30-day flights were under development in preparation for the first mission late in 1968. A small pigtailed monkey will be aboard the satellite for studies of the central nervous system, cardiovascular and metabolic functions, and possible skeletal changes due to weightlessness. Equipment for the monkey was being tested at the University of California (Los Angeles), while the spacecraft systems were being tested by the contractor. The 21-day Biosatellite—to conduct investigations of 24-hour biological rhythms and studies of weightlessness on rats, plants, and human cells—was scheduled for a first flight late in 1969.

Behavioral Biology

Space biologists have obtained further information on the control of circadian rhythms in a wide range of organisms, in various physiological systems, and under a variety of environmental stimuli. In experiments at the Max-Planck Institute for Behavioral Physiology, a weak electromagnetic field was found to shorten the daily rhythm, and to maintain synchronization between activity and other rhythms of the body. Techniques for analyzing data developed at the University of Minnesota, demonstrated that exposures to relatively short space flights as experienced by Project Gemini astronauts and Vostok cosmonauts did not disrupt the basic daily rhythms of the heart.

Bioscientists also learned more about the role of circadian rhythms in arousing animals from hibernation. In addition, advances in molecular biochemistry have begun to provide a new theoretical basis to guide experimenters in their search for the origins of circadian phenomena.

Physical Biology

Research on the processes of evolution begins with the simpler protein molecules assumed to be formed early in the earth's evolution and proceeds to the complex proteins found in organisms living today. Protein, made up primarily of amino acids, contain nitrogen that is a necessary part of the cells of plants and animals. Through comparing two proteins by matching the sequential arrangement of their amino acids, bioscientists have developed a new technique to study these evolutionary processes. Since there are 20 amino acids, there is about a 5 percent chance that two of them in any two different sequences will be the same.

Ferrodoxin, a protein found in spinach, was compared with a corresponding protein in an anaerobic bacteria (one which lives in an oxygen-free atmosphere only). Only half as large, the bacterial protein has functions similar to those of the spinach protein. And the sequences of arrangement of the amino acid in both protein molecules were found to be identical in major regions but not identical in a few other regions. The difference between the two sequences was due to the process of evolution taking place at the molecular level.

The anaerobic bacteria may be a living remnant of the era before the atmosphere of the earth contained oxygen. *Ferrodoxin* could be one of the oldest "chemical fossils," its composition furnishing a clue to the chemistry of life existing long before there were green plants.

Bio-information Retrieval.—A basic problem in retrieving any bio-information from spacecraft during flights to Mars or to the other planets is the limit to the bits of information (about 10^9) able to be telemetered by the spacecraft. This limitation imposes severe restrictions on designing systems for detecting extraterrestrial life. To help overcome this deficiency, a new technique was developed which would apply methods used with the electron microscope to store information for direct retrieval. The electron microscope uses ultraminiaturized matter imprinted directly onto reels of very thin special photographic film measuring only 10 by 10 microns under the microscope. (A micron is a millionth of a meter.) When enlarged photographically 12,000 times this condensed information fits onto an 8- by 10-inch print.

Apollo Lunar Surface Experiments Package

The Apollo Lunar Surface Experiments Package, ALSEP, is part of the program of experiments to be conducted and activated on the lunar surface by astronauts (*16th Semiannual Report,* p. 98). ALSEP will be carried to the moon aboard the Apollo Lunar Module. After deployment it will provide data on the magnetic fields of the moon; the lunar interior, thickness, and density; the charged particle environment of the moon; and the pressure and composition of ions in the atmosphere.

This geophysical station will transmit scientific information to the earth for a year. It consists of 8 experiments (4 or 5 to be carried on each Apollo flight); a central station to receive commands and transmit data to the earth; and the SNAP-27 Radioisotope Thermoelectric Generator to provide the nuclear power to operate it. Three of these experiments packages will operate simultaneously at different lunar locations.

Significant progress was made in the ALSEP program during the first six months of this year. Noteworthy were:

- Testing of engineering and prototype models, about as specified.
- Final design by the Atomic Energy Commission of the SNAP-27 fuel cask and AEC's operation of this radioisotope thermoelectric generator above its guaranteed power estimate of 56 watts.
- Exceptional performance of the central station during tests.
- Development of all experiments on schedule except one or two scientific instruments.
- Expansion of systems testing to meet the revised Apollo schedule.

Light and Medium Launch Vehicles

NASA used Scout, Delta, Agena, and Atlas-Centaur launch vehicles for its unmanned space missions during the first six months of 1967.

Scout

Six Scout vehicles were launched and four missions successfully completed. A launching for the Defense Department was unsuccessful on January 31 when the vehicle's fourth-stage motor failed. After investigation and re-design, a new fourth-stage motor nozzle was qualified and the flights resumed satisfactorily. On April 13, April 26, May 5, and May 18 Scout successfully launched two missions for the Defense Department and orbited the San Marco B and UK-E satellites. On May 29, a Scout was unsuccessful in launching the ESRO II satellite.

The launch of the San Marco satellite from the Italian launch range off the coast of Kenya, Africa marked the successful completion of the second phase (p. 43) of the San Marco program.

Delta

Delta launched six missions boosting the vehicle's record to 16 consecutive successes—overall 45 successes in 49 attempts.

Intelsat II-B and Intelsat II-C were orbited for the Communications Satellite Corporation on January 11 and March 22. The TOS-B weather satellite was launched on January 26; the OSO-E scientific satellite, March 8. Another weather satellite (TOS-C) was launched on April 20; another scientific satellite (IMP-F) on May 24.

Agena

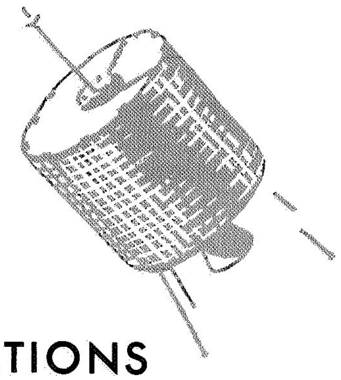
Agena was successful in three of its four launch attempts. Lunar Orbiters III and IV were launched in February and May by Atlas-

Agena vehicles. The Atlas-Agena placed the spacecraft on the planned lunar trajectories and all vehicle test objectives were achieved. The second Applications Technology Satellite (ATS-II) was launched in April, also by an Atlas-Agena. The early part of the flight was a success. However, Agena second burn did not occur as programmed, and the spacecraft remained in a highly elliptical orbit rather than the planned circular one (ch. 3). Another Atlas-Agena, in June, launched Mariner V to flyby Venus. All vehicle objectives were realized in this flight—considered by the spacecraft tracking networks to be the most accurate injection ever performed by Atlas-Agena.

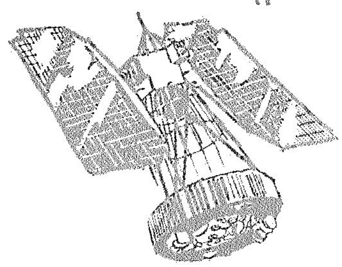
Launch Vehicle Status.—Atlas-Agena, currently scheduled for phaseout early in 1968, will be used in three more missions—a Lunar Orbiter, an Applications Technology Satellite, and an Orbiting Geophysical Observatory. Preparations were on schedule for these three launches. Thor-Agena was being readied for a Polar Orbiting Geophysical Observatory and a Nimbus launch.

Atlas-Centaur

The third operational flight of the Atlas-Centaur was successfully carried out on April 17 when it boosted Surveyor III into the desired lunar transfer trajectory. The spacecraft soft landed on the moon and successfully completed its mission. Three more Surveyors will be launched in 1967 with this vehicle. The Atlas booster will be up-rated for the fifth Surveyor and subsequent flights to increase its payload capability by about 300 pounds.



3 SPACE APPLICATIONS



Promising even more substantial future accomplishments by similar spacecraft, the first Applications Technology Satellite supplied data on tropical cloud motions and air circulations, took part in voice communications between aircraft and ground stations, and helped telecast a program by 17 nations reaching an estimated 14 percent of the world's population. Also noteworthy were the performances of weather satellites providing thousands of good pictures to forecasters and meteorologists in many countries, and communications satellites over the Atlantic and Pacific Oceans supplying commercial service. Geodetic satellites were helping earth-based observers locate continents, islands, and other geographic points in establishing a unified global control reference system. In addition, various types of instrumented aircraft flew over test sites gathering earth resources data leading to the development of satellites able to make more comprehensive earth resources surveys.

Meteorological Satellites

ESSA and TIROS

To assure continuous Automatic Picture Transmission (APT) coverage around the world, ESSA IV was launched for the Environmental Science Services Administration, ESSA, on January 26. NASA turned the weather satellite over to that Agency about two weeks after launch and the APT system was providing excellent quality pictures. (The National Operational Meteorological Satellite system, inaugurated by ESSA I, completed its first year of successful operation in February.) At ESSA's request, NASA launched ESSA V—the second TIROS Operational Satellite with an Advanced Vidicon Camera system—on April 20. This spacecraft was turned over to ESSA's National Environmental Satellite Center on May 8.

The cameras aboard ESSA V furnished excellent pictures. Its low resolution infrared radiation monitor measured the short-wave radiation reflected by the earth and its atmosphere, as well as the long-wave radiation emitted by the earth. These measurements will be used to chart the global heat balance. Fig. 3–1 (p. 60) shows computerized analyses performed by ESSA III using Advanced Vidicon Camera photographs taken by operational weather satellites.

NASA signed the hardware contract for the TIROS M research and development spacecraft (*16th Semiannual Report,* p. 103) in April. The contractor is fabricating the major subsystems. The contract calls for delivery of the flight model spacecraft in May 1969. Meeting this date will assure that the next generation of ESSA spacecraft (Improved TOS) will be ready to be incorporated into the operational meteorological system by 1970.

TIROS VII, VIII, IX, and X continued to provide meteorologically usable pictures. TIROS VII, which completed 4 years of successful operation June 19, has provided over 121,000 cloud photographs.

Nimbus

Nimbus II successfully completed a year in orbit on May 15 (table 3–1), greatly exceeding its design expectations. Stabilization of the satellite remains within $\pm 1°$ in about all three axes, and its control gas supply should be adequate for five more years. The Automatic Picture Transmission (APT) system was still transmitting good quality photographs to ground stations around the world. The APT system has operated for over 4,172 hours. Figures 3–2 and 3–3—APT pictures taken

Table 3–1. Nimbus II experimental results on completing orbit 4860, May 15, 1967

Sensor	Status	Cumulative
Automatic Picture Transmission System	Operating	4,172 hours
Advanced Vidicon Camera System	Partially Inoperative	113,233 frames
High Resolution Infrared Radiometer	Inoperative	1,576 hrs., 54 min.
Direct Readout High Resolution Infrared Radiometer.	do	1,336 hrs., 3 min.
Medium Resolution Infrared Radiometer	do	1,312 hrs., 32 min.

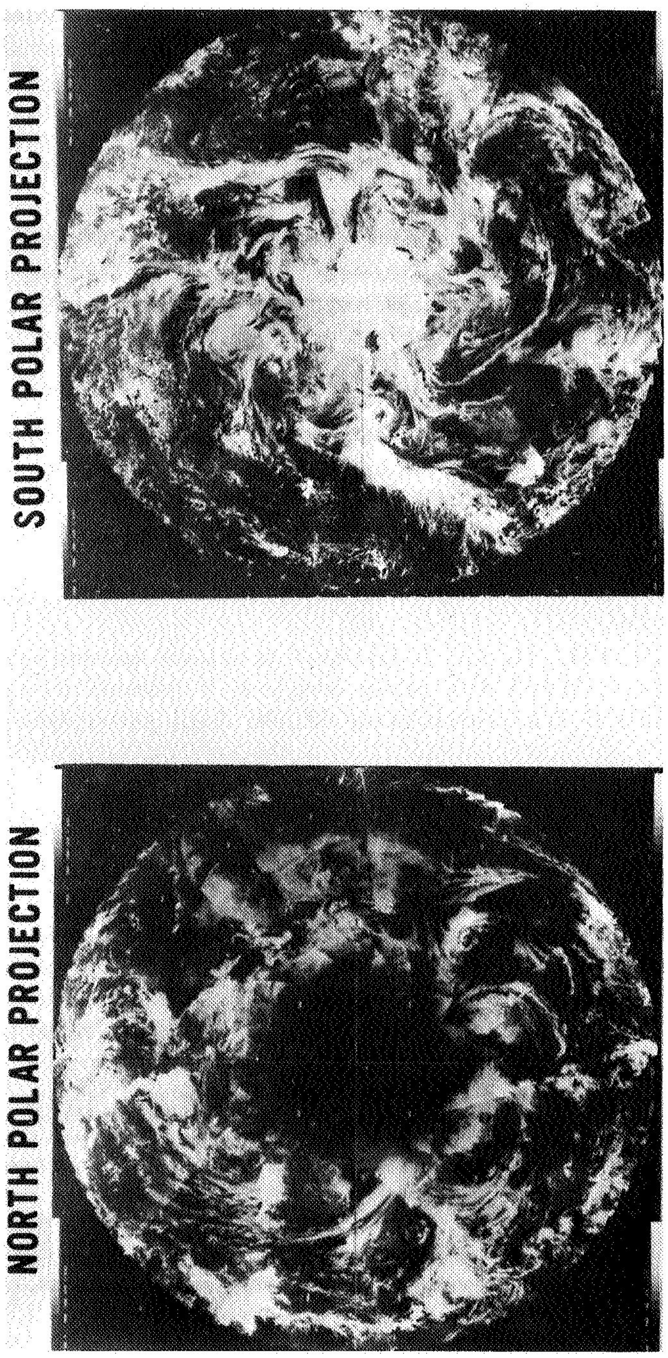


Figure 3–1. ESSA III's 24-hour world cloud coverage (January 6, 1967).

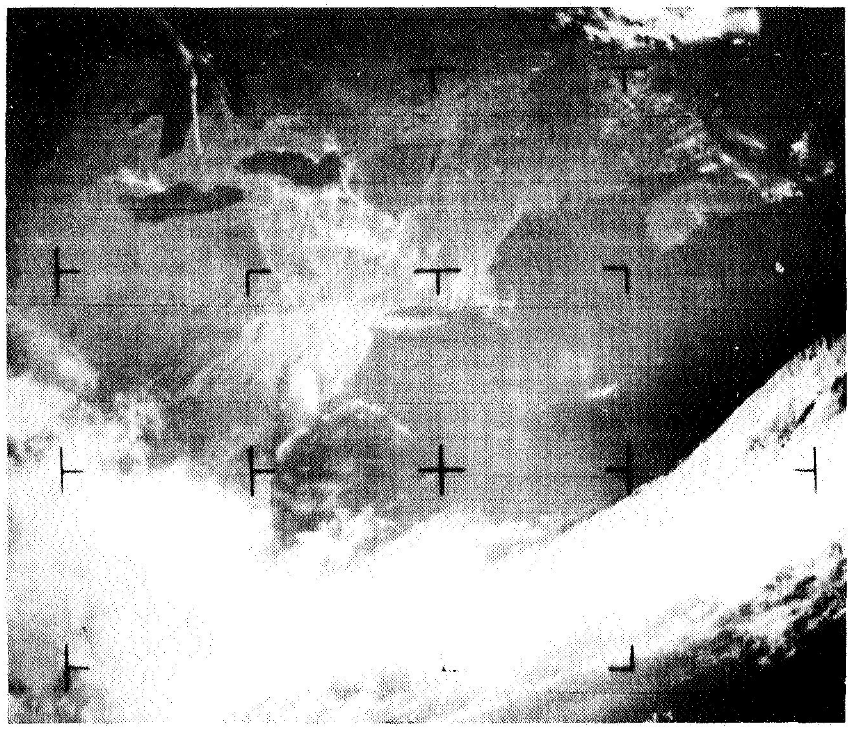


Figure 3–2. Nimbus II APT photograph of the Great Lakes (July 16, 1966).

about a year apart—demonstrate the performance of this system after the first year of operation. The Advanced Vidicon Camera system (AVCS) was operative in real time only to NASA's ground stations in North Carolina and Alaska.

Nimbus B continued to be on schedule for its launching early in 1968. All flight experiments were delivered except the Infrared Interferometer Spectrometer and the Satellite Infrared Spectrometer. Integration of flight spacecraft and sensor subsystems was initiated.

All Nimbus D contracts for major spacecraft subsystems and experiments were awarded except contracts for the Interrogation, Recording, and Location Subsystem; Image-Dissector Camera System; Monitor of Ultraviolet Solar Energy, and the power supply.

Meteorological Sounding Rockets

Sounding rockets were used to obtain meteorological measurements above altitudes reached by sounding balloons and below those of satellites. Acoustic grenades, pitot-static tubes, and light-reflecting or luminous-vapor experiments were employed.

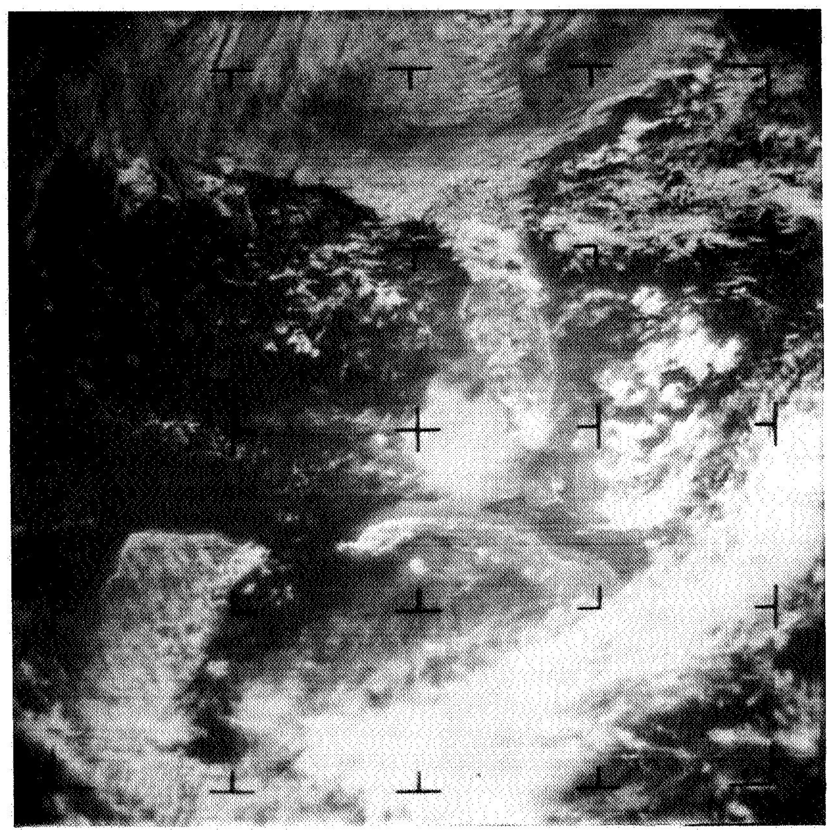


Figure 3–3. APT picture of the U.S. and Cuba from Nimbus II (June 7, 1967).

Six grenade experiments were launched from Pt. Barrow, Alaska, and 6 pitot-static tube, and 6 chemical release experiments from Ft. Churchhill, Canada. These launchings, on January 31 and February 1, should supply data on the wavelike temperature structure at high latitudes during the winter, auroral heating, and the source of midwinter heating at an altitude of 50 miles. At the same time two grenade experiments were launched at Wallops Station, Virginia, for circulation analyses in conjunction with these temperature structure and heating studies. Twelve single grenade experiments were launched from Pt. Barrow and Wallops Station between March 31 and May 15 to study the spring decay of the westerly flow that forms the winter polar vortex, and the early phases of the easterly flow of the summer months. On June 21 three grenade experiments were successfully launched from Natal, Brazil, during a 24-hour period to obtain data for studies of the tropical mesosphere (about 250 miles above the earth).

Meteorological Sounding Rocket System.—An inexpensive meteorological sounding rocket system for reliable routine launches, range support, research, and network operations is needed for adequate observational coverage of the atmosphere above 20 miles. Parallel coordinated approaches were underway to develop the launch vehicle and the payload for this system. NASA and the U.S. Army continued this cooperative program to develop self-consuming rocket cases to reduce or eliminate the falling mass hazard.

In this part of the program 67 rockets were launched for development and test work and range support operations, and full data were obtained in 75 percent of the launches.

Field Experiment Support.—By sharing the costs of mutually beneficial research activities with other nations, NASA obtains useful meteorological data. For example, the Agency has set up a cooperative program for testing and cross-calibrating sounding rockets, payloads, and ground equipment developed by other nations with similar U.S. equipment (ch. 7).

Communications Satellites

Relay and Telstar

Relay II and Telstar II continued to function in orbit, although no communications experiments were conducted with them. Relay was used to gather data on radiation and radiation effects. (Telstar II was launched in May 1963; Relay II in January 1964).

Syncom

The Department of Defense used Syncom II and III for operational communications in the Indian and Pacific Ocean areas. Syncom II has orbited the earth for about four years and oscillates around 73° East longitude. Syncom III—launched in August of 1964—was drifting slowly westward from 160° East longitude.

Intelsat

On January 11 NASA launched Intelsat II-B for the Communications Satellite Corporation (Comsat). The satellite was injected into a synchronous orbit over the Pacific Ocean, to enter into commercial service on January 27. Intelsat II-C was orbited by NASA for Comsat on March 22. Placed into a synchronous orbit over the Atlantic, this Intelsat provided commercial service to countries bordering the Atlantic Basin. As part of this service, the two communications satellites will support the Apollo lunar landing program.

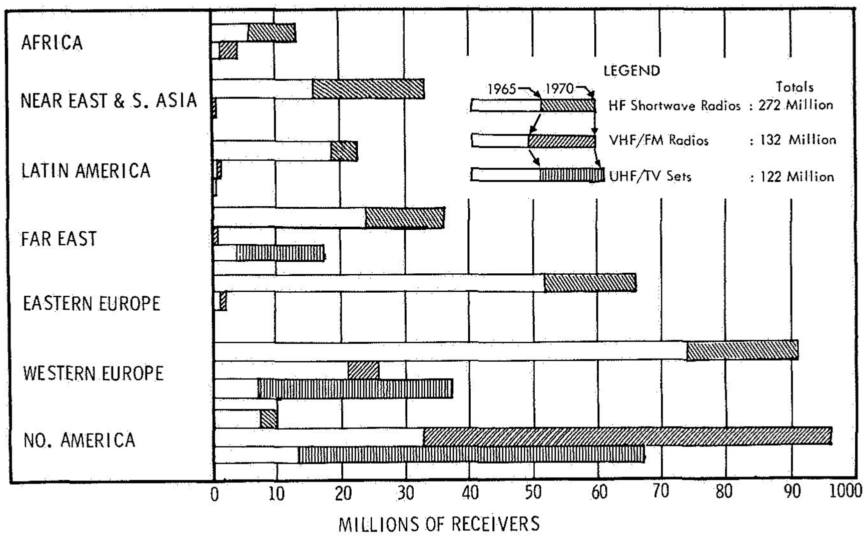


Figure 3–4. Radios and television sets in the world (1965–70).

Echo

The Echo I and II passive communications satellites were used for geodetic and air drag studies only. These two spheres were launched in 1960 and 1964, respectively.

Supporting Research and Technology

Studies were completed of four types of active communications satellites suitable for voice broadcasts directly to conventional home receivers. These studies point up the feasibility of broadcasting to short-wave radios, FM receivers, and the sound section of UHF television sets. The distribution of radio and TV receivers in various parts of the world (fig. 3–4) was studied to determine the cost effectiveness of various types of spacecraft for these broadcasts.

In addition, several studies were conducted to investigate the possibility of deploying large reflecting structures in space (such as the Echo I and II spheres) for use as passive communications satellites or as large aperture antennas.

Navigation-Traffic Control Satellites

The Federal Aviation Administration and the Coast Guard, Department of Transportation, have asked to take part in NASA's Omega Position Location Experiment (OPLE). Being developed for an Appli-

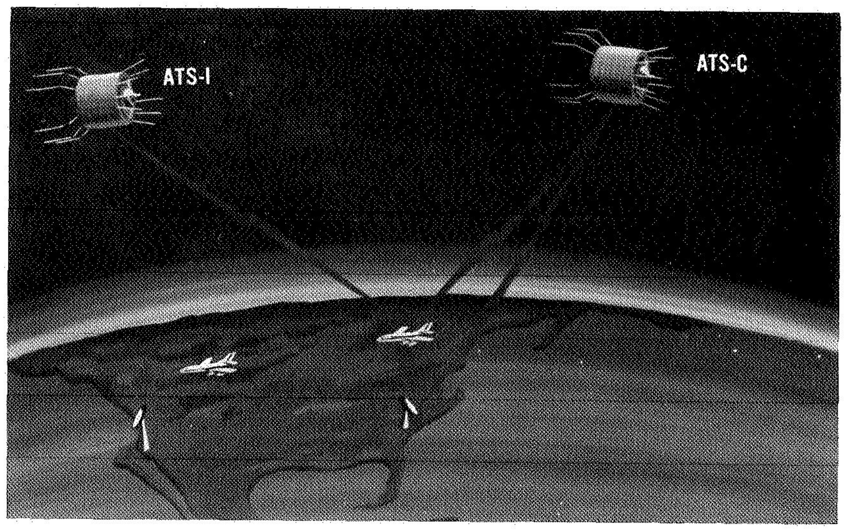


Figure 3–5. Sketch of the potential navigation-traffic control experiment.

cations Technology Satellite mission (ATS-C), this experiment will provide engineering information on the possible use of the OPLE system for aircraft and ship navigation and traffic control. Both of these agencies will conduct tests with their own aircraft and ships using OPLE and ATS-C. The FAA has also requested that NASA perform a navigation experiment using range signals between an aircraft and the ATS-I and -C geostationary satellites (fig. 3–5). These tests will provide experimental data on the dual-range VHF satellite navigation technique extensively studied by NASA and private industry.

Twelve aerospace companies responded to a request for proposal for an 8-month advanced mission study of a Navigation and Traffic Control Satellite. A contractor should be selected early in fiscal year 1968.

Applications Technology Satellites

ATS-I Telecasts

On June 25 Applications Technology Satellite I (ATS-I) linked Japan and Australia with the United States in the two-hour "Our World" telecast. Seventeen nations took part in this telecast which also used three Intelsat satellites to reach a potential 500 million viewers on five continents—14 percent of the world's population. This satellite—launched on December 6, 1966—carried an 8-hour program on June 6 from Montreal to the Australian TV network marking Australian day at Expo '67.

ATS-I Experiments

Three-station, multiple-access voice communications tests were conducted successfully with ATS-I during its first six months in orbit. Over 2,000 spin scan meteorological pictures were taken by the spacecraft which also supported the Line Island tropical meteorological experiment in the Pacific Ocean with two weeks of full coverage amounting to more than 50 pictures daily. Part of this Line Island supporting data was transmitted back to control headquarters via WEFAX (Weather Facsimile Transmission) using the ATS-I VHF transponder. During the report period WEFAX operated for 272 hours and transmitted 3,084 successful pictures.

Use of this ATS-I VHF transponder to test air-ground communications via satellite continued as Japan Air Lines joined the airlines participating in this Applications Technology Satellite experiment (table 3–2). The same VHF transponder was used in 27 hours of transmissions conducted between the ATS ground station at Mojave, Calif., and a station aboard the U.S. Coast Guard Cutter *Klamath* which was located half way between the West Coast and Hawaii.

ATS-II

ATS-II, the first three-axis gravity gradient stabilized spacecraft, was launched by an Atlas-Agena on April 6. The Agena stage failed to ignite for a second burn causing the satellite to remain in a highly elliptical orbit (apogee 6,700 miles, perigee 120 miles) rather than the planned 6,900-mile circular one. All spacecraft systems functioned properly, but many of the data being received were of limited value due to the satellite's instability caused by this unplanned orbit. No data on gravity gradient stabilization performance were obtained.

Table 3–2. ATS-I transmissions in aircraft tests (December 1966—June 1967)

Aircraft	Hours of transmission
Pan American Airways	71
Qantas Airways	12
United Air Lines	46
American Airlines	21
Eastern Airlines	2
Avianca Airlines	3
Japan Air Lines	29
Federal Aviation Administration	101
Air Force	16

Geodetic Satellites

PAGEOS

PAGEOS-I, after completing a year of successful operation on June 23, showed no appreciable deterioration. A 100-foot balloon of the Echo-I type, PAGEOS reflects sunlight providing an orbiting point source of light which was being photographed by earth-based observers to help locate continents, land masses, islands, and other geographic points for a unified global control reference system. The satellite was being observed by about 40 stations around the world.

GEOS

On January 14, GEOS-I (Explorer XXIX) lost its telemetry becoming optically inactive. On February 8 the range transponder failed, reducing the spacecraft's value as a geodetic instrument, but its passive laser cubes and several of the Doppler beacons continued to function.

The GEOS-B launching was planned for no later than the first quarter of 1968. A backup satellite was scheduled to be orbited within 4 to 5 months after this launch if needed.

Table 3–3 provides selected information on stations taking part in the GEOS and PAGEOS projects of the National Geodetic Satellite Program. The program involves NASA and the Departments of Commerce and Defense, with the Smithsonian Astrophysical Observatory, Ohio State University, and the University of California (Los Angeles) as participants.

Table 3–3. Participation in the GEOS-I and PAGEOS projects

Network	Participating sites (total 80)	Observation instrumentation
NASA Space Tracking and Data Acquisition Network.	9	MOTS-40 camera
	1	Laser
Smithsonian Astrophysical Observatory	20	Baker-Nunn and Geodetic 36 cameras
	1	Laser
U.S. Coast and Geodetic Survey, U.S. Army Map Service.	24	BC-4 camera
U.S. Navy	22	Doppler beacon
France	3	Laser

Earth Resources Satellites

Partly in response to an expressed need by such agencies as the Departments of Interior and Agriculture for a small satellite able to make earth resources studies, Goddard Space Flight Center has begun to investigate various basic concepts leading to the development of such a spacecraft. The satellite would carry two types of instruments, one able to transmit images in three spectral bands simultaneously and the other to relay data. It would be designed to operate for a year in a sun-synchronous orbit at altitudes of 300 to 500 miles.

Potential applications for the first of these Earth Resources Satellites (ERS-A and ERS-B) include—

- Making photographic image maps of the world, and land-use maps of the U.S. for classification of broad soil features such as drainage.
- Preparing agricultural maps of this country to develop techniques for monitoring crop health and identifying broad soil features.
- Relaying information gathered by remote site data collection stations such as moored buoys.
- Observing natural disasters like floods and earthquakes.

Experiments for Apollo Applications Program

Considerable progress was made in determining space applications experiments for the Apollo Applications Program. The mutually complementary experiments being studied may help scientists decide what natural and cultural resources data could best be acquired by astronauts from space. At the Manned Spacecraft Center extensive descriptions were prepared of the proposed instruments and what was needed to support them (for example, power, cooling and controls).

Airborne Data Acquisition

A number of airborne electronic and electro-optical remote sensors were supplying geoscientists with earth resources data about certain areas. Remote sensor data were being correlated with actual conditions in the areas, and agricultural, geologic, and other features were being interpreted by means of the data.

Several instrumented aircraft were used to acquire these data. Among them were a NASA Convair 240A for altitudes up to 20,000 feet and a NASA Lockheed Electra P3A for up to 40,000 feet. They carried such instruments as infrared imagers, microwave radiometers, radar, and special cameras (fig. 3–6). Aircraft belonging to other agencies and to private industry were also gathering earth resources data on a part-time

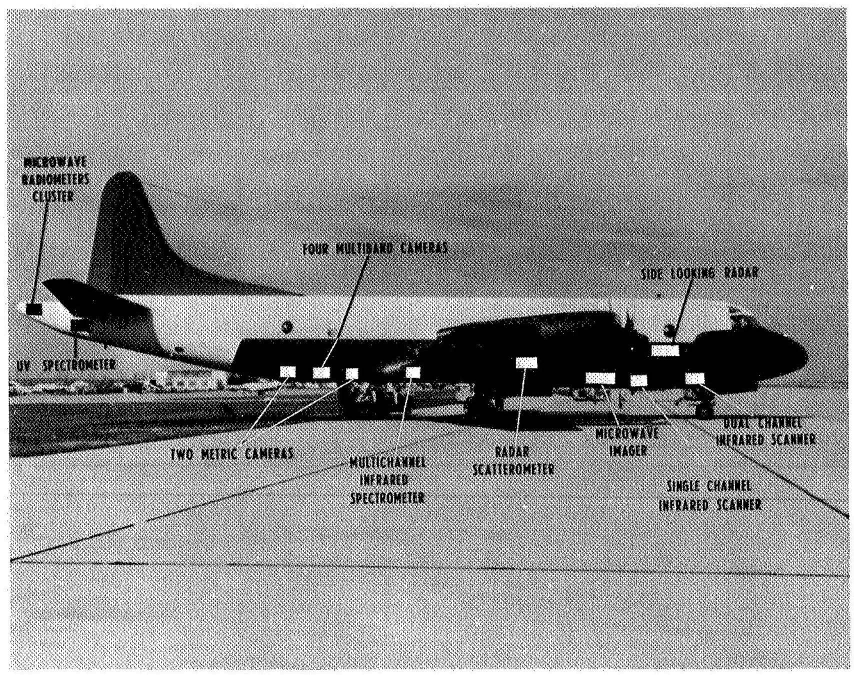


Figure 3–6. Instruments carried by an earth resources survey aircraft.

basis. A data processing and distributing unit was set up at the Manned Spacecraft Center to handle the research data generated by these aircraft, by ground sensors, and, in the future, that to be supplied by spaceborne sensors. A number of different data formats (film, paper, tapes, and charts) provide records presenting the data in various ways, such as in digital, analogue, and alphanumeric form.

Earth Resources Data From Space

An example of the invaluable earth resources data obtained from space is shown by this picture of the Columbia River Basin in the Pacific Northwest transmitted by the Advanced Vidicon Camera system of Nimbus II (fig. 3–7). This picture furnished evidence to substantiate the theory that the Columbia River was blocked by an ice sheet at one time and was forced to drain across the scablands of the eastern part of the State of Washington. The ancient stream channels show clearly where the light-colored soil has eroded away to reveal darker basalt bedrock.

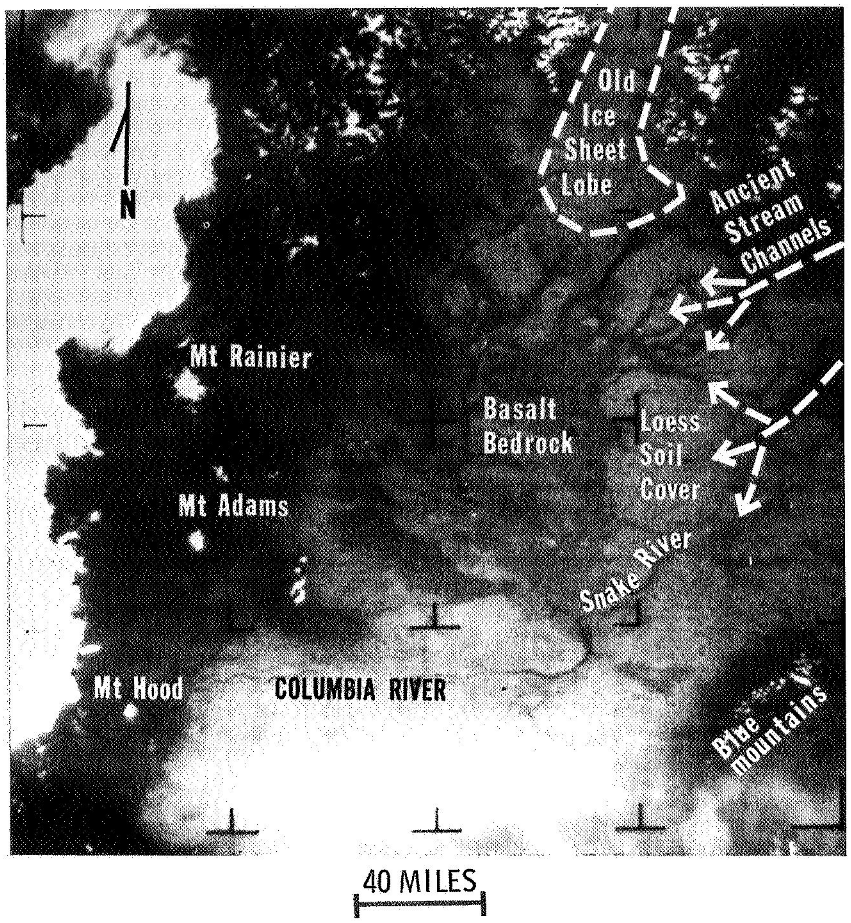


Figure 3–7. Nimbus II earth resources data on the Columbia River Basin.

Also, a TIROS IX picture of Finland and Norway (fig. 3–8) revealed two geologic faults, leading to a better understanding of the major fault systems in northern Norway. These faults were found to be associated with mineral occurrences elsewhere in Scandinavia.

Fisheries and Oil Research

Results of research on detecting gases and vapors by optical remote sensing methods indicate that these techniques might be used to detect and distinguish between fish and mineral oil slicks on the ocean surface.

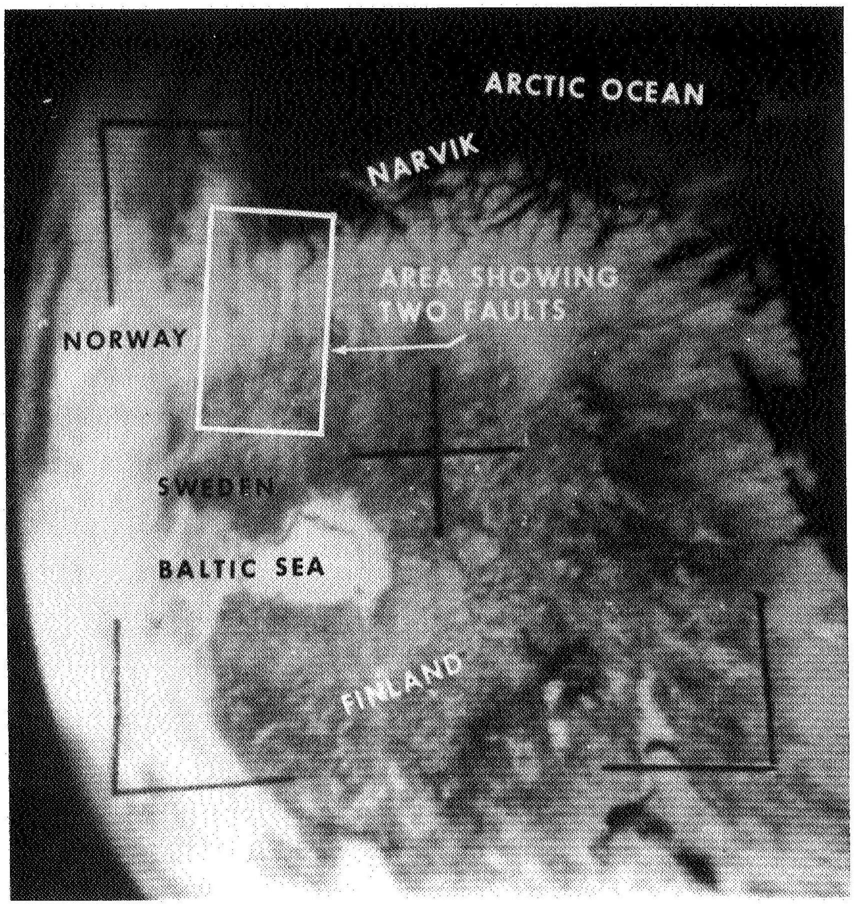


Figure 3–8. TIROS IX revealed unknown geologic faults in northern Norway.

This could be of value to commercial fishing operations in spotting schools of feeding fish. A specialized multiband camera operating in the ultraviolet might be used to identify various types of oil slicks during daylight hours and to produce high resolution imagery indicating their location.

Infrared Emissions Identify Rocks

Techniques were developed which use infrared spectra emitted by rocks to identify the types of rocks making these emissions. Fig. 3–9, p. 72, shows four different rock types in the Mono Lake area in California clearly defined by this method.

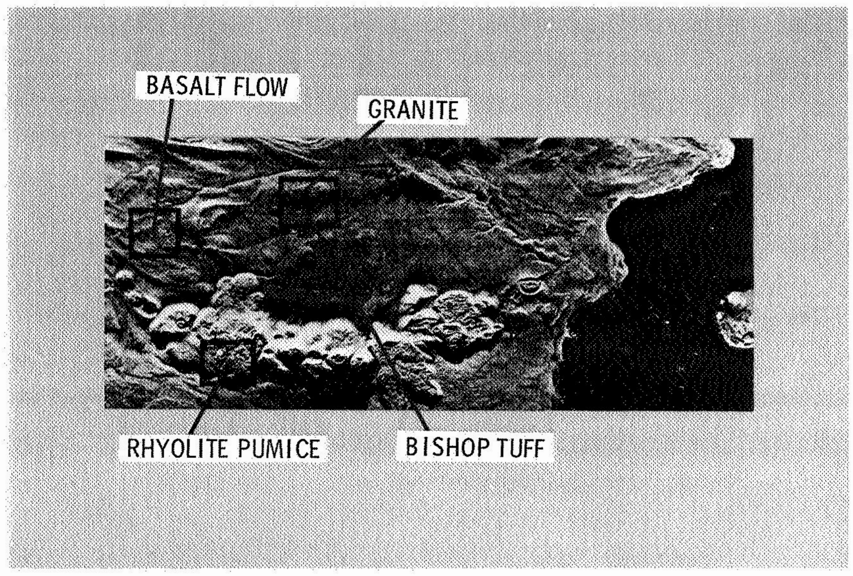
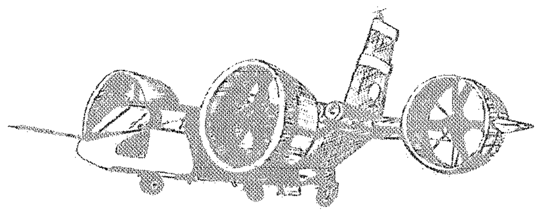


Figure 3–9. Rocks identified by their infrared emissions.

4

ADVANCED RESEARCH AND TECHNOLOGY



The eight parts into which the program of the Office of Advanced Research and Technology is divided, and which are discussed in this and the following chapter, are the source of the advanced technology for aeronautics and space. In addition, they provide the basis for future advances in these fields, and they make a significant contribution to the scientific and technological strength of the Nation.

Space Vehicles Program

Space Radiation Shielding

A space radiation shield verification technique—the gamma probe—which eliminates the need for large costly accelerator facilities, was developed by OART for use in manned programs. The gamma probe system involves scanning the vehicle with a gamma ray source and using the correlation between the penetration of gamma rays and of protons to verify shielding effectiveness. A system was fabricated and applied to an Apollo spacecraft; (fig. 4–1) good agreement between probe dose determinations and those calculated analytically indicated that the system was adequate and that it verified the shielding effectiveness of the spacecraft.

Meteoroid Hazard

During February, a ¾-gram pure iron simulated meteor fired down through the atmosphere at approximately 56,000 ft/sec provided sufficient data to establish the luminous efficiency of pure iron in the en-

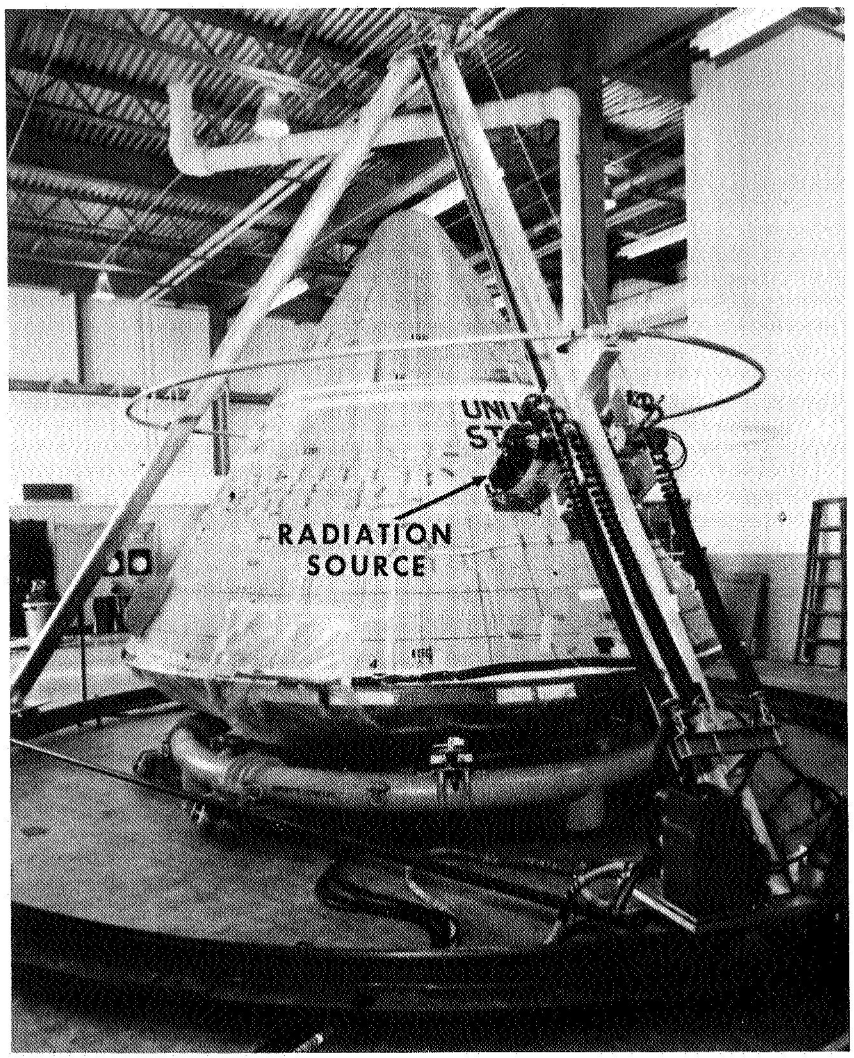


Figure 4–1a. Using the Gamma Probe in the Apollo spacecraft.

vironment of natural meteors at a velocity about 16,000 ft/sec faster than that of previous simulated meteors. The luminous efficiency data, which were obtained by the Langley Research Center as a part of the meteor simulation project, will serve as the basis for a better understanding of meteor masses.

The three Pegasus satellites launched in 1965 have now been in orbit for from twenty-three to twenty-eight months and have recorded over 1700 meteoroid penetrations. The Pegasus data support the conservative

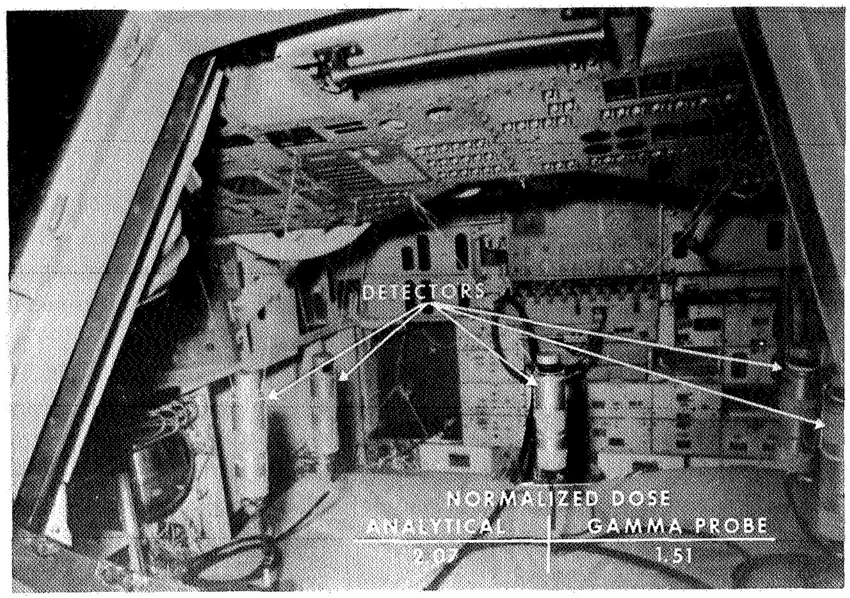


Figure 4–1b. Using the Gamma Probe in the Apollo spacecraft.

nature of the meteoroid environment model used for vehicle designs, and they were used with data from Explorers XVI and XXIII to formulate improved meteoroid design criteria. They have also brought about a downward modification of the Apollo design criteria and a consequent reduction in protection requirements.

Spacecraft Thermal Control

The zinc-oxide-pigmented potassium silicate white coating selected for use on the Apollo radiator, although significantly more stable than other similar coatings in the space environment, is difficult to apply and has a relatively short shelf life. Goddard Space Flight Center developed a coating containing both aluminum oxide and zinc oxide pigments and having similar space stability and high-temperature resistance. However, it is more easily applied and has a longer shelf life than the first Apollo coating. The silicone coating which was used on Lunar Orbiter II and III was also improved. This paint, which contains a protected zinc oxide pigment, was given a longer shelf life by eliminating the need for mixing it immediately before application.

Work continued on heat pipes which can operate in zero gravity without mechanical pumps to transfer warm liquids and vapors in thermal control systems. Efforts concentrated on reducing the temperature gradients between screen-type wicks, which utilize surface tension to do the work, and the external walls of the system. An experiment to test the operation of a heat pipe in orbit was being considered.

Lifting-Body Flight Program

The program includes two NASA vehicles, the M–2 and HL–10 (*16th Semiannual Report,* p. 116) and one Air Force vehicle, the X24A (SV–5P) (fig. 4–2). Its purpose is to investigate landing problems and determine vehicle flying quality characteristics at Mach numbers up to about two.

The M–2 has a total of sixteen unpowered glide flights. On flight 16 (May 10, 1967), however, the vehicle was severely damaged in a landing accident, and the test pilot was injured. The HL–10 vehicle in its one flight exhibited a control deficiency which is being corrected. The Air Force X24A vehicle was nearing completion at the contractor's plant and is expected to have its initial flight test in 1968.

Advanced Gliding Parachutes

Wind-tunnel and flight research on flexible parachute-like gliding wings was intensified in order to develop the technology for potential applications to land-landing systems for spacecraft such as Apollo. Such devices appear to be able to provide controlled terminal descent, soft touchdown with low forward speeds, and the ability to cope with surface winds. Research goals are to develop high reliability of deployment and operation, structural integrity, good controllability, acceptable rough-air characteristics, adequate glide range, low vertical velocity at touch-

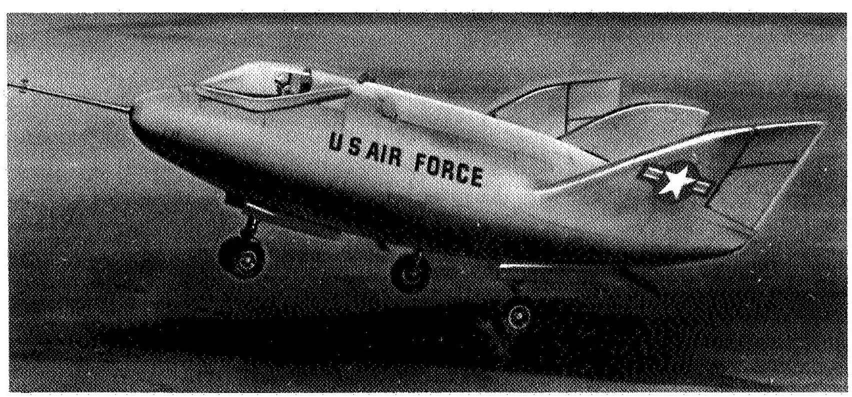


Figure 4–2. The X24A.

down (15 feet per second or less) preferably without a terminal flight path flare maneuver, and low weight and volume requirements for rather severe packing considerations.

The Langley Research Center conducted research on a near-triangular device known as the parawing and a higher aspect ratio device known as the sailwing (fig. 4–3). In addition to extensive wind-tunnel tests, approximately 200 successful helicopter drops were made with a parawing having a 24-foot keel length and a 400-pound suspended payload. The military services and industry have made about 1,000 successful live personnel parawing drops without malfunctions. Plans were being made to flight test 5,000- and 15,000-pound-size parawings. Approximately 170 manned sailwing drops have been completed by industry, and the Manned Spacecraft Center sponsored flight tests of a 90-foot-span sailwing sized for a 5,000-pound payload.

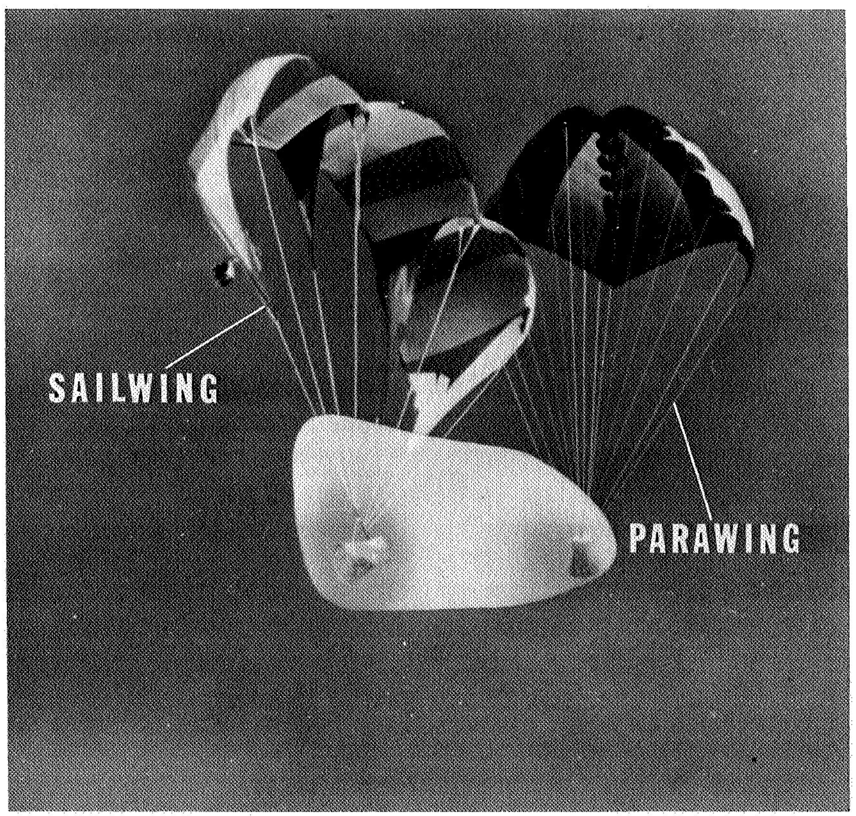


Figure 4–3. Sailwing and Parawing.

Planetary Entry Parachute Program

Langley Research Center continued flight and laboratory research on candidate parachutes for soft landing an instrumented capsule on the surface of Mars (fig. 4–4). Three rocket-launched tests of two candidate parachute types were completed. In a flight test of the cross-type parachute in February, the parachute tore loose during deployment, but the information gained led to a completely successful test of the same type parachute in June. The ring-sail type parachute successfully tested in May provided significant new data on the porosity which should be incorporated in parachutes to operate in the very low-density Martian atmosphere. Additional balloon and rocket-launched tests were continuing. (Fig. 4–5)

High-Frequency Vibration

During the launch phase, space vehicle systems are subjected to a broad spectrum of intense high-frequency vibrations. An evaluation of the state of technology in this area resulted in a decision to increase research emphasis on the critical aspects of high-frequency dynamics

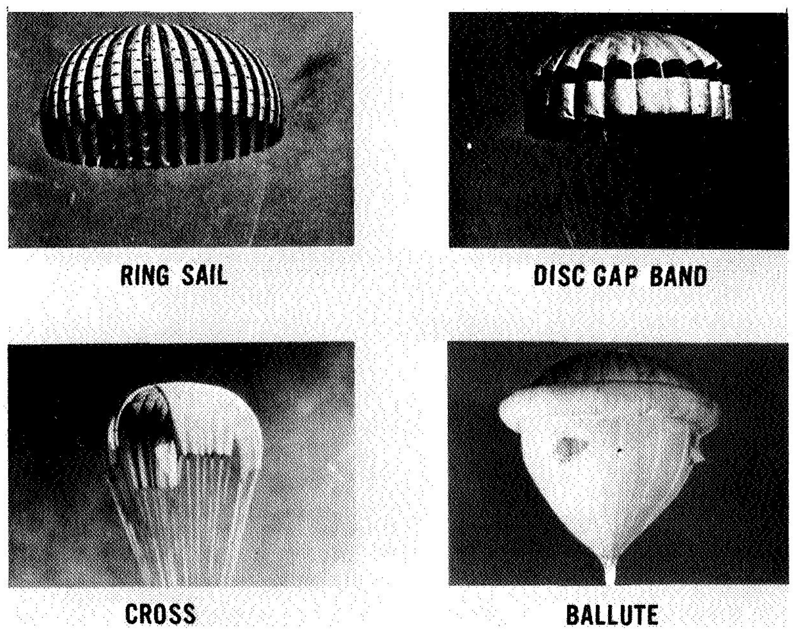


Figure 4–4. Parachutes for unmanned Mars entry and descent.

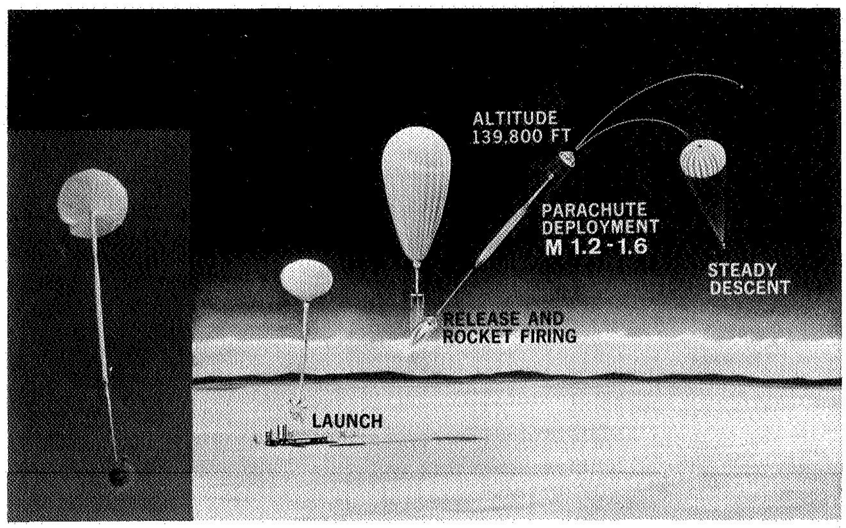


Figure 4–5. Balloon-launched parachute test flight sequence.

relating to engine and aerodynamic noise, transient loads, random analysis, and test techniques.

Structural Analysis Computer Program

As a result of a comprehensive survey of industrial and governmental computer programs used for structural analysis of aerospace systems, the NASA Goddard Space Flight Center was assigned responsibility for obtaining a standardized structural analysis computer program with a common language suitable for use by all NASA Centers, other government agencies, and industry as well. Progress on the contract effort established for the program included the determination that the program will be relatively independent of the type of computer available and will greatly facilitate exchange of structural information among organizations concerned with various components of a system. It was also determined that the program will be able to combine the best features of current programs and permit analysis of larger and more complex structures than has been possible. These features have also given rise to considerable interest in this program outside the aerospace field.

Spacecraft Electronics and Control

Avionics Systems Studies

NASA is applying advanced electronic systems techniques derived from the space program to the solution of problems resulting from the combination of increasingly sophisticated aircraft, the complex National Airspace System, and the need for all-weather operations. Activities included operating a commercial aircraft flying laboratory for all-weather landing systems studies, planning a VTOL automatic take off and landing research program, and carrying on broad-based research on advanced flight control system techniques and advanced display devices.

An advanced supersonic transport avionics research program plan was developed by the Electronics Research Center. The plan will be the basis for research at NASA Centers on SST problems which require new technological information in communications, guidance and navigation, power generation, flight instrumentation and measurement, hazard avoidance, flight control and displays, all-weather landing, and related information processing.

In the general aviation area, a representative aircraft was procured which will be used as a research tool to define flight control and display requirements. Several NASA research centers were working simultaneously on specific problems of navigational displays, control system mechanization, attitude display techniques, and collision avoidance.

Communications and Tracking

The application of waveguide techniques at optical frequencies was investigated successfully by a NASA contractor. The overall objective was to develop single mode optical waveguide and waveguide components for laser systems analogous to present microwave frequency waveguide systems. Of several waveguide configurations investigated for feasibility, the dielectric waveguides seemed to be most satisfactory on the basis of low loss and adaptability to component design. This work is a key element in the development of optical technology for astronomical instrumentation and for high data rate communication systems.

A technique was developed, under a NASA grant, for improved telemetry information coding. Tests indicated that the technique will more than double the rate at which information can be telemetered, or increase the communication distance approximately forty percent. In either case, errors will be essentially zero. The technique, called convolutional encoding and sequential decoding depends on transmitting, in addition to the basic data, specially selected information with which a computer can identify and correct errors in the basic data. Use of the technique will require the addition of a small data encoder in the spacecraft and a subroutine in the tracking-station computer. It may be employed in future spacecraft of the Pioneer series.

Spacecraft Attitude Control

Research on the use of the Control Moment Gyro (CMG) system to provide 3-axis orientation and stabilization of the Apollo Telescope

Mount (ATM) spacecraft (*16th Semiannual Report,* p. 121) continued. Langley Research Center scientists in coordination with the Marshall Space Flight Center ATM engineers established design limitations on some ATM configurations which will enable the spacecraft designers to avoid significant operational problems. Knowledge derived from application of the CMG to the ATM spacecraft will be useful in planning and developing future long-term manned orbiting scientific space stations.

Guidance and Navigation

The MSFC developed an optical (laser) radar for spacecraft rendezvous and docking which offers significant advantages in weight, volume, power, and accuracy over existing microwave rendezvous radars and combines rendezvous and docking capability in one system. A prototype system was ground-tested in a six degree of freedom simulator to evaluate docking dynamics and accuracy. In 200 test runs, the radar guided the spacecraft from a distance of 15 meters to a target vehicle with a maximum radial error at docking of 7.5 cm. This error was further reduced in later simulations to 2.5 cm. Additional ground-to-air tests were planned to evaluate the rendezvous subsystem of the radar.

Instrumentation

Langley Research Center developed electro-optical techniques to measure the velocity of small (1/16″) spherical projectiles at 18,000 ft/sec with an accuracy of better than 0.35 percent. Photomultipliers detecting light scattered by the projectile, synchronize image converter cameras which take projectile photographs with exposure times as short as 5 nanoseconds. These techniques will be useful in research on hypervelocity impact phenomena and meteoroid effects on spacecraft.

To measure material behavior and to detect surface cracks, Ames Research Center (ARC) developed a noncontacting probe which permits continuous observation during fatigue and fracture tests. Based on microwave techniques, this method eliminates mechanical and electrical contacts and will detect hairline cracks and grooves as small as 100 microinches. The sensitivity of the system, which now operates at 16 GH_z, will be improved in future models by incorporating higher frequencies. In other work at ARC, an extremely small pressure cell transducer (.043″ in diameter), originally developed for testing small models in wind tunnels, was successfully modified for advanced blood pressure studies. Such a sensor, with very thin wire attachments, can be inserted into the desired position in the blood stream by means of a hypodermic needle. In contrast to conventional devices, such as catheters, which distort the pulse wave form and clog the artery, the new device has high sensitivity and high frequency response, permits more realistic pressure measurements, and provides an indication of the elasticity of the blood vessels from the rate of wave propagation.

Data Processing

As a direct outgrowth of research in data processing techniques to recover Ranger, Surveyor, and Mariner spacecraft television pictures, investigators at the Jet Propulsion Laboratory developed computer methods applicable to processing medical X-ray photography. X-ray photographs are converted to digital form, stored in a computer memory, and there operated upon by a special algorithm to enhance contrast, remove distortion, and selectively reinforce the frequency spectrum for emphasis of relevant features. Biological anomalies at the threshold of perception in the original photograph are clearly exposed after processing. The National Institutes of Health in coordination with NASA's Office of Technology Utilization were investigating medical applications of this technology. Fig. 4–6 illustrates an application of the technique. The chest X-ray photographs on the left were taken at different times, processed, and subtracted from each other to reveal the difference in tissue growth shown on the right.

Investigators at the Electronics Research Center (ERC) demonstrated techniques which can be used to program computers to auto-

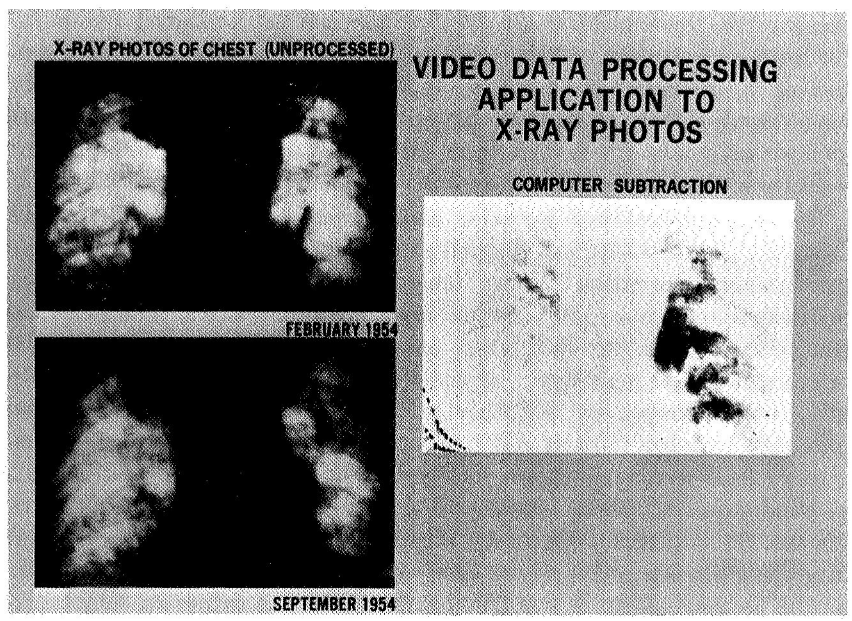


Figure 4–6. Data processing application to X-ray photos.

matically classify visual scenes according to established criteria and extract the significant features. The techniques incorporate a logic process which enables the computer to recognize such features as vortex patterns in meteorological photographs or planetary topology seen by spacecraft television cameras. Preliminary tests showed decision accuracies approaching that of skilled human technicians in the classification of cloud types using photographs from the Nimbus satellite. The ultimate goal of this research is to develop techniques which will reduce the ground processing work load for satellite meteorology and increase the amount of significant information that can be transmitted from deep space vehicles such as Mariner.

The ERC applied computer methods for manipulation and display of three dimensional graphic information in the study of advanced spacecraft design. The technique, developed by NASA–sponsored investigators at N.Y.U. allows a designer to simulate a spacecraft configuration and, through a computer generated visual display, continuously manipulate and rearrange the structural components under computer control to arrive at an optimum design with a minimum of computation. The technique was also applied in the study of advanced displays; here, artificial holograms generated by a computer were used to project a simulated spacecraft image in full three-dimensions for detailed study.

Electronic Component Development

An ERC contractor developed a process for manufacturing integrated circuits at room temperatures and produced a series of such devices. Tests indicated that the components meet most of the criteria for good integrated circuits and reduce surface contamination below that of circuits manufactured under current methods, which use relatively high temperatures (300°C). Resistors were improved in range, accuracy, and stability, and voltage breakdown levels of capacitors were increased. In-house research at ERC and contract work were continuing to further refine the technique.

Aeronautical Research

Aircraft Aerodynamics

A three-day conference on hypersonic aircraft technology (the fifth NASA aeronautical conference in the past two years), was held at the Ames Research Center in May. Over 300 representatives from industry, universities, and government agencies attending the conference heard reports on recent research in five principal areas of aircraft design:

mission studies, configuration aerodynamics, hypersonic viscous flow, propulsion, and structures and materials.

NASA initiated an experimental program to investigate the effects of aft fuselage-mounted engine nacelles on the aerodynamic characteristics of a typical twin-turbojet airplane. In one phase of the program, tests were performed at Mach numbers from 0.63 to 0.82, and nacelles and pylons were added to the configuration. As a result, the drag coefficient increased about eight percent at speeds below Mach 0.76 but decreased with increasing Mach number until it was about 2 percent at Mach 0.82. The nacelles and pylons also caused a reduction in lift coefficient at a given angle of attack and a decrease in pitching-moment coefficient at a given lift coefficient. However, increasing nacelle incidence, moving nacelles rearward, canting nacelles 3.5°, and modifying the local area distributions near the nacelles all affected the transonic drag rise of the configuration favorably. Thus, it appears that combining the effects of these geometric variables may reduce drag coefficient of the basic configuration with nacelles by as much as 10 to 15 percent at Mach 0.82.

In other research, studies were made of heating caused by the shock-wave from the forward part of the fuselage of a hypersonic aircraft impinging on the wing leading edge. Tests were conducted at Mach 8 with an unswept cylinder and a flat plate, used as a shock generator, inclined at an angle of 12° to the air flow. Comparison of the data with those from earlier tests on similar configurations indicated that the magnitude of the peak in heating depends on the proximity of the shock impingement to the tip or root region. The conclusion was drawn that for leading edges at small sweep angles, shock impingement occurring far from the root of the leading edge causes only moderate increases in heating. If impingement occurs near the root of the leading edge, heating can be five to ten times the undisturbed heating level. Previous investigations showed that shock impingement on a leading edge which is at a large sweep angle causes no local increase in heating.

Aircraft Loads and Structures

Detailed measurements of sinking speed, altitude, airspeed, and other landing conditions were made of about seventy XB–70 airplane landings, and the data analyzed statistically. The results can be applied in developing landing-load criteria for the design of such future large aircraft as the supersonic transport. A similar statistical analysis was made of landing condition data collected from about 130 landings of the X–15 research airplanes. Since these airplanes have a skid-type main landing gear and flight characteristics representative of hypersonic reentry vehicles, the flight results furnish information on landing conditions applicable to a new class of aircraft.

Atmospheric turbulence, like landing, is an important load source particularly with respect to structural fatigue. Loads resulting from turbulence can be specified adequately in statistical terms, such as power spectra, but no adequate means for correlating fatigue characteristics to a loading history defined in spectral terms is available. In efforts to develop such a means, a number of aluminum alloy specimens were subjected to random force time histories with markedly different spectral shapes. It was found that fatigue life was related to the root-mean-square nominal applied stress, but not to statistical parameters such as spectral shape. Also, fatigue life under random loading was found to be much lower than that under sinusoidal loading.

Aircraft Operating Problems

Fog.—In research on warm fog properties and modification concepts, laboratory experiments in a 30-foot test chamber indicated that hygroscopic nuclei, such as salt, can be used to preseed an atmosphere to prevent the formation of dense fogs. Research was resumed on drying the atmosphere after the fog forms following the recent development of a method for manufacturing uniformly sized desiccant or salt crystals. Tests indicated that hygroscopic particles with a radius of about 5 microns were near optimum, requiring much less desiccant than previous tests would indicate to achieve significant improvement in visibility. Field tests were scheduled for the preseeding and desiccant concepts.

Rotor Burst Control Research.—Research equipment to spin turbine engine rotating components to test velocities was installed at the U.S. Navy Aeronautical Engineering Laboratory, Philadelphia, and investigation of containment/deflection concepts to protect aircraft against failed rotor fragments has begun.

Lightning.—In a series of laboratory tests which extended investigations made several years ago by NASA, the sizes of holes burned in metal alloys by simulated lightning were correlated with the energy content of the lightning stroke. Results were being analyzed and will be reported when the study is completed.

Noise Abatement

Two contractors were selected in May to conduct studies of turbofan nacelle modifications which will minimize fan-compressor noise radiation. Over a 32-month period, both companies will carry out analyses and wind tunnel tests, redesign nacelles as necessary, and perform ground run-up and flight tests to determine optimum nacelle designs for minimum noise radiation. At the same time, the economic trade-offs between costs and possible noise reduction will be studied. The project, which is managed by the Langley Research Center, is a major element of the Interagency Aircraft Noise Alleviation Program.

V/STOL Aircraft

In a study of VTOL and STOL short-haul transports conducted for the Ames Research Center, a variety of concepts (fig. 4–7) were analyzed to determine those most suitable for commercial operation and the research required to bring them to full operational status. The studies covered airplane design, operational techniques, noise and public acceptance, acquisition cost, direct operating cost, technical risk, and research requirement; several of the concepts reviewed appeared capable of attaining operational status in the 1970–75 period. Results of the studies indicated that the potential direct operating costs of most of these aircraft should be comparable to those of conventional short-haul jet aircraft over 500-mile stage lengths; they should be lower than the operating costs of present turbine helicopters for very short trips down to 25 miles.

The Langley Research Center evaluated three different prototype light observation helicopters and two large load-lifting helicopters in simulated military operations. Purpose of the studies, in which helicopter flight recorders were used, was to provide a basis for extending

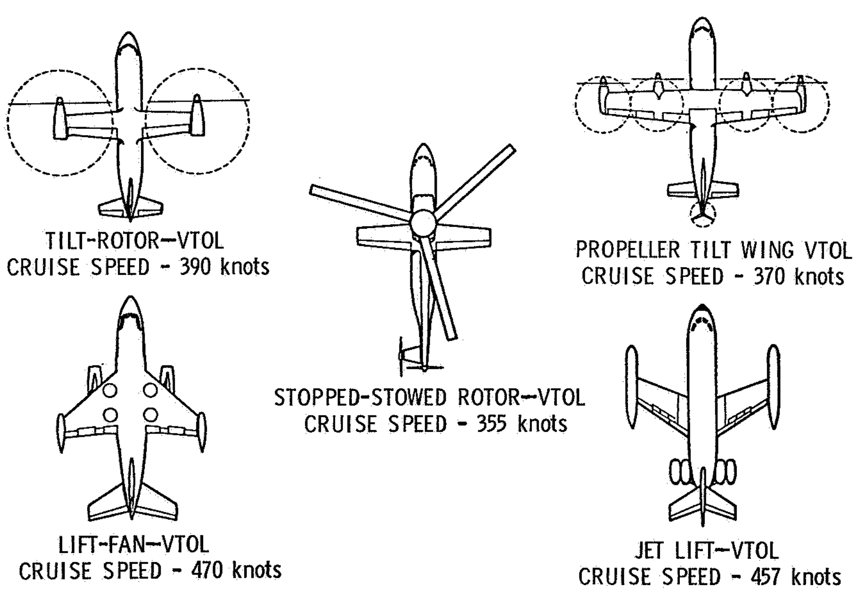


Figure 4–7a. VTOL concepts studied.

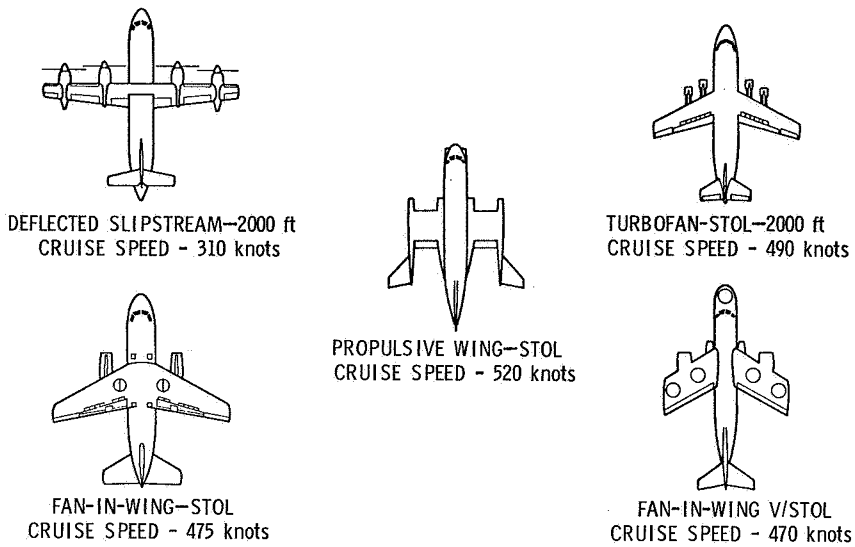


Figure 4–7b. STOL concepts studied.

helicopter design and service life criteria. Each of the light observation class helicopters flew a specified number of profiles representative of their anticipated service usage. The larger helicopters performed load-lifting tasks and internal and external cargo transfers typical of combat support missions. Results of the survey: each helicopter spent a large amount of time in the upper portion of the speed range and exceeded its handbook maximum velocity for a small percentage of the total flight time; rates of climb and descent varied broadly over a wide range of airspeeds; normal acceleration experiences reached 75 to 98 percent of the aerodynamically attainable maximum estimated for the specific flight conditions; rotor rotational speeds were held at the normal values for most of the flight time, but a large number of values exceeded either the upper or lower red-line limits.

The free-stream interference effects on roll control jets in the transition speed range were investigated using a jet VTOL model in the Langley 300-mph, 7- by 10-foot tunnel. The interference effects of the jets and the free stream induced losses in the effective roll control; however, the losses were reduced as the jets were moved rearward and toward the wing tip. Sideslipping the wing forward or upstream gave negative (unfavorable) interference increments in rolling moment, whereas sideslipping the wing backward or downstream give positive (favorable) increments. Aileron deflection had very little effect on the interference effects between the jets and free stream.

Supersonic Aircraft

Propulsion/Airframe Integration.—NASA instituted a research program on the effects of airframe/propulsion system interactions on the operation of the overall propulsion system. The Flight Research Center collected data defining the real flow environment into the engine of supersonic fighter aircraft in flight. This data will be used by the Lewis Research Center in a program to test an engine (TF–30) similar to that powering the F–111 airplane. Air flow patterns recorded in flight will be simulated at the engine compressor face, and the results will be correlated in an effort to obtain fundamental information for design criteria applicable to future advanced aircraft.

XB–70 Flight Research Program.—NASA and the Air Force continued to use the XB–70 aircraft jointly to obtain flight data, concluding the XB–70 portion of the National Sonic Boom Program on January 17, after nine flights, and beginning the general research program on January 25. Nine flights were made during the first half of 1967, three for the sonic boom program and six for the research program. As of June 30, the XB–70 aircraft had made 110 flights, for a total flight time of 213 hours and 14 minutes, including one hour and 48 minutes at Mach 3 or above. The research program emphasizes the collection of data on stability, control, and handling qualities; dynamic loads; aircraft performance; and propulsion.

Program management, operational control, and funding responsibility for the XB–70 research program were transferred to NASA on March 28, 1967, and the first flight under NASA management was on April 25.

Hypersonic Aircraft

Hypersonic Research Engine.—In March, a contractor was selected to develop and fabricate a liquid-hydrogen-fueled ramjet research engine, capable of operation at the severe conditions associated with Mach 8 flight. Above Mach 5, thrust will be obtained by supersonic combustion of the fuel, while at lower speeds, thrust will be obtained by subsonic combustion of the fuel.

X–15 Research Aircraft Program.—The three X–15 aircraft made a total of 8 flights during the first half of 1967, for a cumulative total of 184 flights by the end of the period. One hundred thirty-nine flights were made at Mach 4 or greater, 98 at Mach 5, or above, and 3 at over Mach 6. Current flight objectives were to obtain data relating to the following experiments: hypersonic research engine (HRE), structural heat transfer at hypersonic speeds, simultaneous photographic horizon scanner, sonic boom characteristics of hypersonic aircraft, and horizontal tail loads and flow-field characteristics.

The HRE tests investigated the stability and control characteristics of the X–15–2 with a ramjet shape installed in place of the lower (movable) ventral fin; evaluated aircraft handling qualities; measured local Mach number; determined flow angularities for the ramjet-installation area; and investigated ramjet jettison, separation, and recovery characteristics.

The heat transfer tests obtained data on heat transfer to cold-wall structures at hypersonic speeds by using a "blow-off" cover panel on the upper rudder of the X–15–3, and on heat transfer to skin panels with step-type discontinuities. The heat transfer data obtained in flight will be compared with data obtained previously in various wind tunnels.

Biotechnology and Human Research

Advanced Concepts

Looking toward the time when astronauts will live and work in a shirt-sleeve environment, and it will be desirable to dispense with attached physiological monitoring systems, the Electronics Research Center instituted an investigation of techniques for obtaining physiological measurements without attaching any equipment to the body. As a result, one such device, the medical monitoring chair, was developed for the Center. It obtains an electrocardiogram, pulse rate, respiration rate, and a phonocardiogram from sensors mounted in a chair. In the illustration (fig. 4–8), an ordinary swivel chair was used to hold the sensing equipment. The subject merely sits normally in the chair, and the data are immediately available. In order to validate them, the data collected by the unattached sensors were being compared with data obtained by more conventional measurement techniques.

Life Support Systems

The Partially Regenerative Life Support System at the Langley Research Center is a full-scale working model of a physico-chemical regenerative life support system and environmental control system associated with possible extended manned flights during the 1970's. It was run continuously in January for seven days at a pressure of one atmosphere with a gaseous environment of about 21 percent oxygen and 79 percent nitrogen. The test demonstrated the ability of the system to satisfactorily control chamber environment and run continuously for a period of time. System maintenance requirements were relatively high toward the end of test when the chamber was occupied to collect data

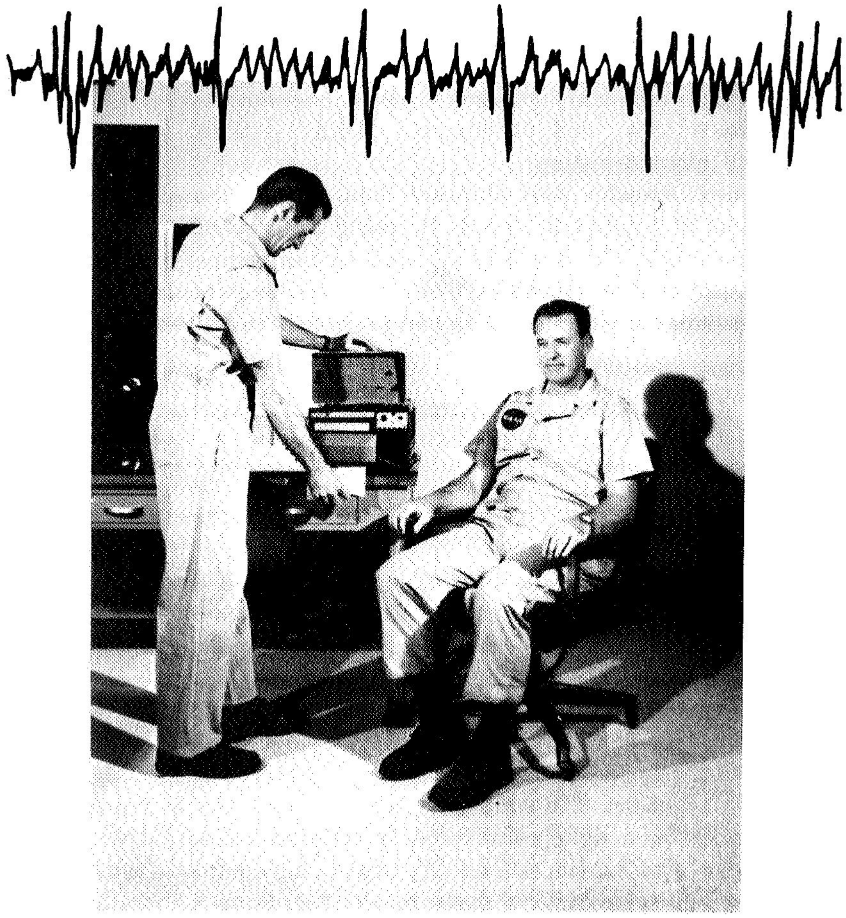


Figure 4–8. Medical monitoring chair (phonocardiogram).

and to service equipment. Another five-day test was completed in May, with particular emphasis on the bacteriological aspects of the system.

A membrane diffusion technique for reclaiming potable water from urine and condensate was studied. (Fig. 4–9) Because urine contains various electrolytes, water soluble and suspended organics, and several volatile substances with boiling points very close to that of water, separation by distillation is difficult. In the membrane diffusion technique, the water passes through a selective membrane and evaporates from the other side into an evacuated chamber where it is condensed on a cooled porous plate. Waste heat from other spacecraft systems is used to pro-

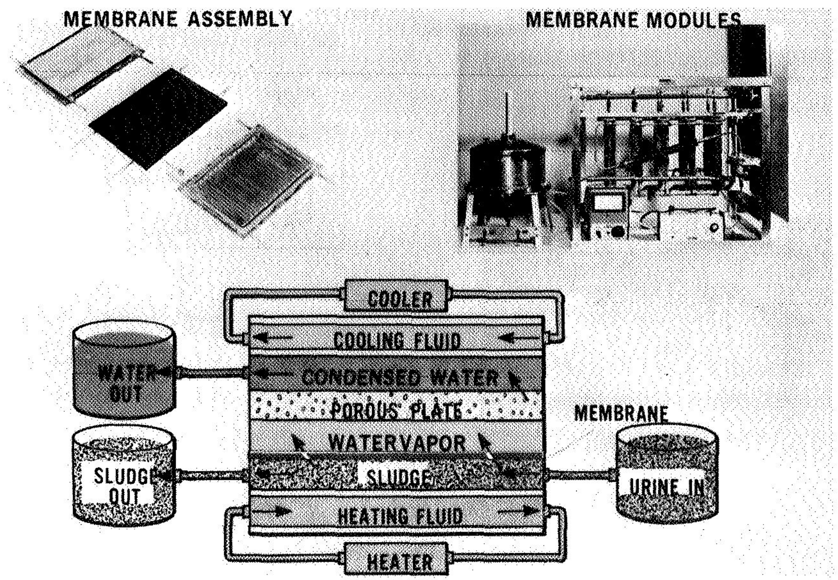


Figure 4–9. The membrane diffusion method of water recovery.

vide the driving force necessary to overcome the resistance of the membrane to water vapor flow. The purified water is condensed and collected by capillary action. Plans were made to continue testing and membrane improvement studies.

Hard-Space Suit Developments

The hard space suit program conducted for OART by the Manned Spacecraft Center saw the delivery of the RX–4 suit. It met the design goal of an overall weight of 63 pounds. Designed for 8-hours of lunar operations, the suit uses a unique helmet-visor system and hard, sabot-type boots. In thermal tests of the boots, subjects were able to withstand 250° surface temperature for 1 hour.

The Ames Research Center completed fabrication of the AX–1 hard suit, which embodies a constant volume joint principle developed to reduce energy expenditure during extravehicular activity. The joint concept was incorporated in the shoulder, elbow, wrist, hip, knee, and ankle articulations; in tests, the joints showed satisfactorily low torque rates. (Fig. 4–10)

Human Research

In a study of the causes of spinal injuries suffered by individuals ejected from military aircraft, it was found that in some cases the cata-

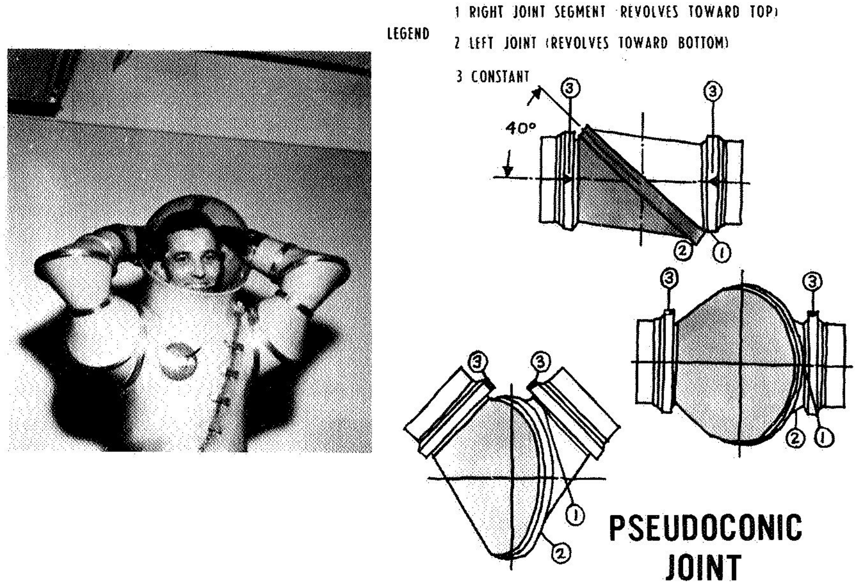


Figure 4–10. The AX–1 hard suit and joint concept.

pult thrust causes compression fracture of the vertebrae. Dynamic stress/strain measurements were made on the spinal column using forces similar to those of ejection, and the interactions between vertebrae under dynamic loading were studied. This work should account for the observed nonlinear behavior and assist in the development of design criteria for improved ejection seats.

The Space Science Board of the National Academy of Sciences sponsored a 1966 summer study on long duration space flight and its effects on respiratory physiology. The study identified a potentially serious effect of weightlessness which increases the possibility of aspiration of particulate matter. This effect results from the fact that in zero gravity conditions dust particles do not settle out but become respiratory tract deposits which may cause pulmonary disease. Consequently, the study recommended further investigation of particle sizes, numbers, composition, and removal methods. For this purpose a compact instrument ($4 \times 5 \times 8$ inches; $5\frac{1}{4}$ pounds) capable of recording the size and number of such particles in a spacecraft, was developed, flight qualified, and scheduled to be carried on an early manned flight. The size and convenience of this type of instrument may also make it useful in air pollution studies. (Fig. 4–11)

An extensive research program in vestibular physiology continued investigating problems of balance and adaptation to weightlessness with

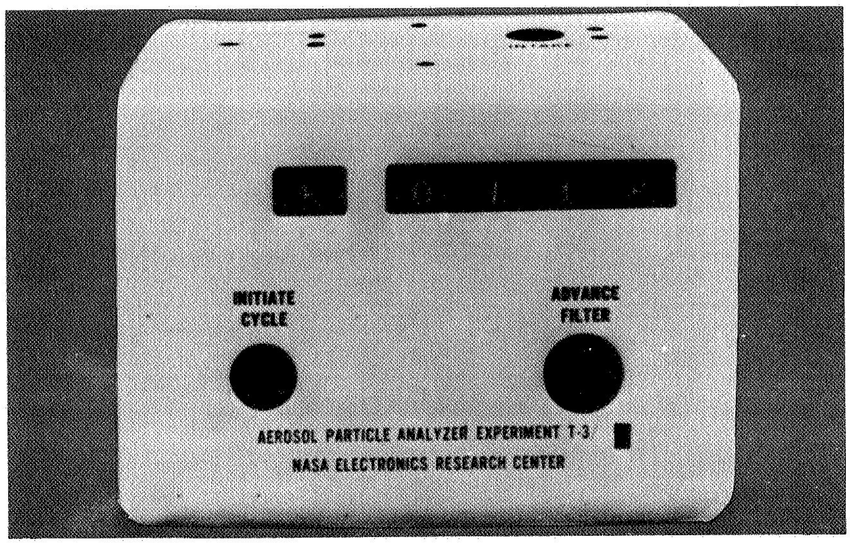


Figure 4–11. Particle analyzer.

flight experiments to measure otolith activity and studies of primate reaction to extended flight. (Fig. 4–12) Plans were formulated for a biotechnology laboratory to serve as a base for additional animal research, experiments on life support technology, medical monitoring of astronauts, and human work performance. It could also be used for life sciences research now conducted by means of flight experiment programs.

Man-Systems Integration

Research to advance technology in maintainability and maintenance is typified by a Langley Research Center study of astronaut capabilities to perform extravehicular maintenance and assembly functions in simulated weightlessness. The subjects wore pressurized space suits at 3.7 psia and operated in a large water tank at neutral buoyancy or in a gimbal suspension system. (Fig. 4–13) Their ability to apply forces, to handle various size masses, to assemble structures, and to maintain stability at the work sites while weightless was measured, and the effects of various tether and restraint devices were studied. (Fig. 4–14) The devices included foot restraints, flexible waist and chest tethers, and a "bird cage" that astronauts could use to support their bodies or exert force against. Maintenance task performance was virtually impossible if

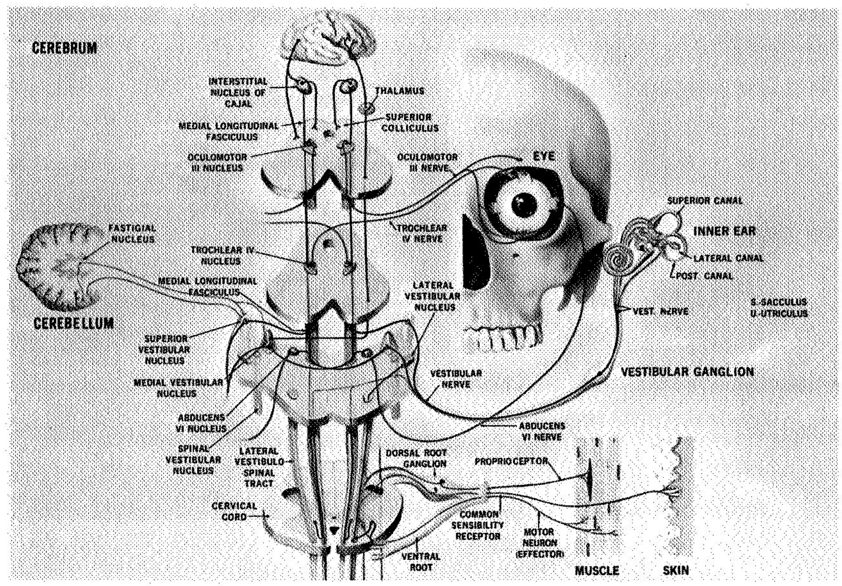


Figure 4–12. Human balance control.

the subjects were free floating, but with appropriate tethers and restraints, subjects showed a high capacity for working in simulated weightlessness. A three point restraint system was found to be far more effective than one or two point anchors. The bird cage, later modified to a three–tiered rail, combined with a waist tether was the most effective. Metabolic rates which were measured to determine the energy expenditures involved in performing these tasks averaged 1500–1600 BTU/hr., with an occasional peak at 2000 BTU/hr. This information is also applicable to the design of life support systems.

Studies were carried on to develop tools for use in space. For activities requiring the exertion of large torques or repetitive tasks such as removing or replacing a large number of bolts, power tools will reduce the astronaut's energy and time expediture. Although small power tools that fit over the pressurized glove to protect it from puncture or abrasion were investigated, manual tools will be used whenever feasible because they are simpler and smaller. (Fig. 4–15) The MSFC experimented with a modification of the Yankee screwdriver for use where simple rotation actions are required and will study the various tool concepts in the six-degree-of-freedom simulator.

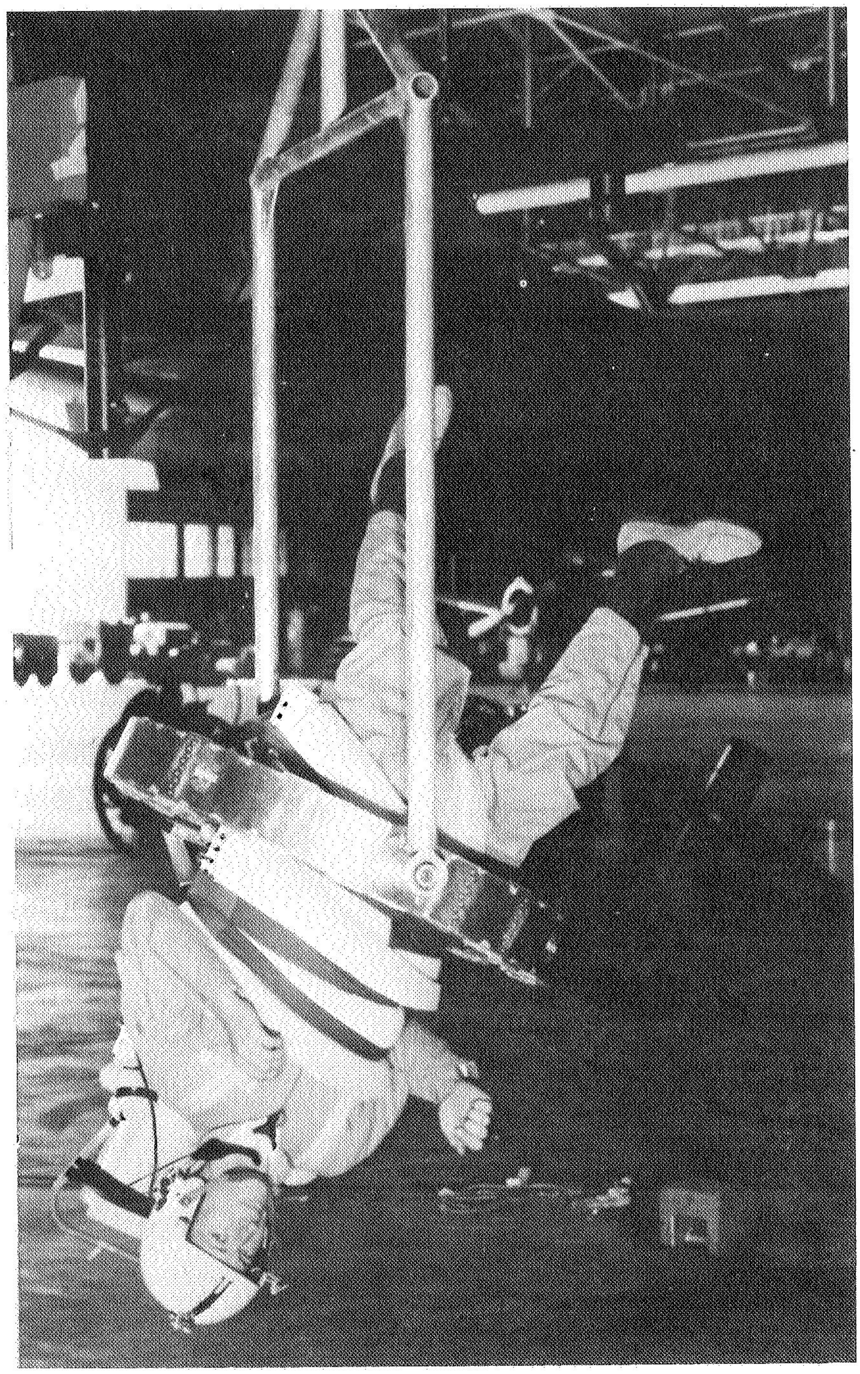


Figure 4–13a. Gimbal suspension and water immersion systems.

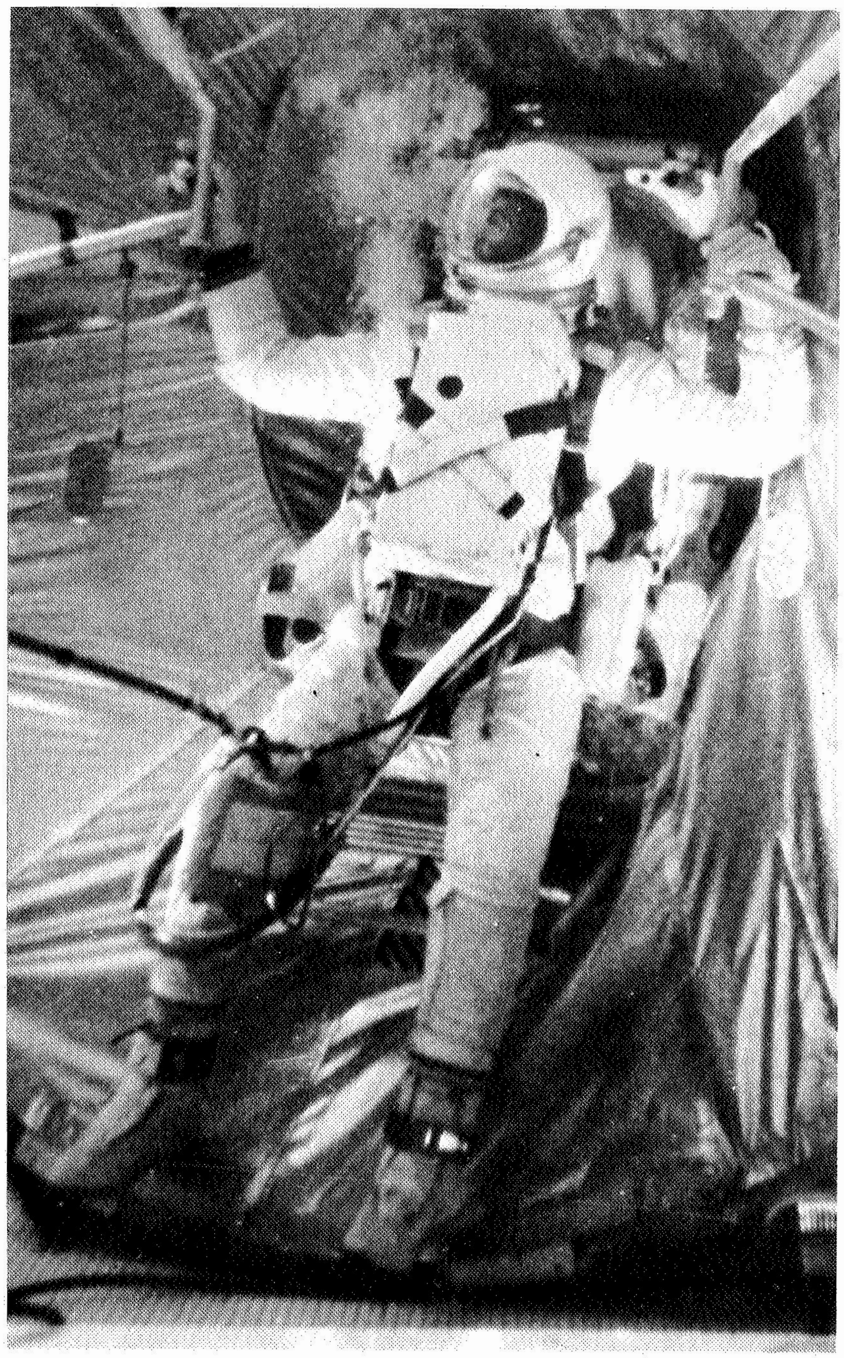


Figure 4–13b. Gimbal suspension and water immersion systems.

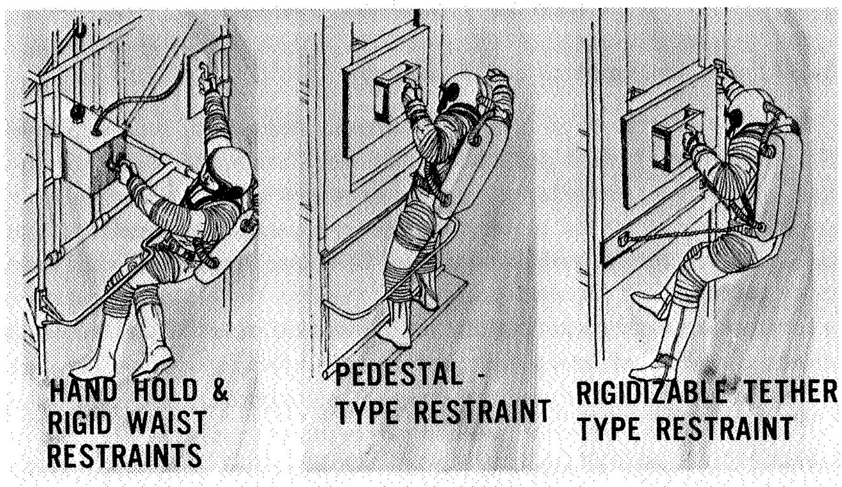


Figure 4-14. Work site restraint concepts.

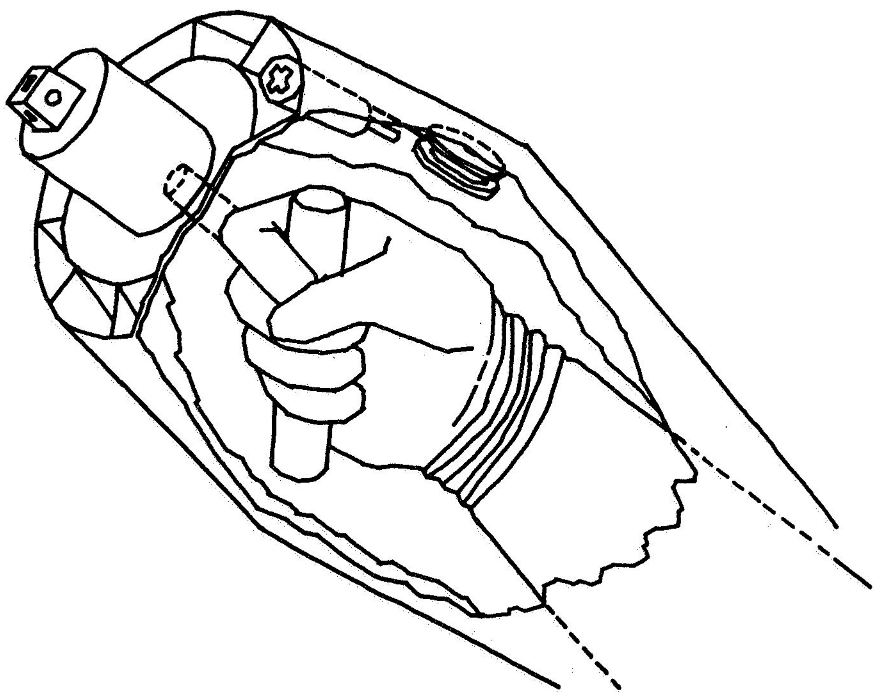


Figure 4—15. Gauntlet concept hand tool.

Chemical Propulsion Systems

Solid Propulsion Research and Technology

Progress continued on a number of technology areas which increase the capability of solid propulsion systems. Developmental effort on a heat sterilizable propellant for systems which may impact planetary environments advanced materially. The synthesis of trifunctional prepolymers promises to yield binders and therefore propellants with much more reproducible physical properties, work on the characterization of a controllable solid rocket motor employing fluid injection as the control means moved ahead, and a high performance hybrid system was brought to the point where it is ready to proceed into engineering development.

The propellant polymer mechanical behavior program at JPL developed the theory of stress softening. (A stretched propellant undergoes a change in modulus and dilatation—smaller modules, greater dilatation—that is, it softens. The greater the number of cycles the greater the effect, until failure.) The JPL model is the first to predict the softening on theoretical grounds, and it is the only one to explain experimental facts. Thus, it gives a firmer basis for stress analysis of systems undergoing cyclic stress.

A new project utilizing the technique of electron paramagnetic resonance (EPR) was initiated; it should significantly advance understanding of the fracture mechanism of covalently bonded materials such as solid propellants. In the bonded state, the "shared" electrons are "locked" into a given quantum spin state, which makes it impossible for these electrons to align with any applied magnetic field. If the bond is broken, the electrons tend to align their magnetic vector with the applied field. In the presence of an applied magnetic field, broken chemical bonds can absorb electromagnetic radiation of the appropriate frequency. By measuring the microwave absorption, the number of free radicals resulting from bond breakage can be measured. In principle, the shape of the absorption spectra should make it possible to determine not only the number but also the type of bonds broken during the fracture process.

Although only a limited amount of quantitative information has been obtained thus far, it confirmed the ability of EPR to detect bonds broken by mechanical damage. The hyperfine detail was very good, indicating that the future fracture studies should be highly productive. In addition, the method might be very valuable for studying such things as aging, accumulation of mechanical damage, and fatigue.

Solid Propulsion Experimental Engineering Program

The final phases of the third 260" motor technology demonstration firing were completed. By January the motor case, previously fired in September 1965, was cleaned up, reinsulated, placed in the below-ground load and fire pit, and loaded with propellant—1.7 million pounds over an 18 day period. The motor and propellant were held at 135°F for several weeks, allowed to cool, and the 175,000-pound core, which formed the inner surface, was extracted in late April. During the same period, the ablative nozzle, the largest ever made (the throat measured 7½ feet across), was being completed, and in May the motor was assembled and checked out. (Fig. 4–16)

In the course of the firing on June 17, the motor generated a maximum of 5,700,000 pounds of thrust in 70 seconds of operating time. The test was considered successful except for some propellant burning irregularities which caused pressure fluctuations and, late in the test, expulsion of a relatively small amount of solid propellant. Shocks from the ejected propellant pieces caused a small portion of the nozzle cone to break off after 65 seconds of burning, and a larger portion only a few seconds before motor burnout. The propellant burning irregularities may have been caused by trapped air or weak bonding to the case wall resulting from the high viscosity of the propellant.

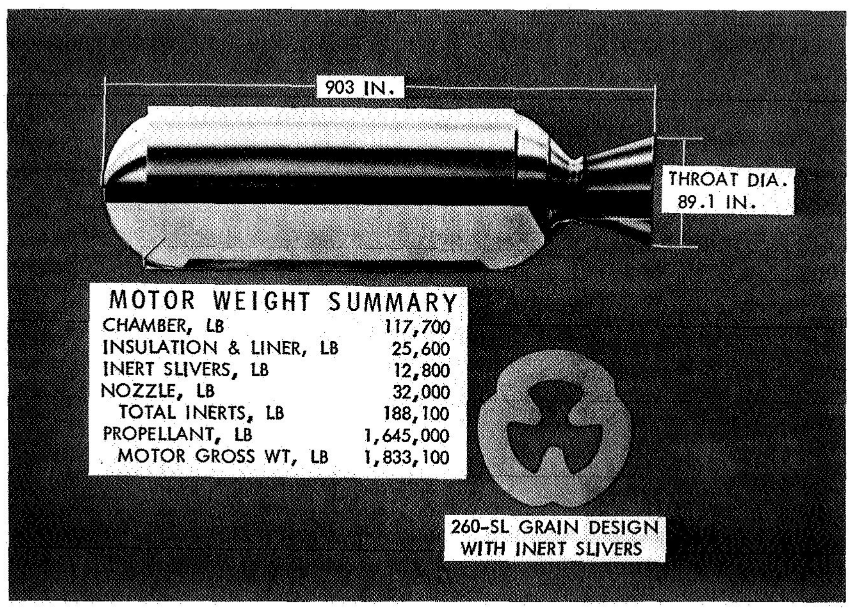


Figure 4–16. The 260-inch motor.

The most critical section of the nozzle—the throat and the forward lip which is suspended within the motor during burning—performed very well, eroding less than the predicted amount. Inert slivers bonded inside the motor case before propellant casting were responsible for shortening the final thrust tailoff significantly, and the simulated insulation burnthrough failure warning system performed well, giving the signals which had been expected.

In research on small high energy motors, proposals for a design definition phase of a 2500 pound prototype were being evaluated. The motor, whose characteristics were derived from analysis of a number of application studies, will represent the latest developments in propellant, nozzle, and case design, including a capability for burning to be stopped and restarted at least once. Successful testing of this advanced prototype would make it possible to proceed with development of a motor which could be used several years from now to add significantly to the capabilities of our standard small launch vehicles.

Liquid Propulsion Research and Technology

This program was being redirected to emphasize performance and operational problems of future engines, particularly those identified by mission analyses as relating to advanced space storable propellants. Contracts were being negotiated for applied research on such phenomena as altitude starting explosions and on injection and combustion performance, because these were problem areas with earth storable propellants. Several new design concepts in injector and thrust chamber construction were investigated in an effort to reduce the cost of components, improve their producibility, and to allow for design changes during development.

Work on liquid hydrogen systems continued, stressing storage for extended mission applications. Subjects investigated included tank insulation, liquid circulation systems, improved venting, and propellant improvements, such as slush hydrogen, all of which offer superior storage capability. Equipment for propellant transfer, tank fluid orientation, gas phase venting, and reduced gravity heat transfer was also under analysis. Materials, particularly polymers and thrust chamber materials such as pyrolytic graphite and refractory metal carbides, were being studied.

Liquid Propulsion Experimental Engineering Programs

Launch Vehicles.—Two high pressure (above 5,000 psia) turbopump programs for liquid hydrogen and liquid oxygen established the feasibility of cryogenic turbopumps for the high pressure topping cycle engine. (Fig. 4–17)

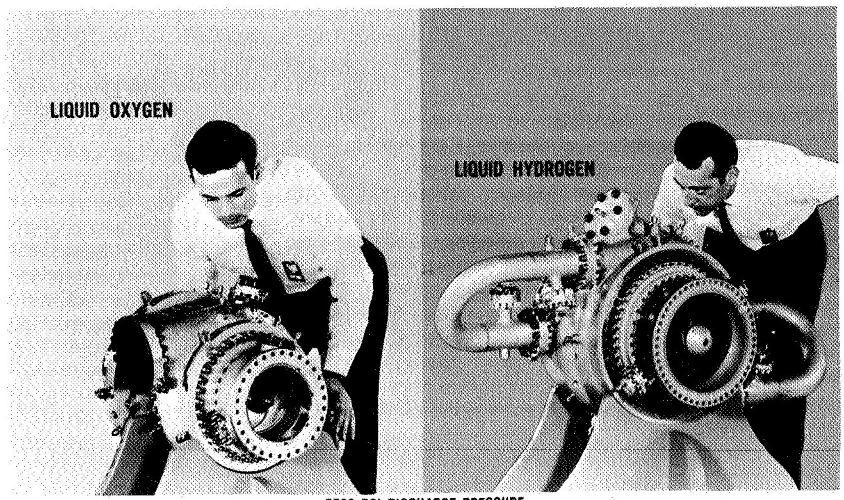


Figure 4–17. High pressure turbopumps.

The thrust chamber for a 250,000 lb. thrust hydrogen-oxygen annular aerospike engine was fabricated and tested to determine transient characteristics. Subscale testing on segments of the full circular annulus was conducted to establish performance characteristics, verify fabrication techniques, and to confirm design parameters.

In-depth analytical studies of both the high pressure bell nozzle engine (fig. 4–18) and the annular aerospike concept (fig. 4–19) were made to determine system interactions and component performance requirements, and to evaluate the need for additional technological improvements. Several technology efforts were initiated to develop improved turbomachinery concepts. The work, which will first be conducted at subscale using water rather than cryogenic propellants, is expected to verify the analytical studies and conceptual designs.

Space Propulsion.—Testing of the 1,000 lb. thrust internally cooled beryllium chamber with earth storable propellants continued. (*16th Semiannual Report*, p. 145). Significant progress was made towards fulfilling the purpose of the test program—to evaluate design parameters for both steady state and transient (throttling) operation—so that analytical tools for predicting engine characteristics over a wide range of operating conditions can be improved with empirical data. As a result, the analysis will be applicable to design studies for such spacecraft as the Voyager lander.

The RL–10, A3–3, configuration was readied for fluorine-hydrogen engine testing following completion of thrust chamber tests. Other

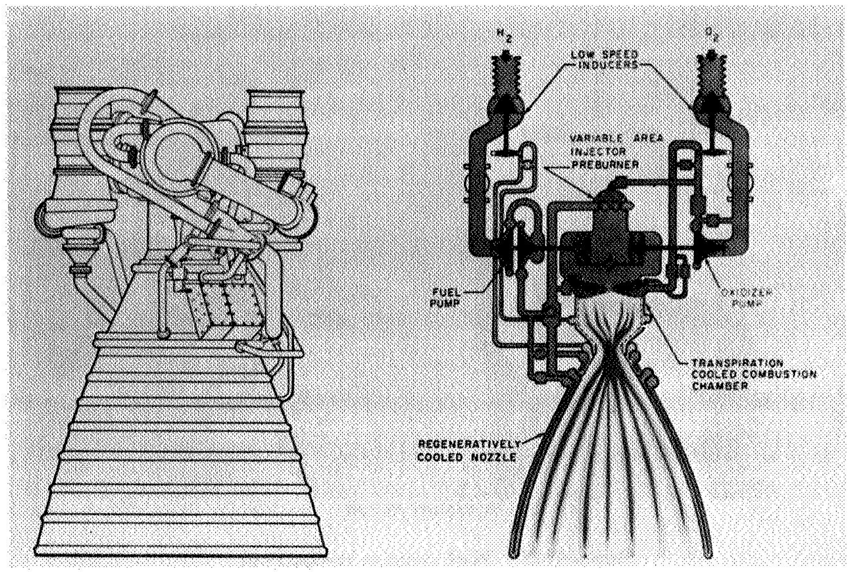


Figure 4–18. High pressure engine.

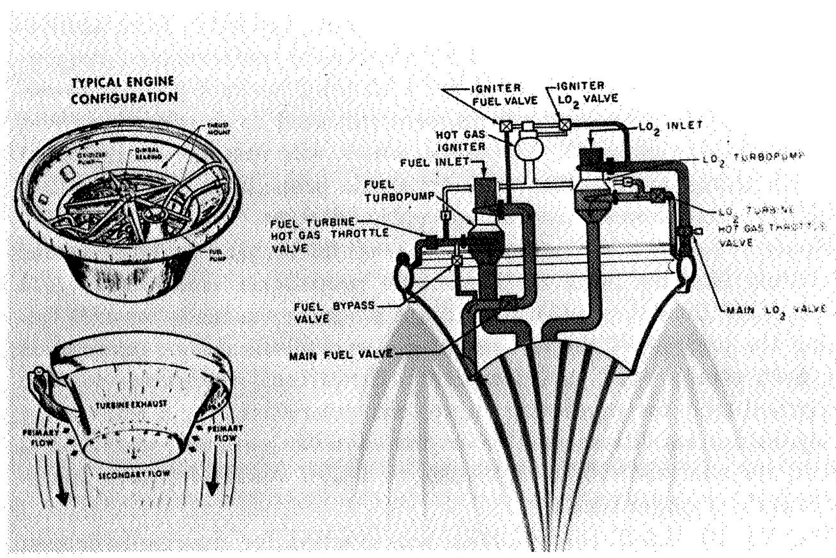


Figure 4–19. Aerospike concept.

engine components modified and tested included two liquid fluorine pumps tested for 30 min. each at the Lewis Research Center Plum Brook Test Facility. Flight–weight fluorine feed system components (fill and drain valve, and vent and relief valve) were successfully tested to confirm design criteria for flight components.

In the space storable propellant area, new work was started to develop parametric design data for higher pressure (500 to 1,000 psia) pump-fed engines, which should be applicable to volume-limited planetary landing and ascent missions and to those calling for extended stays on the lunar surface. Subjects of primary interest are engine performance and cooling and the design and operation of small turbomachinery with highly reactive propellants. Further research on oxygen difluoride (OF_2) as a space storable oxidizer was planned as a result of work at the National Bureau of Standards. The Bureau established an apparently firm heat of formation for oxygen difluoride which is somewhat higher than that previously assumed and should add about 2 percent to the performance of propellant combinations utilizing OF_2 as an oxidizer. Engine tests were scheduled to confirm these data empirically.

Auxiliary Propulsion.—Work was started to investigate the possibility of using the high energy space storable propellants for auxiliary systems as well as for primary spacecraft propulsion. The possibility of integrating the primary and auxiliary systems by utilizing the same propellants offers a number of advantages. However, the higher combustion temperatures and reactivity of the propellants and their products of combustion require new design concepts; a number of these were being evaluated. It was also necessary to initiate additional research on a problem associated with monopropellant hydrazine thrusters. The problem—chamber pressure spiking which occurred under the condition of a cold catalyst bed and a vacuum environment—was being investigated.

Basic Research

Fluid Physics

New data were obtained on the transport properties (thermal and electrical conductivities, and viscosity) of ionized gases in a number of independent experimental facilities. Shock tubes, radio frequency heaters, and arc heaters were employed to produce gas samples at temperatures from 2,000 to 20,000°K, and measurements were made by interferometric, ultrasonic, and heat transfer methods. New theoretical investigations which were also completed provide better agreement between theory and experiment for high temperature gas transport properties.

Studies of sonic boom were initiated at a number of universities, and the investigators met with NASA and other leading aerodynamicists in April to review the status of their research and to assess the possibilities for progress in this area. Areas calling for further research were outlined and those concerned with predicting sonic boom signatures were distinguished from those related to minimizing it. To predict boom for steady flight additional research must be conducted on the effects of the atmosphere, of local topography, and of atmospheric turbulence. To minimize boom under the same flight conditions, research must focus on the mid-field signature, the extent of the mid-field region, and subjective response.

An implosive driven shock tube was investigated for use in experimental research on high temperature gas-dynamics. Investigators employed a jetting driver consisting of a cylinder of high explosive that progressively collapses a glass tube and projects a diffuse glass jet into the shock tube. The jet acts like a solid piston traveling at twice detonation velocity, and in turn, it drives a shock wave into the test gas. This technique produced a flow with energy higher than can be obtained in advanced chemical or electric shock tubes without adding to the complexity of the driver and without interface mixing problems of the conventional shock tube. (Fig. 4–20)

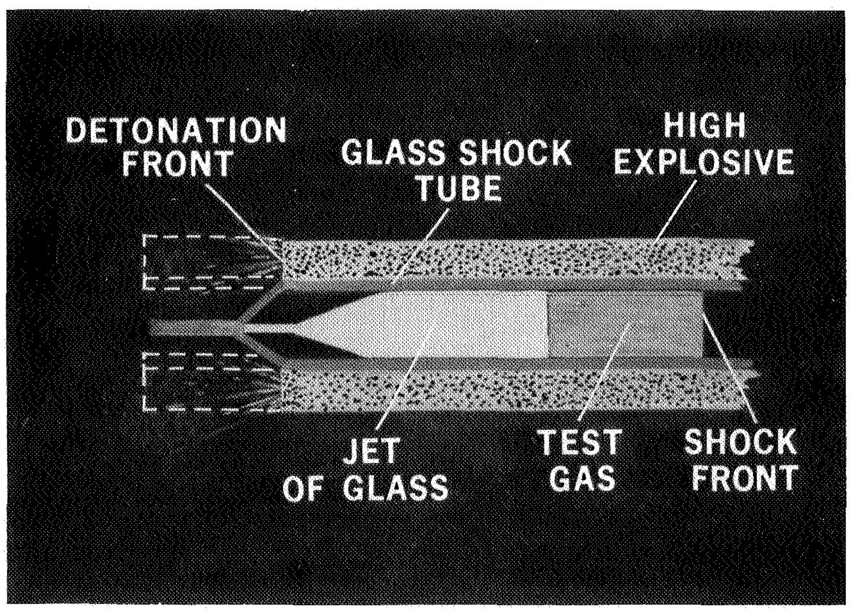


Figure 4–20. Implosive shock tube.

Applied Mathematics

In research on programming high speed airplane flights to minimize trip time and fuel consumption, a new analytic programming theory was developed which employs the more realistic assumptions necessary for accurately predicting analytically the optimal performance of modern high performance aircraft under accelerated conditions. In application to a practical case—how to pilot a plane travelling 330 miles per hour so as to climb 9,000 feet in 7 miles as quickly as possible—the new mathematical program effected a saving of 15 percent in time and fuel consumption over any trajectory which could have been found by the old theory. For supersonic flights, which will be almost entirely climbing and coasting, the economic advantage of using the new mathematics may even exceed 15 percent. (Fig. 4–21)

Materials Research

In studies of high strength alloys for use at high temperatures, the Lewis Research Center developed a cobalt-tungsten alloy that, in addition to high strength, has high magnetic induction. The alloy retained its magnetism at least 10 times longer and to a temperature about 100° higher than the standard commercial magnetic alloys at equivalent loads and at temperatures as high as 1400°F.

NASA-sponsored research on glass chemistry produced several high magnesium oxide glass compositions with improved stiffness, or higher

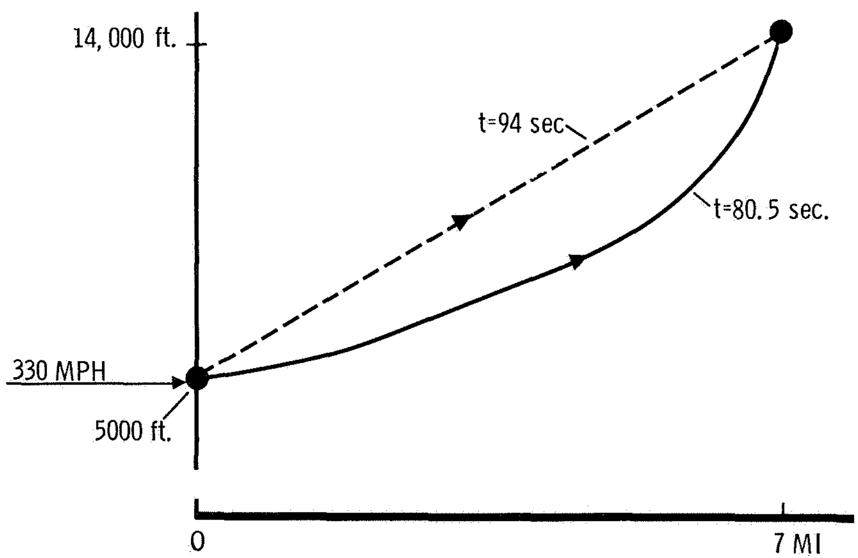


Figure 4–21. Calculating an aircraft trajectory.

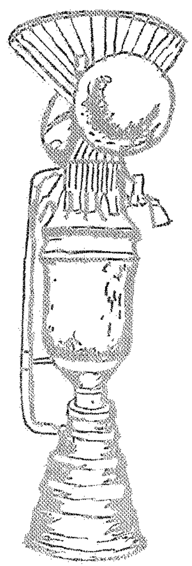
modulus of elasticity, than previously reported. Several glasses were made with a modulus of elasticity of 17 million compared to 12 million for commercial glass fibers. If this approach can produce stiffer glass reinforced plastics, it should enhance the utility of such plastics in aeronautics and space applications where weight saving is important.

Electrophysics

Investigators produced a pure uranium high density gaseous plasma in an arc discharge and were determining the characteristics of the plasma by spectroscopic and plasma diagnostic techniques. Data from the measurements will be helpful in deciding whether the gaseous-core nuclear reactor, a concept offering a very high specific impulse for space propulsion, is feasible.

Progress was made in understanding and improving superconductors. A new concept based on the pairing of electrons within a superconductor was investigated. According to the new idea, the pairing takes place when the individual electrons are in separated thin films, and experiments on layers of aluminum and silicon monoxide thin films showed a critical temperature of 5.7°K compared with 2.7°K for a single aluminum thin film. Data on other combinations were being obtained, and research proceeded to formulate a proper theoretical foundation. The objective of this work is to double the present maximum critical temperature of 20°K and make it possible to use hydrogen instead of helium as a cryogenic coolant. If the goal to reach room temperature (273°K) can be achieved, extensive refrigerating equipment will not be needed.

Research on superconductors is applicable to space studies where these devices can reduce the size and cost of magnets used for MHD power supplies and electrical engines, for spacecraft shielding against high energy particles, and for reducing heat during reentry. They also have potential industrial applications in computers, high voltage transmission lines, motors, and generators.



5 NUCLEAR SYSTEMS AND SPACE POWER

Work in the nuclear rocket program continued to move toward development of a high-powered nuclear rocket engine, with emphasis placed on both reactor and engine system technology. Meanwhile, certain advanced nuclear rocket propulsion system concepts were undergoing study and assessment. In addition, the SNAP-8 project, nuclear electric power research and technology, the electric propulsion program, and non-nuclear space power research and technology efforts received increasing attention.

Nuclear Rocket Program

The joint NASA/AEC nuclear rocket program placed major emphasis on achieving the remaining graphite reactor and engine system technology goals. Such achievement is necessary to establish the base of technology required to develop a high-powered NERVA engine of approximately 200,000 pounds of thrust. Most of this technology is now in hand, and the remaining objectives should be met within the next two years.

Reactor technology objectives to be achieved include (1) scaling up the reactor technology demonstrated in the NRX, KIWI and Phoebus 1 reactor tests to the powers needed for the NERVA engine reactor (to be designated NR); (2) extending reactor lifetime to sixty minutes; and (3) increasing power density. Engine system technology objectives to be achieved include (1) continuing mapping of engine performance characteristics; (2) gaining experience in operating nuclear engines in a down firing test stand (ETS–1) under simulated altitude conditions; and (3) gaining experience in the remote maintenance of a radioactive nuclear engine assembly.

Reactor Technology Development

The Los Alamos Scientific Laboratory (LASL) effort to advance reactor technology is being accomplished under the project heading of Phoebus. The objectives are to increase the temperature, power density, and endurance capabilities of graphite reactors. To meet these objectives, LASL initiated a two-phase development effort. The first phase involves the design, fabrication, and testing of KIWI-sized Phoebus 1 reactors to evaluate the important elements of large reactor technology. The second phase involves the design, fabrication and testing of large-diameter Phoebus 2 reactors leading to the definition and selection of a high-performance reactor design suitable for adaptation in the NERVA engine.

In February, LASL completed the first phase of this technical plan through the development testing of the Phoebus 1–B reactor (fig. 5–1.) The purpose of the 1–B test was to operate the reactor at a power level of 1500 megawatts and a fuel element exit gas temperature of about 4500° Rankine; such an operation would simulate the reactor environment and fuel-element power densities approaching those planned for the 5000-megawatt Phoebus 2A reactor and NERVA engine reactors, from a standpoint of both fuel element corrosion and thermal stresses. Other objectives were to operate the reactor for a 30-minute single power run to study the effectiveness of certain design experiments in reducing corrosion and to observe the behavior of other new design features planned for inclusion in the Phoebus 2–A reactor.

LASL conducted the full power test of the Phoebus 1–B on February 23. During this test, the reactor was operated at power levels approaching the 1500-megawatt design rating. The reactor ran for about 46 minutes, of which about 30 minutes were above 1250 megawatts. (Approximately 10 minutes of power operation was accumulated two weeks earlier during a reactor and instrumentation calibration test.)

The data from the LASL Phoebus 1–B experiments indicated the reactor test profiles were as planned during startup and shutdown. Thermocouple drifts caused the reactor power to decrease gradually during the full power run. The run was successful in meeting the major objectives of the full power test. Fuel element corrosion resistance was demonstrated to be greatly improved because of a new processing technique developed by LASL. Other major test objectives which were successful were the demonstration of structural design improvements

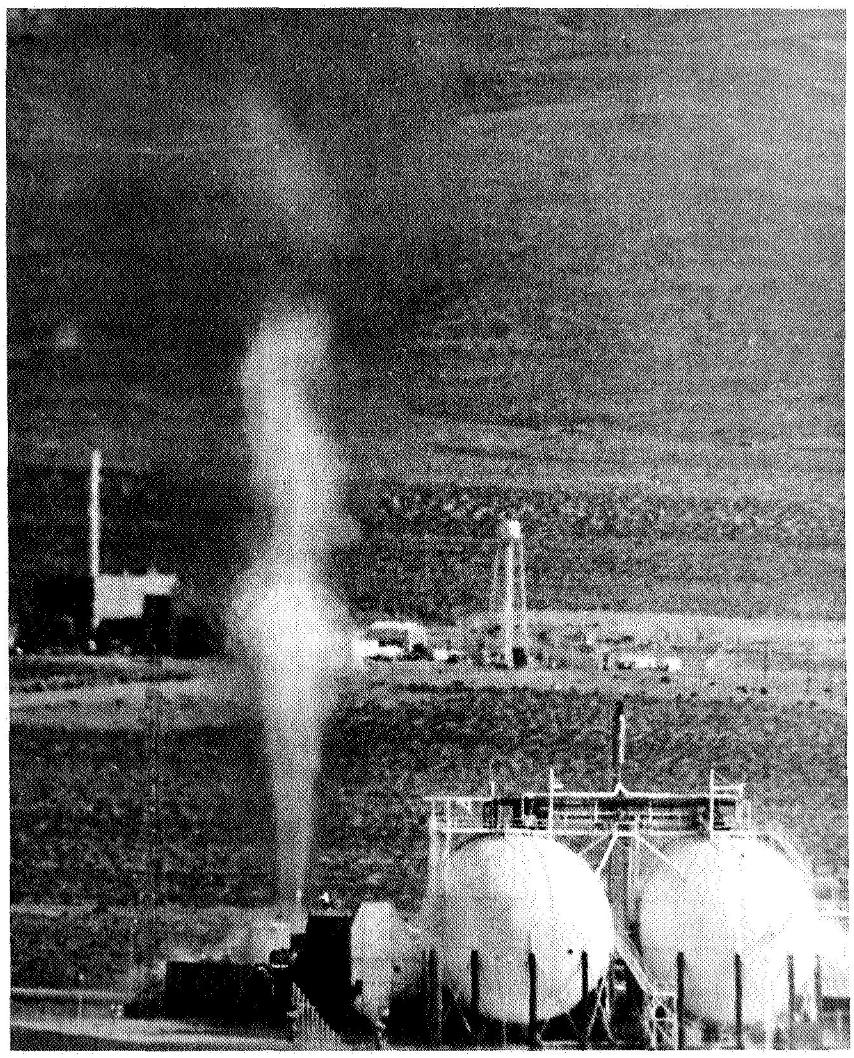


Figure 5–1. The Phoebus 1–B reactor at full power.

which reduced the amount of structural by-pass coolant flow, yielding a substantial increase in specific impulse, experiments to reduce corrosion in the unfueled perimeter area, and other improved structural components.

While carrying on the Phoebus 1 reactor work, LASL also began to scale-up the available KIWI/NRX technology and to design and fabricate the high-power test reactors required to carry-out phase 2 of the

Phoebus technical plan. The first of these reactors, a cold-flow assembly called the Phoebus 2CF, was moved to the cell on June 16, as shown in fig. 5–2. On July 12, LASL began testing it under cold-flow conditions. The objectives of the test were to verify the structural and mechanical integrity of the Phoebus 2 reactor design, to evaluate the startup profile planned for the Phoebus 2A hot test, and to obtain as much run profile data as possible. The reactor system and test facility operated as planned, meeting all test objectives.

Hardware for the second test reactor was being shipped to the Nuclear Rocket Development Station (NRDS) for assembly in the Reactor Maintenance, Assembly and Disassembly building (R-MAD). This second reactor, called Phoebus 2A, is a scale-up of the 1000 to 1500 megawatt KIWI/NRX/Phoebus 1 reactors. The Phoebus 2A has a power level of approximately 5000 megawatts. It is expected to provide the basic design and performance data for the high-powered NERVA engine reactor. Hot testing of the Phoebus 2A should begin in the winter of 1967/1968.

The objective of one contractor's effort is to obtain design information

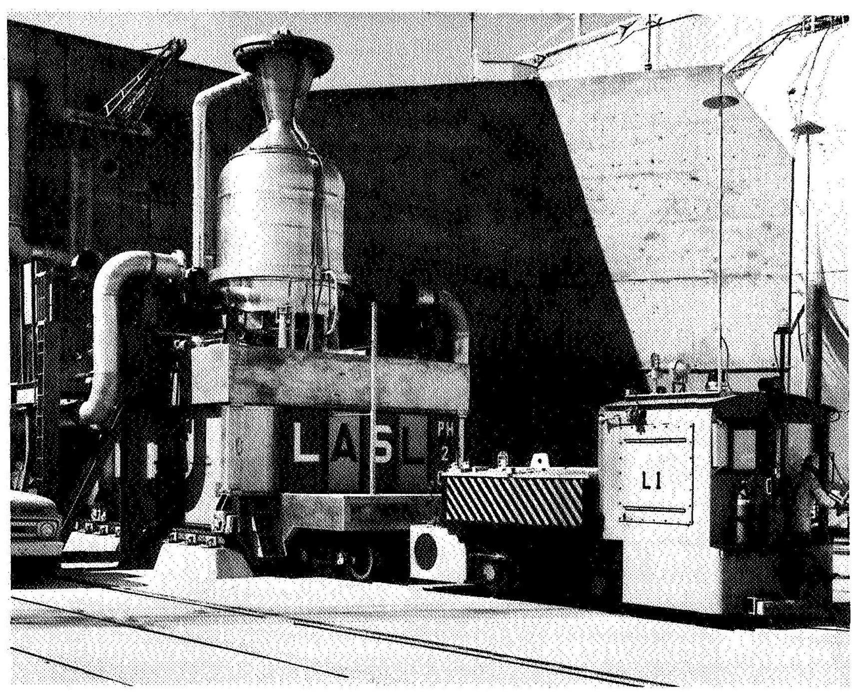


Figure 5–2. Installation of the Phoebus 2 cold-flow reactor at Test Cell C, NRDS.

applicable to the design and development of the NERVA engine reactor through a series of scaled down NERVA reactor experiments based on the LASL KIWI-B reactor technology. The test reactor being used by this contractor is a flight-type version of the KIWI-B called the NRX-A.

In the winter of 1967/1968, this contractor is expected to test NRX-A reactor number 6 (NRX-A6) at NRDS. The major objective will be to operate the NRX-A6 reactor at full design conditions (1100 megawatts) for as long as sixty minutes. The post-mortem analyses of the NRX-A6 should provide the answers to many questions relating to the design of the NERVA engine reactor. In addition, the post-test analyses of A6 fuel-elements should indicate how accurately electrically-heated, furnace corrosion tests of single fuel elements can predict fuel-element performance in test reactors. Assembly of the NRX–A6 reactor was in progress at the end of the period, with hot testing scheduled for November/December 1967.

It is significant that the NRX–A6 will contain the first fuel-elements ever rated for 60 minutes of reactor operation. The development of the process for producing these elements is the culmination of years of effort by many program participants.

Engine System Technology Development

The remaining technology goals are to be achieved through ground experimental engine (XE) investigations in Engine Test Stand No. 1 (ETS–1) at NRDS. (Fig. 5–3.)

The design of the XE engine is similar functionally to the Breadboard Engine System (NRX/EST) tested last year. The major difference between the two engines is in the physical arrangement of components; the XE engine arrangement more closely approximates that of a flight configuration. Also, the XE engine is assembled in two major subassemblies to facilitate the remote replacement of subsystems should such maintenance be required during an engine test.

During this report period, assembly of the major components of the first XE engine, a cold flow assembly (no uranium fuel in the reactor core), was completed. This engine, called the XECF, will be used to verify that Engine Test Stand No. 1 is ready for hot engine testing. It will also be used to investigate engine startup in the test stand under simulated altitude conditions. Other objectives include verifying operating procedures that have not been demonstrated in previous tests and investigating engine malfunctions under simulated conditions. The XECF test program was scheduled to start during the last quarter of 1967.

In addition to the work on the XE cold-flow engine, assembly of

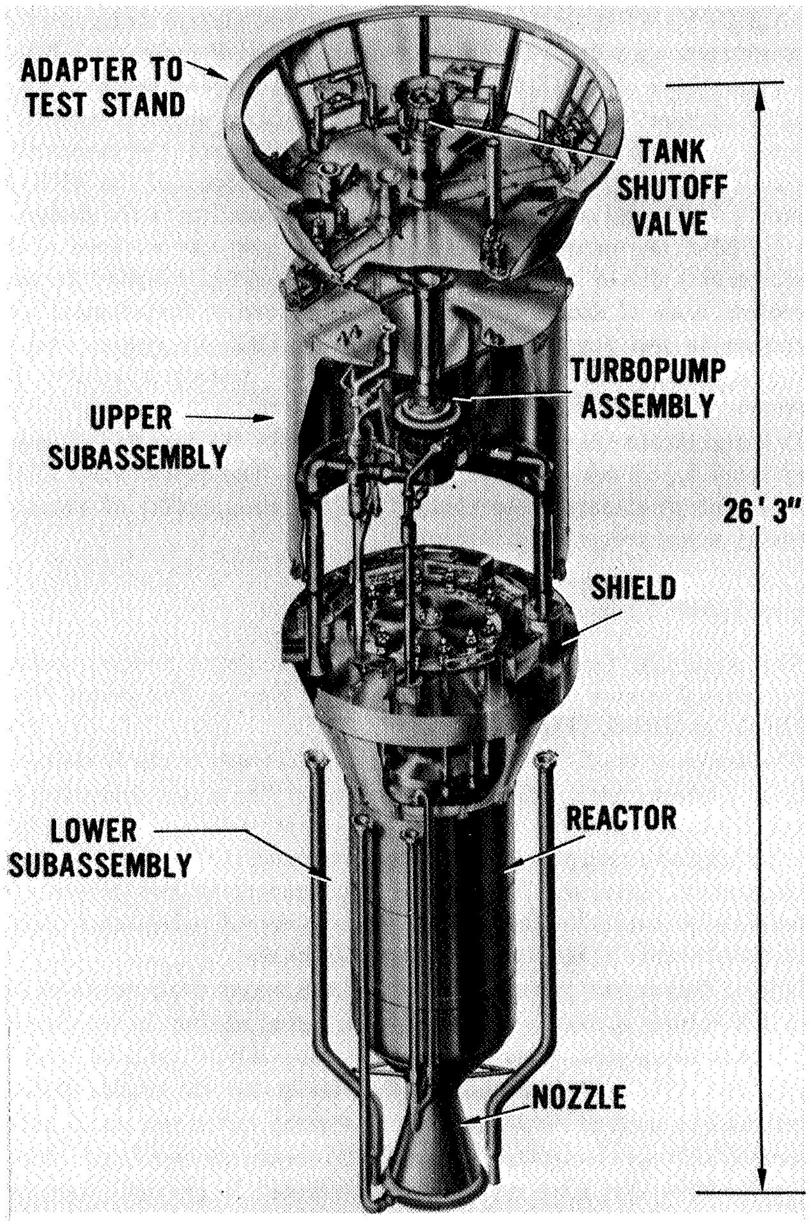


Figure 5–3. Ground experimental engine (XE).

the XE-1 "hot" engine was initiated at NRDS. Tests of the XE-1 were scheduled to begin in the first quarter of 1968.

The testing of the XECF, XE-1, and XE-2 engines will take place in ETS-1 at NRDS. Each engine will be fired downward into an exhaust duct in a manner that will simulate high altitude operation.

The construction of ETS-1 was essentially complete, and facility experimental plans were in progress to verify the various facility systems. The test stand safety systems were under intensive study, and some delays were anticipated so the systems could be modified to preclude operational difficulties.

A radioactively "hot" engine from ETS-1 is to be removed remotely by a locomotive driven Manned Control Car and Engine Installation Vehicle (MCC/EIV) (Fig. 5–4.) These vehicles were acceptance tested at NRDS during this report period and were ready for operation.

All XE engines are to be maintained, assembled, and disassambled in a building called E-MAD at NRDS. This building was partially activated on June 8 and should soon be ready to support engine testing.

Other Development Activities

Each test of reactor and engine conducted at NRDS is the culmination of many concerted development activities. In addition, each test serves as a building block for advancing the current state of the technology

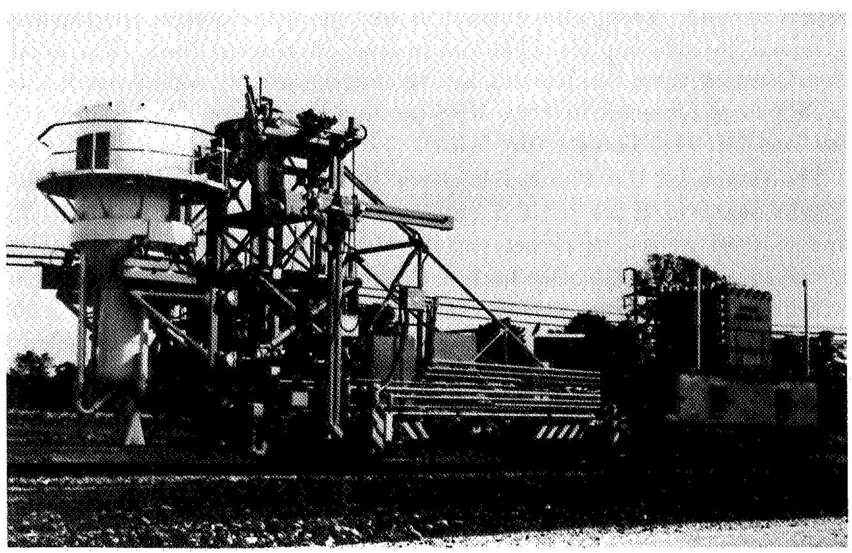


Figure 5–4. Engine remote installation equipment with Engine Mock-Up.

and for designing, developing, and fabricating the components required to conduct the next test.

The primary component development effort in the reactor program is devoted to extending the duration and temperature capability of the reactor graphite components (fuel elements, etc.). Corrosion of these components by the hydrogen propellant limits the duration in which a reaction can be operated at appreciable powers. Recent development work on fuel elements, as born out by electrically-heated corrosion furnace testing, indicates that process improvements in the coating of these graphite components have provided better resistance to corrosion. Fuel elements coated by the improved process have consistently experienced less corrosion in 60 minutes of corrosion furnace testing than the average corrosion experience by the fuel elements in the NRX-A5 after 30 minutes at full power.

For other reactor core components, the use of improved materials seems to offer the best solution for extending duration and temperature capability. The search for such materials has led to the development of an entirely new class of materials referred to as metal-carbide-graphite composites. They have the good thermal-shock resistance characteristics of graphite and the corrosion resistance of the metal carbides. The temperature limits for these materials have not yet been determined, but there are indications that they will provide a substantial increase in temperature capability. All of these improvements will be demonstrated in future reactor tests.

In addition to the reactor component work conducted during the report period, work also continued on the non-nuclear components required to conduct the next generation of reactor tests. The most significant of these components are the regeneratively-cooled nozzle for the Phoebus 2 reactor and the NFS-3b liquid hydrogen feed system for the Test Cell "C" facility (fig. 5–5.)

The design of the Phoebus 2 nozzle is similar to the design of the U-tube nozzle used for NRX-A reactor testing, except that Hastelloy X was selected as the principal structural material (instead of stainless steel) to accommodate the higher Phoebus 2 operating temperatures and stresses. The larger size of the nozzle also required developing and using new fabrication techniques. These techniques yielded excellent results.

During this report period, two Phoebus 2 development nozzles were fabricated. One of these nozzles was used on the Phoebus 2CF reactor, tested in July. All of the technology from this development effort is to be applied directly to the development of the nozzle for the high-powered NERVA engine.

During the first half of 1967, the NFS-3b propellant feed system was

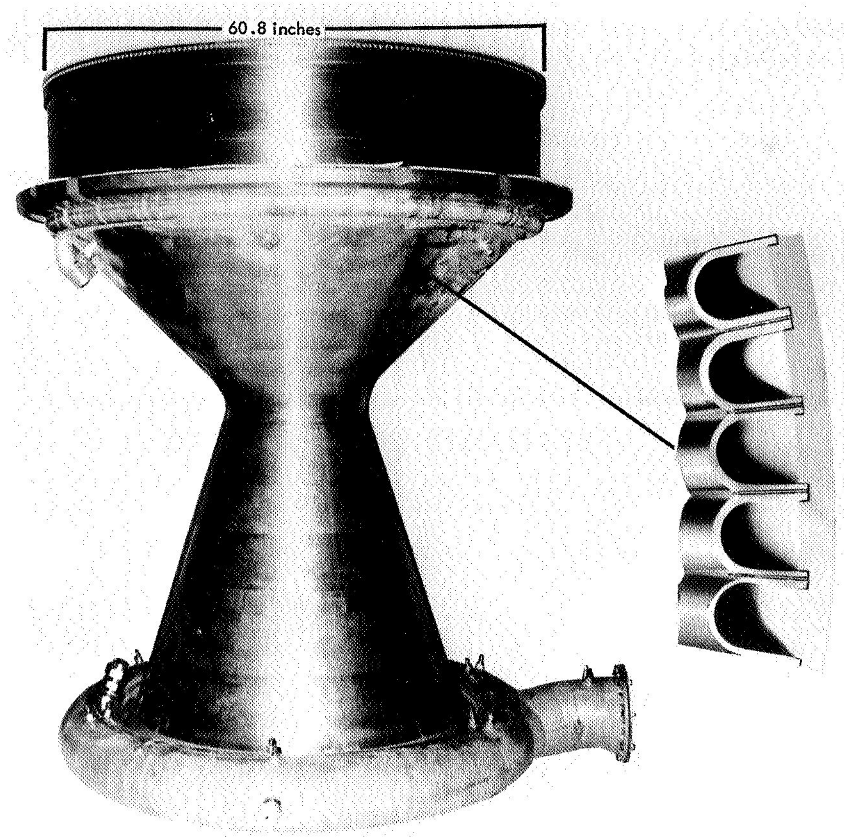


Figure 5–5. Phoebus-2 U-tube nozzle.

development tested (fig. 5–6.) As described in the Sixteenth Semiannual Report, the basic unit of this system is the Mk 25 turbopump. For the NRX and Phoebus 1 series of reactor tests, a single Mk 25 turbopump is used and the feed system is run in what is called single-mode operation. For the Phoebus 2CF reactor test, two turbopumps were coupled in a parallel arrangement (dual-mode operation) to provide the required flow rate (approximately 285 lb./sec.). This same configuration is to be used in the future tests of the Phoebus 2A and NERVA engine reactors.

During test runs, the NFS-3b system performed in an excellent manner. The system was operated in both the single and dual modes to obtain frequency response information, and pump mapping data to 34,000 rpm. In addition, the system was operated in the single mode to obtain data on the flow conditions for the NRX-A6 reactor, to investi-

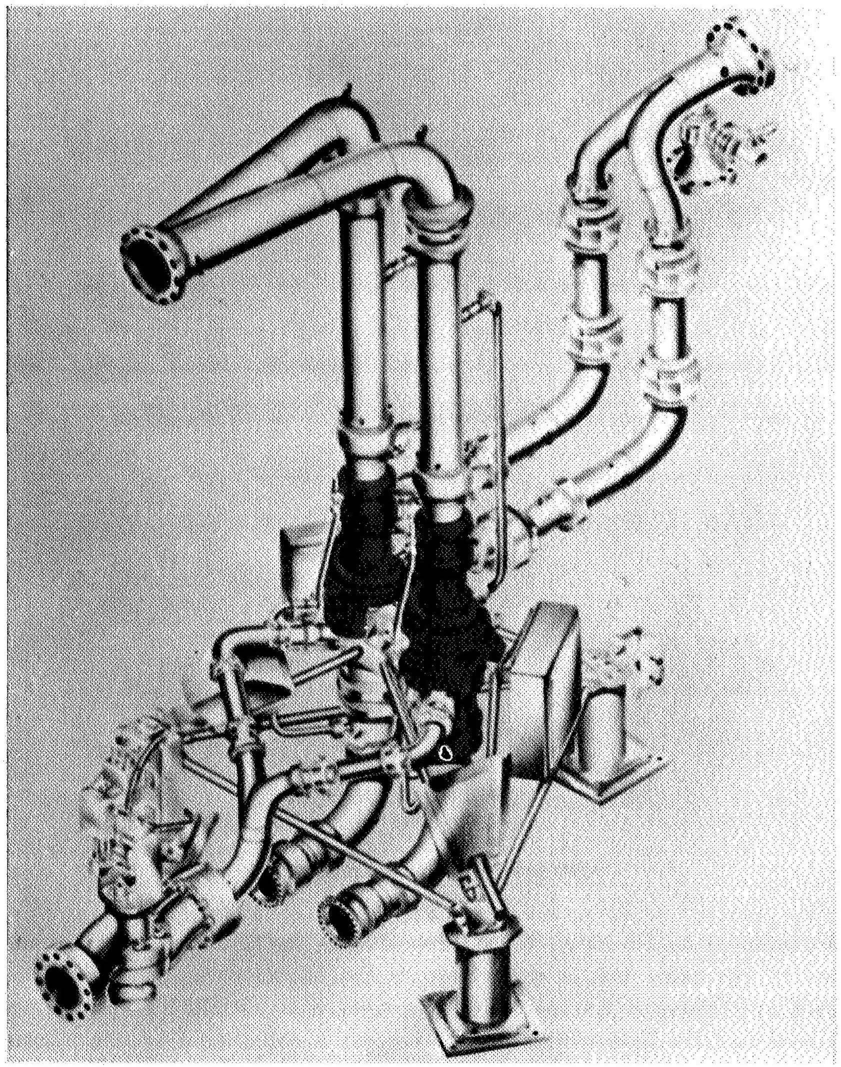


Figure 5–6. NFS–3b feed system for Phoebus reactor.

gate system stall characteristics, and to study the behavior of the complete hydrogen flow system during shutdown. Approximately 30 minutes of operation at 34,000 rpm were accumulated on a single turbopump. In one test, the same assembly was operated at 36,000 rpm to demonstrate overspeed capability. System performance was smooth and stable at this speed.

NERVA Engine Development

Preliminary studies and design were underway on the NERVA engine. In addition, the specifications for many of the engine components and subsystems were being prepared. Long range planning studies indicate that the first full-power ground tests of the engine could be carried out in the 1972–73 period.

The NERVA engine will be tested in a facility complex called Engine/Stage Test Stand 2–3 (E/STS 2–3) to be located at the Nuclear Rocket Development Station (fig. 5–7.) E/STS 2–3 is a large test complex that includes two test positions, an underground control point, storage facilities and transfer systems for liquid and gaseous hydrogen and nitrogen, an instrumentation and control system, and a system for handling engine exhaust gases. The stands will be able to test a complete propulsion module, or nuclear rocket stage, when stage development is initiated.

One of the largest and most difficult parts of the new test facility will be the exhaust handling system. This system is to have the dual function of providing altitude simulation and channeling the engine exhaust.

A hydrogen tank and associated hardware, termed a Ground Test Module (GTM), is to be installed in Engine/Stage Test Stand 2–3 for engine tests. Development of the GTM will be an integral part of the NERVA engine development activity. The GTM will be a battleship

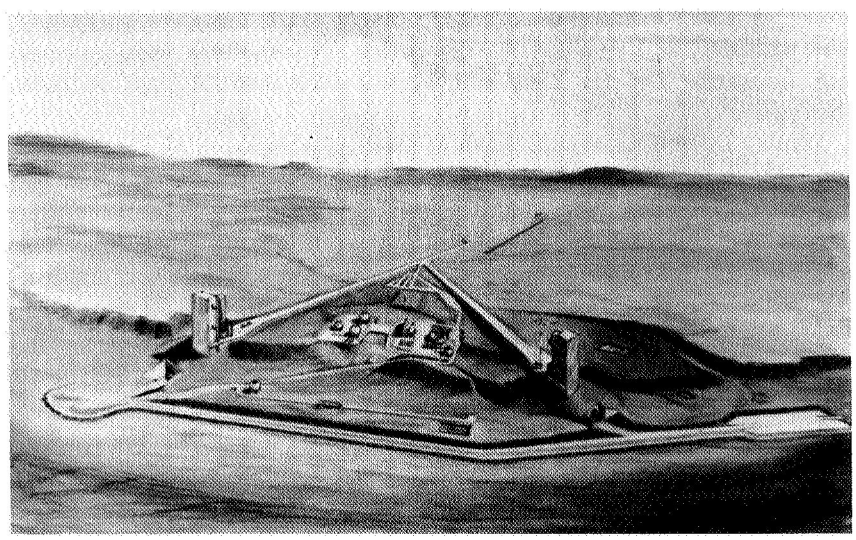


Figure 5–7. Engine/Stage Test Stand 2 and 3 Complex Site Plan.

tank fitted with a flight-type tank bottom and necessary propellant-handling subsystems (such as pressurization and venting). It will be similar in size and configuration to a nuclear propulsion module designed for flight application.

In addition to being a necessary part of the NERVA engine development tests, the GTM will provide data on propellant heating and dynamic behavior, sub-systems functional compatibility, and engine/stage interface problems. These data would be useful in flight stage design, improvement of analytical techniques for predicting flight conditions, and the development of stage subsystems.

Two GTM units are to be installed at NRDS, and a third is to be used for cold flow testing at the Marshall Space Flight Center (MSFC). The NRDS units will be installed in E/STS 2–3 for the NERVA engine test program. MSFC (in-house) is to design and fabricate the GTM. Cold flow testing will be done in the existing S-IC test stand for the first stage of the Saturn V at MSFC. Thus, the GTM program would make maximum use of existing components and the manufacturing and test facilities already available from the Saturn program.

Advanced Nuclear Rocket Propulsion Concepts

Certain non-solid nuclear rocket concepts appear to offer greater propulsion performance than that demonstrated by solid core nuclear rockets. The objective of the advanced concepts portion of the nuclear rocket program is to assess the feasibility and performance potential of such concepts. The major efforts center on Gas Core Nuclear Rocket Concepts and research on fuel containment, high temperature radiant heat transfer, and nuclear characteristics. These efforts were continuing, using the Coaxial Flow and Vortex Stabilized Concept to focus the research.

During the period, results of fluid mechanics research on the containment characteristics of the vortex stabilized concept indicated that the loss rate of nuclear fuel would be too high to be a useful propulsion device. Accordingly, the efforts on this approach were discontinued. Work on the fluid mechanics of the Coaxial Flow Concept was continuing, with some emphasis on larger scale experiments and on the effects of peripheral walls, nozzles, and buffer layers.

The glow plug or light bulb concept was selected as the second concept upon which to focus research activities. This concept would use a transparent material such as fuzed silica to separate the nuclear fueled region from the propellant region of the cavity reactor; however, while it offers the possibility of complete containment, it adds a complex materials problem to the gas core problems.

Research work on high temperature radiant heat transfer was also continued, using three additional techniques: a flash heating experiment, a free piston compressor, and RF (radiant flow) heating to generate the high temperatures required.

Work on the nuclear characteristics of cavity reactors included experiments with gaseous nuclear fuel (UF_6) replacing the uranium foils used in previous cavity reactor critical assemblies. While UF_6 would not be suitable for the propulsion application, it is useful for experimental purposes since there is no need to correct data for flux depressions and geometry effects associated with foils.

The SNAP-8 Development Project

During this period, emphasis was placed on getting the boiler and turbine to perform satisfactorily and on obtaining endurance data on the remaining components which have already met their design requirements. Testing of the first SNAP-8 turbine was completed, and an improved turbine and boiler were fabricated.

Both components were redesigned to correct life and performance deficiencies observed from previous testing. Testing of the redesigned turbine and boiler will begin in the last quarter of 1967. A breadboarded power conversion system was nearing completion at the Lewis Research Center, and will provide the first tests of the redesigned boiler.

In addition, three new facilities for testing system pumps, alternator, and experimental single tube boilers were completed and made operational.

Nuclear Electric Power Research and Technology

Continuing research and development work on a number of space power concepts achieved significant results during the period.

Rankine Turbo-Generator Technology

Progress was made in fabricating the following major components: an electromagnetic boiler feed pump, a 235kw 3-stage potassium vapor test turbine, and an advanced alloy 2100°F potassium corrosion loop. The pump and corrosion loop should be completely built and ready for start of tests before the end of 1967. This pioneering work seeks to establish the feasibility of developing high power space systems using alkali metal vapors as working fluids.

Thermionic Conversion Technology

The thermionic conversion program continued to emphasize research concerned with the technology needed for development of a thermionic in-core reactor system. On the basis of recent test results, a tungsten emitter which was processed to expose an active crystal surface showed marked improvement in performance over the other forms of tungsten previously used. Preliminary data also indicate that this crystal orientation is stable and is not destroyed by long term operation at temperature.

Progress was being made in correlating the effects of fuel porosity upon performance of the uranium fuels used in high temperature thermionic cells. A test of one fuel incorporating fission gas venting provisions was recently completed at the NASA-Plum Brook Reactor, and an advanced irradiation capsule has been designed which incorporates a mock-up of the nuclear fuel in a configuration that would

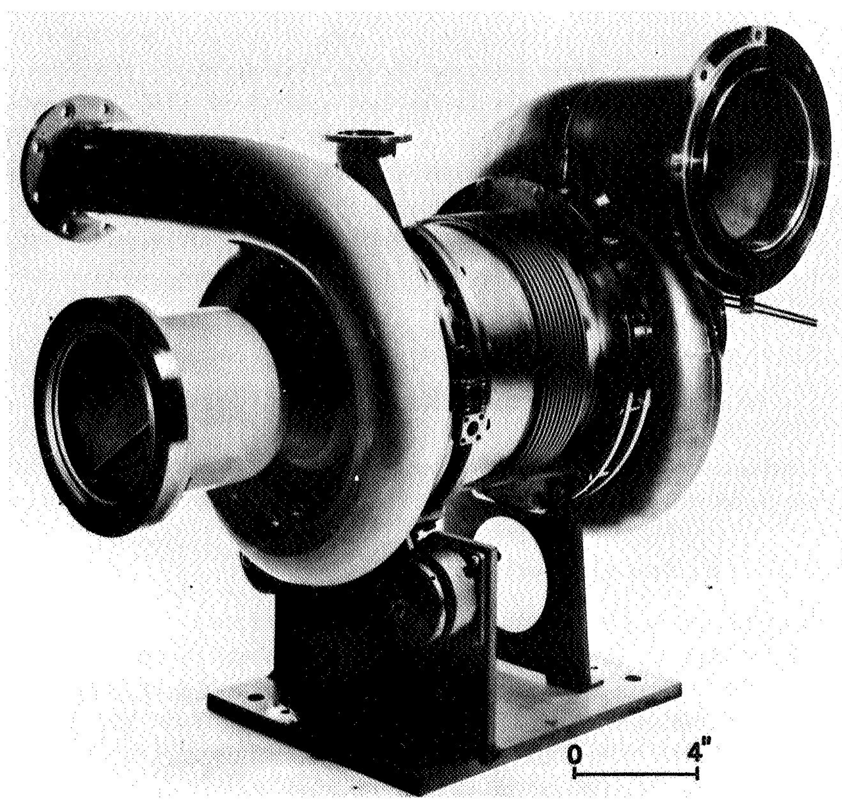


Figure 5–8. Turbo-compressor for Brayton Gas Turbine Cycle.

exist in a thermionic converter. Such capsule testing allows determination of relevant fuel properties without the test complication introduced by simultaneous operation of a converter. A test program is also proceeding, aimed at determining the effectiveness of various "vent" designs which will allow fission gases to escape and at the same time minimize fuel loss due to high fuel vapor pressures.

Low Power Brayton Cycle Equipment

Because of the high cycle efficiency predicted for an isotope-heated Brayton cycle power conversion system, the system is of interest as the power supply for unmanned and manned missions in the 5 kilowatt range. The current technology program is providing answers to the principal technical questions which relate to gas bearing performance, efficiency of low power small-size systems, and turbomachinery packaging problems. "Hot" flow testing of a gas bearing equipped radial turbo-compressor package was continued as NASA-Lewis (fig. 5–8.) One 10-hour closed loop test was performed at design speed and 1490°F turbine inlet temperature without mishap. Final design was completed and fabrication started of the smaller, 5.5km power unit which combines the turbine, alternator, and compressor on one shaft—a configuration more closely suited to near-term mission requirements.

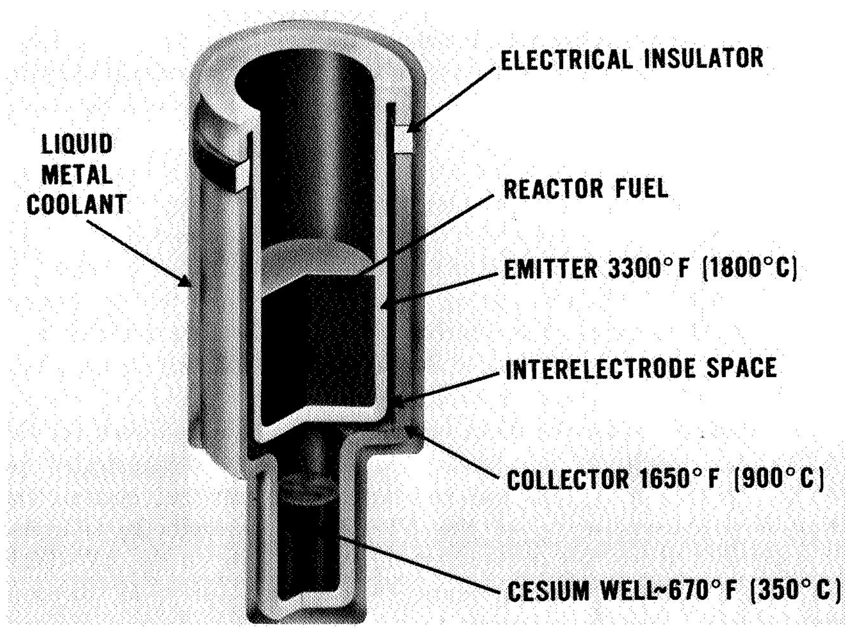


Figure 5–9. Nuclear thermionic converter.

Isotope Power

The SNAP-19 isotope thermoelectric system development was entering its final phase before being integrated with the Nimbus B for launch early next year. The SNAP-27 was also progressing satisfactorily, with construction on the isotope fuel cask being the pacing item. Electrically heated units were tested and qualified. (AEC is developing both SNAP-19 and SNAP-27 for NASA).

Work on the isotope-thermionic converter-heat pipe combination was continuing (fig. 5–9). Various wicking structures were being evaluated to determine limits of performance. Thermionic converters were being built in preparation for intensive testing with an improved heat pipe.

The Electric Propulsion Program

Electric propulsion systems continue to be studied and evaluated for auxiliary and prime propulsion applications. Auxiliary propulsion applications such as station-keeping and attitude control of long duration satellites may be performed by electric propulsion systems with a saving in system weight.

Certain unique features of contact ion engines offer the capability of electrostaticly positioning the thrust vector without the use of mechanical gimbals. Such a capability would avoid the torques which tend to upset the attitude of the spacecraft, a potentially significant factor for satellite control. In the area of prime propulsion, electric propulsion provides potential payload gains or the use of smaller launch vehicles for interplanetary spacecraft.

Auxiliary propulsion systems for the Applications Technology Satellite (ATS) constitute a major program effort. A resistojet experiment with a design thrust level of 5×10^{-4} pounds was conducted on ATS-I which was launched on December 6, 1966 (fig. 5–10.) Results from this flight experiment, analyzed during the period, indicated that the system did not produce thrust. Subsequent analysis of the data revealed that the thruster system was damaged during pre-flight testing or handling, causing loss of propellant prior to flight.

An additional resistojet flight experiment was being planned for the ATS-C spacecraft. If satisfactory performance is demonstrated on ATS-C, NASA intends to use resistojets as operational systems for East-West station-keeping of the ATS-D&E spacecraft. In addition, it is planned to conduct station-keeping experiments on the ATS-D&E with cesium contact ion thrusters. Development for these thruster systems with a maximum thrust level of 2×10^{-5} pounds was initiated in March under the direction of the Goddard Space Flight Center.

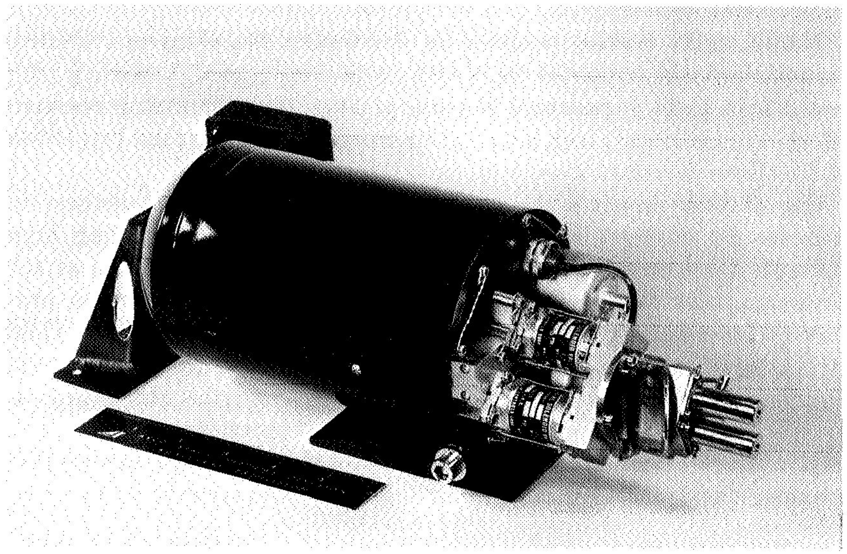


Figure 5–10. Resistojet experiment for ATS.

In the prime propulsion area, major attention was focused on the planned SERT II suborbital flight test, under the direction of the Lewis Research Center. Objectives of this flight are to demonstrate ion thruster system technology in the space environment for an extended time period (6 months), and to assess the extent of interactions between the thruster system and the spacecraft.

The mercury electron-bombardment thruster to be flown on SERT II is being designed in-house at the Lewis Research Center. Thruster efficiency equal to that which was set as a goal at the initiation of the project was demonstrated. This achievement represents the highest thruster performance yet attained for the mercury electron-bombardment ion engine. A preliminary life test of approximately 1000 hours duration indicated that this performance is attainable without any sacrifice in thruster life. Longer duration life tests are planned to conclusively demonstrate the life of this thruster design. A successful SERT II flight (scheduled for 1969) will represent a major step toward the application of prime electric propulsion systems.

Space Power Research and Technology

Solar power generation and electric power technology continued to receive emphasis during the reporting period.

Solar Power Generation

NASA made further progress in developing the aluminum electroforming process (reported in NASA *12th Semiannual Report,* p. 87; and NASA *14th Semiannual Report,* p. 140). Two promising research efforts are underway, both aimed at improving the mechanical properties of the electrodeposited aluminum.

One of these involves the electroforming of composite structures to increase the strength of the aluminum deposit by incorporating high strength fibers or microspheres. The other concerns the alloying of the aluminum with other metals (e.g., magnesium). Both approaches produced encouraging results, providing an increase in tensile and yield strengths of about 100% over the electrodeposited pure aluminum. Significant further improvement in mechanical properties and in process control are expected from future work. Such improvement should lead to a number of important aerospace and industrial applications (for example, the fabrication of very lightweight, non-magnetic solar array substrates).

The present electroforming aluminum process is finding highly useful applications where mechanical strength is not critical: cladding other metals for corrosion protection, and fabricating high integrity liners for pressure vessels. The usefulness of the process will be broadened widely by the previously mentioned mechanical property improvements.

Electrical Systems Technology

During the period, a new control circuit concept was experimentally demonstrated at the Electronics Research Center. This concept may satisfy the long time need for a general purpose standard control block for pulse modulated power conditioning circuits (inverters, converters, regulators). Such control circuits handle very little power, but are critical to the reliable operation of the power conditioning equipment.

If such a single circuit concept can be successfully defined and can accommodate the many varied pulse modulated control applications, it will be possible to consider an integrated circuit for the purpose. Such an application would provide increased reliability. This circuit concept also offers significant improvements in long term stability and accuracy since it inherently compensates for drift or variation in component parameters.

Chemical Power Generation

Notable advances were made in simplifying the operation of the best presently available space fuel-cell system, and in determining its capabilities and resistance to abuse. This is a hydrogen-oxygen module of better

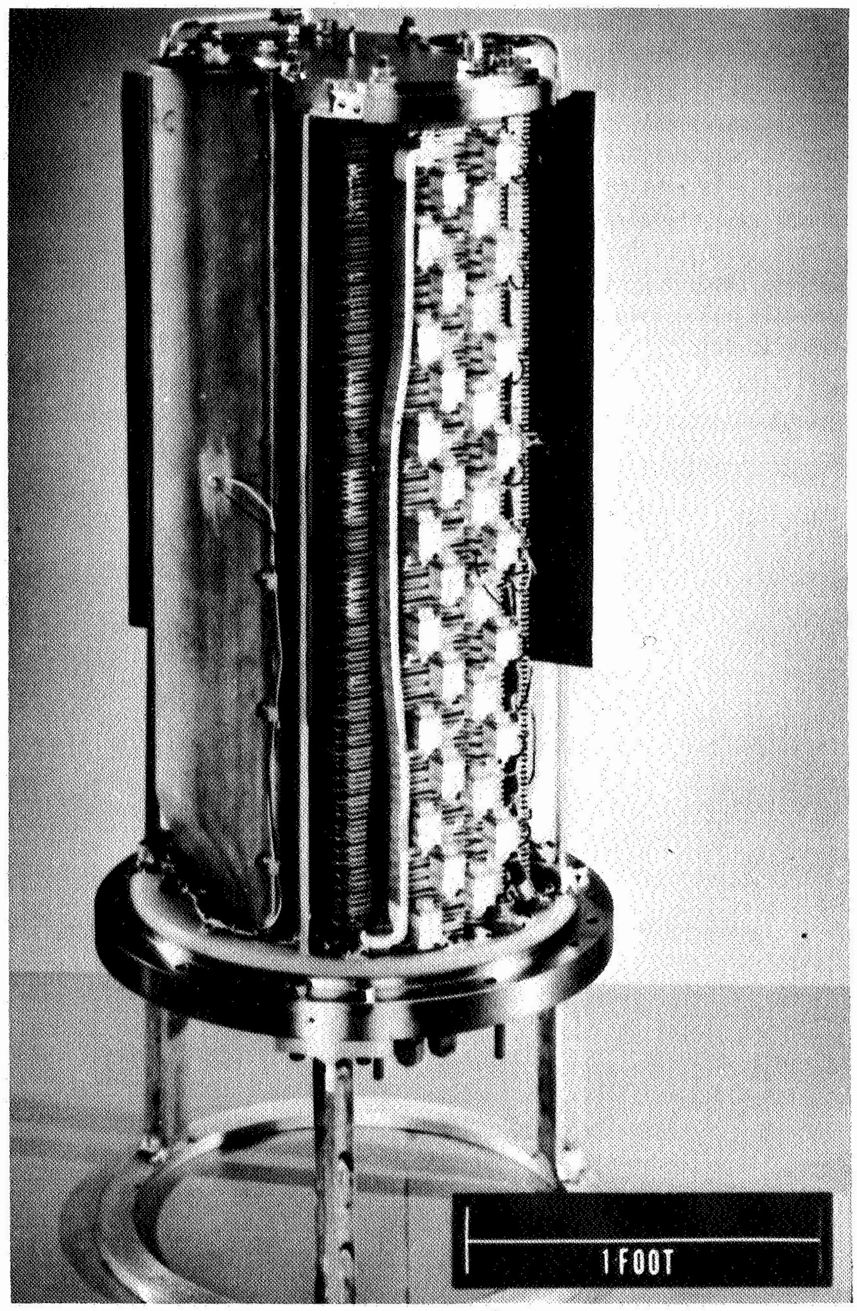
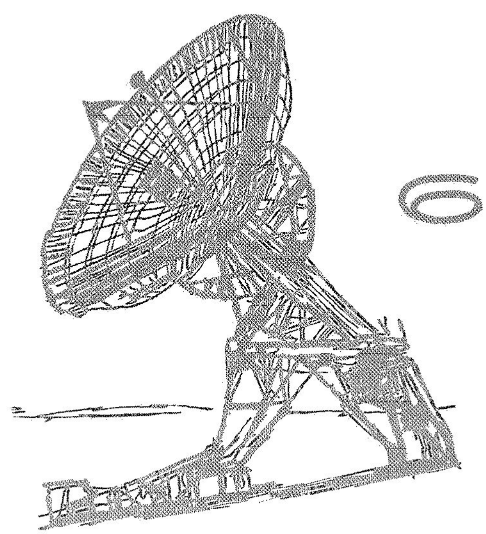


Figure 5–11. One kilowatt hydrogen-oxygen module.

than 1 kilowatt sustained performance, engineered for 2kw peaks, employing an asbestos matrix for the electrolyte, and operating at 190°C (fig. 5–11.)

Through a series of tests, investigators learned that this system can be "bootstrapped" from room temperature to full power in a few minutes, started and stopped dozens of times without ill effect, kept in stand-by condition or turned off without the need for flushing with helium gas, operated even above 3kw for hours and above 5kw for seconds, and run for over 2007 hours within voltage and power specifications. Both improved catalysts and electrode structures and decreased parasitic power consumption have significantly improved the efficiency of this module.



6 TRACKING AND DATA ACQUISITION

The NASA tracking networks supported 62 missions during this report period (fig. 6–1.) Forty-one of the satellites and spacecraft involved in these missions were launched prior to January 1, 1967. Some of the major NASA missions initiated and supported during this period were Lunar Orbiters III and IV, Surveyor III, and the Mariner V mission to Venus.

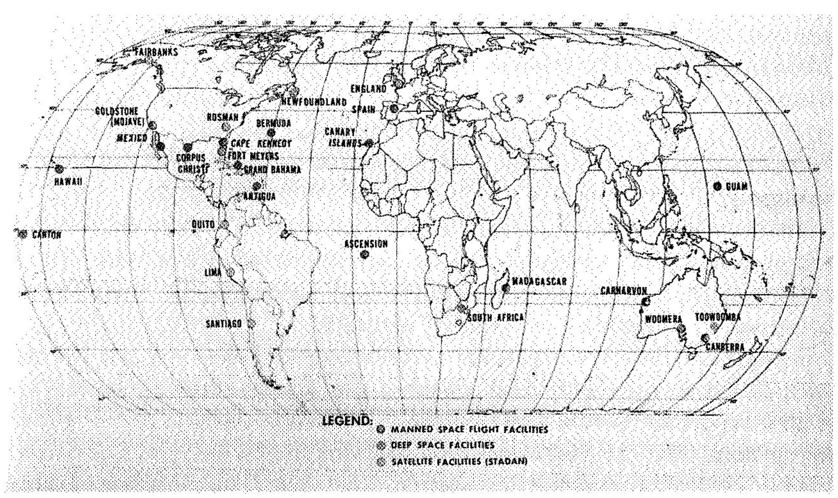


Figure 6–1. NASA Tracking and Data Acquisition Stations.

One of the highlights of the report period occurred during the support of the Surveyor III spacecraft which successfully soft landed on the moon on April 19, 1967. After receiving verification of the spacecraft's condition, the Goldstone tracking station monitors sent commands on April 21 to activate the surface sampler. This pantograph mechanism, responding to those commands which were relayed by the Deep Space Network, dug trenches and otherwise manipulated the lunar soil in the field of view of the spacecraft's television camera. The precision with which this experiment was executed clearly demonstrated the Network's ability to command and control a spacecraft resting on the surface of the moon.

Also, the Agency incorporated into the NASA Communications System (NASCOM) the necessary communications satellite service to meet the requirements of the Apollo program. On February 4, NASCOM began receiving service from the Intelsat II F-2 satellite which is in synchronous orbit over the Pacific Ocean. Service from Intelsat II F-3, positioned over the Atlantic Ocean, began on April 7.

The Network augmentations for Apollo continued. New land stations became operational, computer programs were being written, sea trials of the instrumentation ships and delivery of range aircraft continued, and personnel were being trained to operate and maintain the network facilities.

Manned Space Flight Network

The Manned Space Flight Network continued to play an active role in support of NASA flight missions, despite the delay in manned Apollo missions. Selected network stations such as Bermuda and Carnarvon (Australia) provided support during the reporting period to many unmanned missions, including Surveyor, Lunar Orbiter, and the Orbiting Geophysical Observatory. In addition, the network supported the Titan III-C vehicle development flights and other Department of Defense programs.

The network, as configured for Apollo lunar mission support, will consist of ten 30-foot antenna stations, one transportable station with a 30-foot antenna, three stations with 85-foot antennas, five instrumentation ships, and eight instrumentation aircraft.

Substantial progress was made in installing and checking out the network facilities and equipment required for Apollo support. At the end of this reporting period eight of the ten 30-foot antenna stations were operational, and the two remaining stations are to become operational later in 1967. The transportable station, located at Grand Bahama Island, became operational in March.

The 85-foot diameter antenna stations are located approximately 120 degrees apart in longitude at Goldstone, California; Canberra, Australia; and Madrid, Spain. Such spacing makes certain that during a manned lunar mission at least one station will be in contact with the spacecraft. All three of these stations became operational during this reporting period.

Also, the three Deep Space Network stations were modified to provide support to the Apollo Program. These stations are collocated with the Manned Space Flight Network's 85-foot antenna stations, assuring the continuous availability of an 85-foot diameter antenna station during the critical lunar mission phases.

The ships and aircraft were being completed and delivered on a time-phased basis consistent with the current flight schedule.

To accelerate qualification of the stations, the network was using the Lunar Orbiter spacecraft to simulate the Apollo lunar mission operations. After the Lunar Orbiter spacecraft complete their primary mission objectives (photographing the lunar surface), the network stations track the spacecraft and supply real-time data to the Mission Control Center, Houston, Texas. In this way, an end-to-end check is made at very low cost of operational procedures, equipment capabilities, and control programs under near-actual mission conditions. Use of the Lunar Orbiter spacecraft for simulated Apollo missions began in January and will continue through the first quarter of 1968.

Deep Space Network

The Deep Space Network, which supports NASA unmanned flights to the moon and planets, experienced an unprecedented workload during this half year. It was supporting the Mariner IV, Pioneer VI and VII, and Lunar Orbiter II missions, and this support continued throughout the period. Support of the Lunar Orbiter II primary mission objective, receipt of photographs of the lunar surface, was completed during the previous reporting period. This total effort produced over 400 photographs of the moon's surface. The stations continued to support the mission, receiving and recording information on radiation and meteoroids in the vicinity of the moon. Also, the network was acquiring data on changes to the spacecraft's orbit characteristics, permitting a better determination of lunar gravitational and shape constants.

Additionally, the network provided coverage to four major flight missions launched during the period: Lunar Orbiters III and IV, Surveyor III, and Mariner V. The workload was compounded in May, when the Network was supporting seven flight missions while concurrently preparing for the Mariner V mission to Venus (launched June 14, 1967; encounter with Venus due October 19, 1967).

To maintain continuous mission coverage, these network stations are also placed approximately 120 degrees apart in longitude around the earth, so that the spacecraft is always within the field of view of at least one of the ground stations. At the end of the report period, the network consisted of: (a) operational 85-foot diameter antenna stations at Goldstone, California; Woomera and Canberra, Australia; Johannesburg, South Africa; and Madrid, Spain; (b) an operational 30-foot diameter antenna at Ascension Island; and (c) a 210-foot diameter antenna facility at Goldstone. A Launch Checkout Station at Cape Kennedy, Florida, and the Space Flight Operations Facility (SFOF) located at the Jet Propulsion Laboratory in Pasadena, California, complete the network. (Fig. 6–2.)

The SFOF is the centralized control center for the network's tracking and data acquisition activities. It is also the control center for spacecraft trajectory determinations, generation of the commands transmitted to the spacecraft, and analysis and interpretation of the data received. The spacecraft project manager, flight operations personnel,

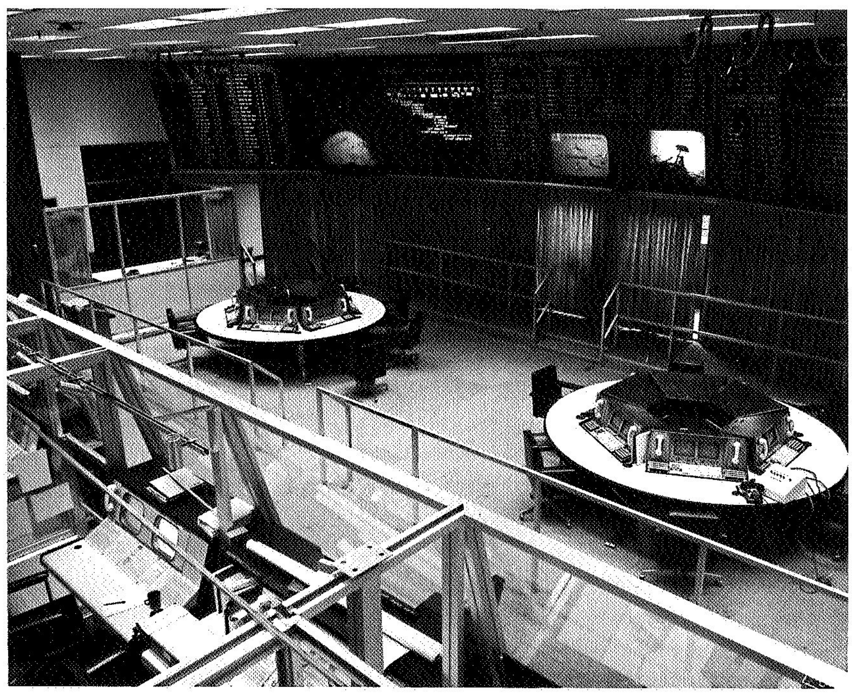


Figure 6–2. The SFOF, located at the Jet Propulsion Laboratory.

spacecraft engineers, and teams of scientific experimenters stationed at the SFOF during the mission are kept constantly informed of the status of the network operations and events and conditions aboard the spacecraft throughout the flight.

It was from the SFOF that the commands were sent to Surveyor III to activate and manipulate the "shovel" which was attached to the spacecraft. The successful operation of this surface sampler was one of the outstanding aspects of network support during the reporting period. In addition to yielding a wealth of scientific data, the shovel experiment demonstrated the network's ability to precisely control physical movements from a distance of 240,000 miles away.

Also extremely successful was the network's support of the Lunar Orbiter IV mission. Launched May 4, the spacecraft received and responded to over 7,000 commands sent from the SFOF. It transmitted 326 photographs of the lunar surface to the network ground stations. These photographs covered over 90% of the moon's surface and provided scientists with an atlas which is far more accurate and detailed than any presently available.

Satellite Network

The Satellite Network facilities support all of NASA's scientific and applications satellite programs. They are also used to support the space efforts of other government agencies, private industry, and foreign governments as well.

The support is provided through the electronic facilities of the Space Tracking and Data Acquisition Network (STADAN), operated under the management of the Goddard Space Flight Center (GSFC). The STADAN, at the end of the reporting period, consisted of facilities at 14 United States and foreign locations and a centralized control center at GSFC, Greenbelt, Maryland. The station locations are as follows:

United States	*Foreign Countries*
Fort Myers, Florida	St. John's, Newfoundland
Fairbanks, Alaska	Winkfield, England
Goldstone, California	Johannesburg, South Africa
Rosman, North Carolina	Tananarive, Madagascar
	Carnarvon, Australia
	Toowoomba, Australia
	Canberra, Australia
	Quito, Ecuador
	Lima, Peru
	Santiago, Chile

An optical tracking network aids the STADAN stations in providing this support. This optical support is provided through Baker-Nunn and

Geodetic camera stations operated by the Smithsonian Astrophysical Observatory.

The number of scientific and applications satellites supported by the Satellite Network continued to increase. During the reporting period, the STADAN facilities supported 56 satellites which collectively contact the network stations more than 650 times per day. Fifteen of these satellites were launched from January 1 through June 30, 1967, as follows:

Mission	*Date Launched*
* Intelsat II F–2	January 11
TOS–B	January 26
OSO–E	March 8
* Intelsat II F–3	March 22
ATS–A	April 5
TOS–C	April 20
San Marco B	April 26
** ERS–18	April 28
** ERS–20	April 28
** ERS–27	April 28
UK–E	May 5
IMP–F	May 24
ESRO	May 29
** Aurora–1	June 29
** EGSR–9	June 29

* Communications Satellite Corporation (ComSat).
** Department of Defense Scientific Satellites.

In April, the successful launch of the San Marco Satellite from Formosa Bay off the East Coast of Kenya, Africa, represented another achievement by the Italian Commission for Space Research (CRS). Under the terms of the intergovernmental agreement, STADAN provided tracking data to the cooperative CRS/NASA project. The San Marco mission is an example of STADAN participation in the increasing international space effort.

NASA Communications System

The NASA Communications System (NASCOM) is a worldwide network of operational communications lines and facilities which interconnect the mission control centers, launch areas, test sites, and the foreign and domestic tracking stations. The domestic portion of the network is fully leased from the communications common carriers, while the overseas portion is leased from the foreign administrations who provide the communications to the tracking sites.

The NASCOM provides communications service in support of all NASA flight programs, as well as programs of other agencies as mu-

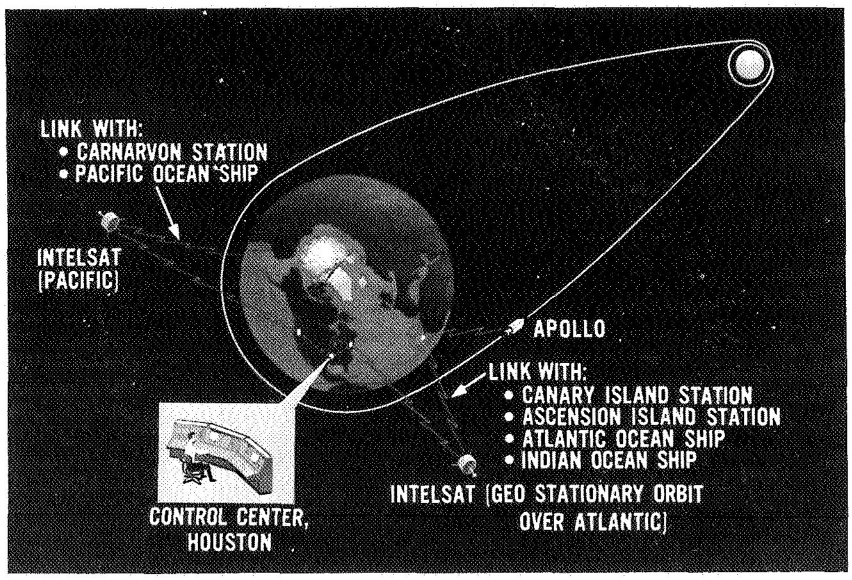


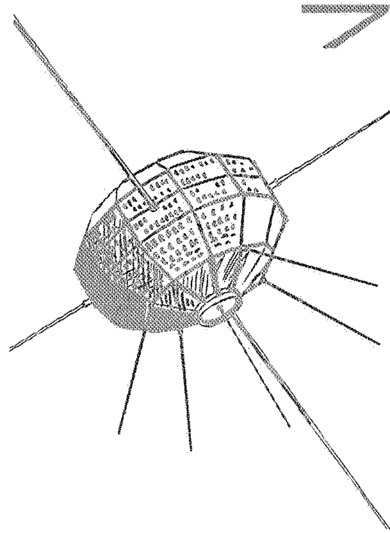
Figure 6–3. Use of Intelsat for Apollo Communications.

tually agreed. Designed as a common user or shared network for multi-program requirements, NASCOM obviates the need for separate circuits to collocated tracking facilities (the same circuits service both the Manned Space Flight and Deep Space Network facilities which are collocated at Madrid, Spain).

NASCOM's reliability was improved significantly during the reporting period by the initiation of communications service via commercial satellites. NASA orginally planned to initiate service in 1966. However, the first Intelsat II satellite, launched in October, 1966, failed to achieve proper orbit, and its hours of operations were therefore restricted. A second satellite, launched by NASA for the Communications Satellite Corporation (ComSat) on January 11, 1967, did achieve proper orbit and is providing continuous coverage of the Pacfic Ocean area. The third of the Intelsat II satellites was launched on March 22, 1967, and is providing service for the Atlantic Ocean area. (Fig. 6–3.)

7

INTERNATIONAL AFFAIRS



The first satellite launching at sea and the signing of an agreement involving the use of a NASA vehicle on a reimbursable basis were among the Agency's accomplishments during this period. Additionally, new international cooperative space and atmospheric projects and international support activities were developed while others were continued.

Cooperative Projects

NASA cooperation with foreign governments in space research produced several new developments during the initial half of 1967. The first satellite launching at sea culminated a cooperative space project, San Marco II, between NASA and the Italian Space Commission. The third in a series of United Kingdom satellites (Ariel III) was successfully launched by NASA on a Scout fourstage rocket from the Western Test Range.

As a result of a tripartite agreement between the United States, Germany, and Brazil, two highly successful launchings of Javelin sounding rockets took place at Natal, Brazil. These were the largest vehicles ever launched from that range. Japan also continued its cooperation with the United States by providing ten of its own small meteorological rockets (the MT 135) for sounding experiments at Wallops Island, Virginia, to compare with ten meteorological rocket systems provided by NASA.

A contract signed by NASA and the European Space Research Organization (ESRO) on March 8, 1967, in Paris, marked a new development in NASA's international affairs program. By this agreement, ESRO will purchase a NASA launching for their HEOS-A (Highly Eccentric Orbit Satellite). The launch will be the first instance of a NASA vehicle being used by a foreign space activity on a reimbursable basis.

In all, six agreements were formalized; two of these involved NASA and Brazil, one involved the European Space Research Organization (ESRO), two were with Germany, and the other involved the United Kingdom.

Australia

In early June, NASA agreed to provide tracking and telemetry support for a small scientific satellite to be launched by the Australian Department of Supply. In late 1967, the satellite will be launched from Woomera on a modified U. S. Redstone rocket. It will carry ultra-violet and X-ray experiments of the Australian Department of Supply and the University of Adelaide. NASA will contribute advice on satellite design, construction, component procurement, and testing.

Brazil

Brazil and the United States cooperated on several projects during the reporting period. In addition to the previously mentioned tripartite agreement involving Germany and Brazil, Brazilian launch crews successfully launched a sounding rocket experiment on a NASA-supplied Nike-Tomahawk vehicle on March 27 from the range at Natal. The experiment measured the intensity of cosmic ray neutrons, charged particles, solar-ray fluxes, Lyman-alpha radiation, and ionospheric electron densities. Natal is a launching site of unique interest since at this point the earth's radiation belts dip down to their closest point in the tropical zones, within reach of sounding rockets.

NASA and the National Commission of Space Activities of Brazil (CNAE) also continued a project pursuant to a Memorandum of Understanding of November 15, 1965. The new phase of this project involves the use of rockets carrying grenade payloads to study wind, temperature, and density changes in the mesosphere at different periods of the year. Three Nike-Cajun rockets were launched at the Natal Range on June 21. A total of 15 rockets will be launched at intervals through the winter solstice.

European Space Research Organization (ESRO)

During the reporting period, ESRO contracted to purchase a launching for its Highly Eccentric Orbit Satellite (HEOS-A). The purpose of the satellite is to carry out an integrated study of solar radiation and cosmic rays. The HEOS-A is to be placed in a near polar orbit and carries experiments designed in France, the Netherlands, and the United Kingdom.

On May 29, NASA provided a Scout vehicle for ESRO II, the first ESRO satellite. ESRO II failed to achieve orbit because the launch vehicle malfunctioned. This was the first failure in the international satellite field, following eight successes. NASA will provide another vehicle for the ESRO II backup, expected to be launched early in 1968.

ESRO I, a satellite for the study of high energy particles and their effect on the ionosphere, will also be ready for a Scout launching in 1968.

France

Plans for the launching of FR-2 (EOLE), the second French cooperative satellite, progressed satisfactorily during the first half of 1967. Preparations for this launching, to occur during 1969 from Wallops Island, Virginia, and to employ a Scout rocket, included training French personnel at NASA installations in flight operation and data reduction. The important objective of the FR-2 will be to determine the feasibility of a satellite/balloon system to gather meteorological data on a global scale. The project is being pursued under a Memorandum of Understanding between NASA and the French National Center for Space Studies (CNES) signed on May 27, 1966.

Germany

NASA cooperation with the German Ministry of Science (BMwF) was primarily oriented toward the cooperative research satellite (Project Azur) late in 1969. To test certain of the experiments, NASA and the Ministry of Science entered into the previously-mentioned tripartite agreement with Brazil providing for two Javelin launchings on June 16 and 18. In addition, these payloads, developed for BMwF, were successful in collecting new data on the spectra and flux of energetic particles in the lower portions of the Van Allen belt.

Between April 5 and April 11, five Nike-Apache sounding rockets were launched from the European Space Research Organization (ESRO) range at Kiruna, Sweden. These experiments investigated the magnetic field line structure and electrical fields in the subarctic auroral zone. The BMwF provided the chemical payloads and the ground observation equipment; it also conducted the launchings with the cooperation of the

Swedish Space Research Committee. NASA provided the rocket hardware and refresher training for launch crews. This was part of a continuing NASA/BMwF program to investigate the behaviour of ionized clouds in space.

India

NASA continued its sounding rocket program in cooperation with the Indian Committee for Space Research (INCOSPAR). NASA supplied five Nike-Apaches for Indian-built sodium vapor experiments for the study of upper atmosphere winds. They were launched from the Thumba range in India during the period March 9–13.

Italy

As the culmination of a three-phase project begun in 1963, the San Marco II satellite was launched on April 26. The launch took place off the coast of Kenya, the first satellite launching from a platform at sea. Italy provided the launch platform complex, the payload, and launch vehicle preparation and launching services. (Fig. 7–1.) NASA contributed the launch vehicle.

The orbital data, based on NASA tracking stations in South America, show the satellite to be properly positioned to accomplish its mission. The principal experiment, a drag-balance to measure variations in atmospheric density, is operating well and providing useful data.

Japan

Japanese cooperative sounding rocket projects with NASA continued during the first half of 1967. Japan provided ten of its own MT-135 meteorological rocket systems for a series of launchings at Wallops Island, Virginia. This particular project also involved ten United States Arcas meteorological rocket systems. Eighteen of the twenty were launched in a 19-hour time period beginning at 4:10 a.m. on April 5. The primary purpose of this project, to gain comparative data on the operational characteristics of the rockets, was successfully achieved.

Norway/Denmark

The Norwegian Committee for Space Research and the Royal Technical University of Denmark cooperated with NASA in the launching of two Nike-Apache rockets on March 3 and 14. These sounding rockets contained experiments designed by all three nations and were launched from the Andoya range in Norway. The object of this investigation was to study the relationships between sudden increase in radio wave absorption

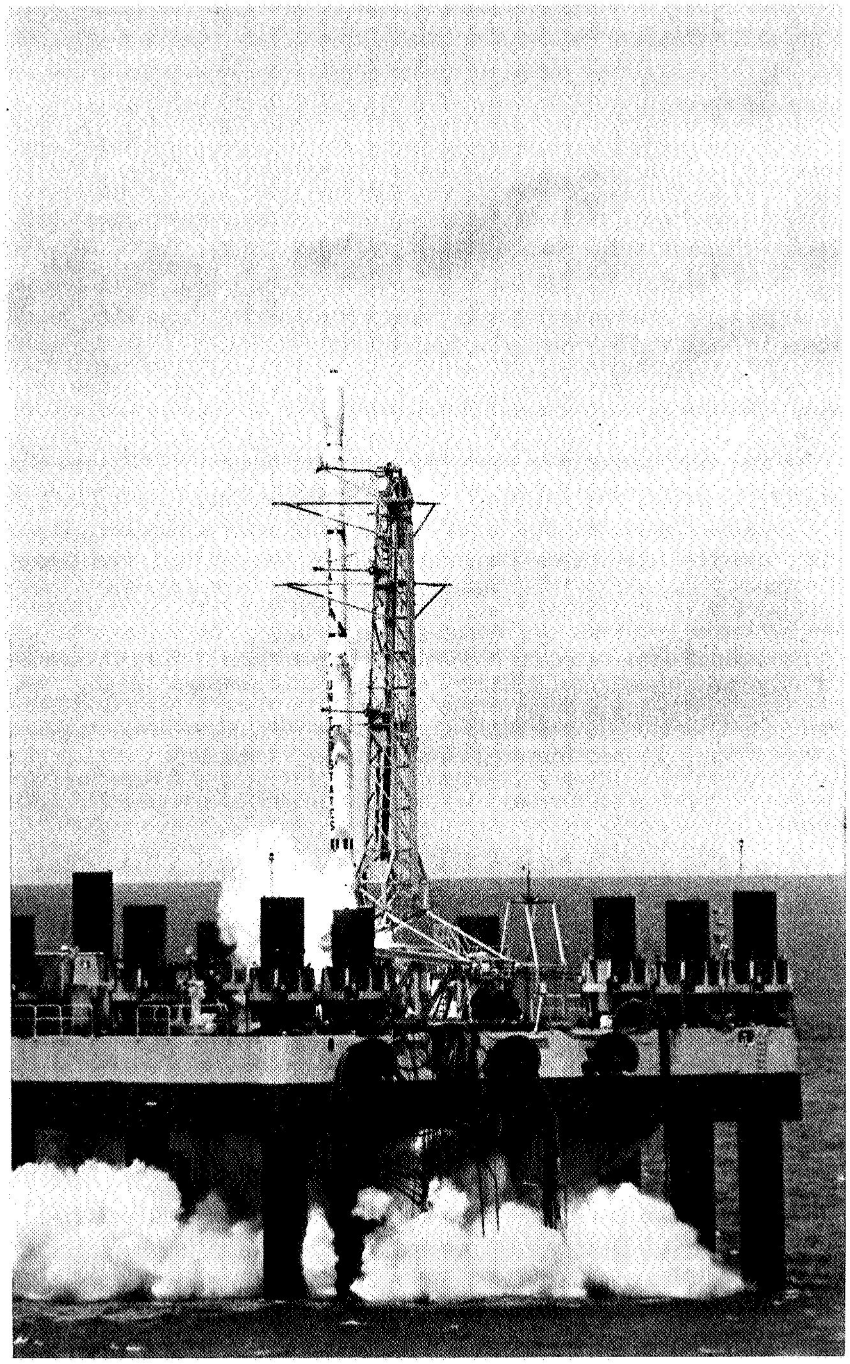


Figure 7—1. Launch of San Marco II spacecraft from platform at sea.

and flux of low energy incoming particles. All experiments were carried out successfully.

United Kingdom

Ariel III, third in a series of US-UK cooperative satellite projects, was launched by NASA on May 5. (Fig. 7–2.) The launch vehicle performed satisfactorily, placing the 198-pound satellite in an approximately circu-

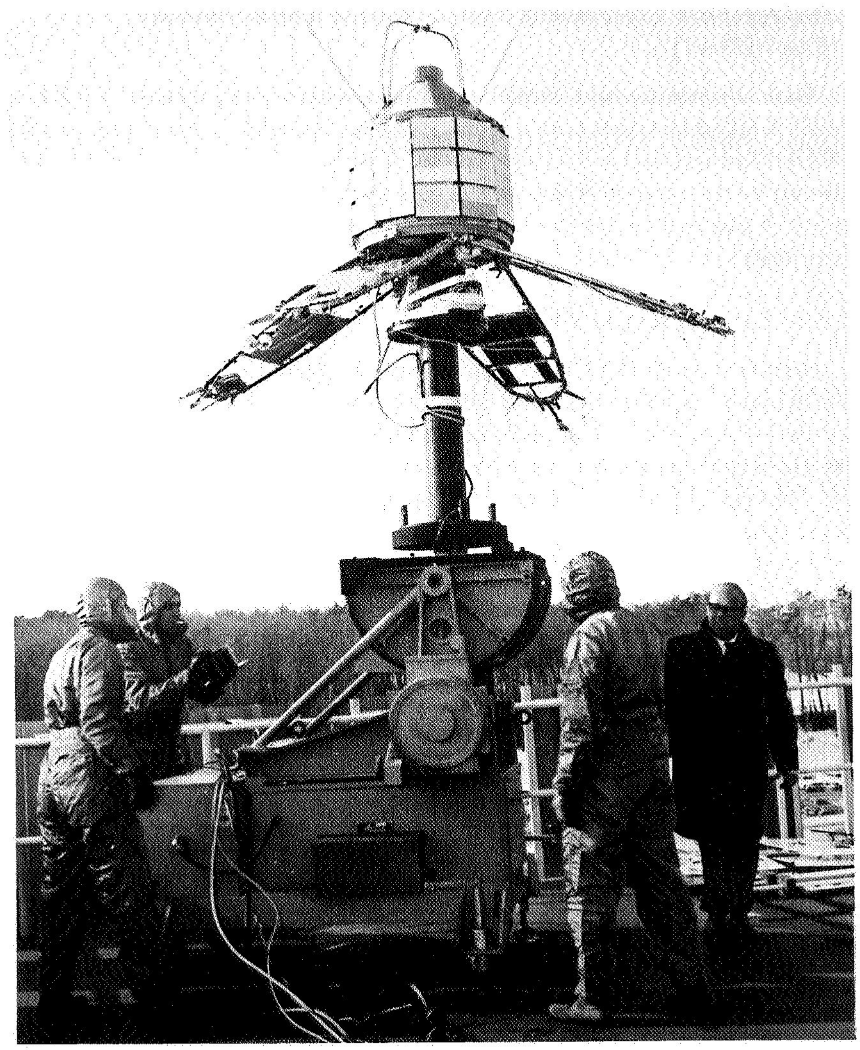


Figure 7–2. Ariel III being tested.

lar orbit, varying from 490 to 600 nautical miles (launched from the Western Test Range).

Four experiments on Ariel III were operating at liftoff, and the fifth was turned on after the third orbit. All were operating normally at the end of the period. NASA tracking stations and UK facilities in both Singapore and the South Atlantic were participating in data acquisition. The primary purpose of Ariel III is to supplement and extend investigations in the atmosphere and the ionosphere conducted by Ariel I and Ariel II (launched April 1962 and March 1964, respectively).

Inter-American Experimental Meteorological Rocket Network (EXAMETNET)

Both Argentina and Brazil continued active participation in EXAMETNET with small meteorological rocket launchings coordinated with NASA launchings at Wallops Island, Virginia. Argentina used five and Brazil seven boosted Dart and Arcas rockets during this period. This work is planned to continue at a rate of about 30 launchings per country per year.

Lunar Surface Sample Analysis

Scientists from the United States and six other countries were selected to conduct experiments with the first samples of the moon's surface returned to earth by U.S. astronauts in the Apollo Program. Thirty-four of the experiments will be carried out by 29 scientists in laboratories in Canada, Finland, Germany, Japan, Switzerland, and the United Kingdom.

The four major investigative areas are mineralogy and petrology chemical and isotope analysis, physical properties studies, and biochemical and organic analysis. The samples will be stored under vacuum, and most of the operations with the samples in the laboratory will be performed under vacuum in order to keep the collected material in an environment similar to the moon's.

United Nations

The Deputy Director of NASA's Goddard Space Flight Center served as the U.S. Representative to a panel of experts, which met in New York in February to prepare for the United Nations Conference on the Exploration and Peaceful Uses of Outer Space. The General Counsel of NASA served on the U.S. Delegation to the meeting of the Legal Subcommittee of the Committee on the Peaceful Uses of Outer Space, which convened in Geneva, Switzerland, on June 19.

Operations Support

Negotiations of inter-governmental agreements were continued with the United Kingdom to establish new NASA tracking facilities, and begun with the Malagasy Republic to continue the existing station. Approvals were obtained from several additional countries for stationing temporary facilities for support of the National Geodetic Satellite Program.

United Kingdom

A revised Inter-Agency Agreement between NASA and the United Kingdom Science Research Council concerning operation of the Winkfield Station was signed on February 9, pursuant to the inter-governmental agreement extended by an exchange of notes, dated December 28, 1966, and January 1, 1967.

In addition, an agreement to establish a tracking station at Antigua in support of Project Apollo was concluded with the United Kingdom by an exchange of notes on January 17 and 23, 1967. Negotiations are in process for operation of a tracking station on Grand Bahama Island in support of Project Apollo.

NASA Aircraft Flights

A NASA instrumented jet aircraft flew over the Yucatan peninsula on June 5, conducting measurements in support of meteorological satellite experiments. A Mexican scientist participated in this flight and in flights over the Southern United States and the Gulf of Mexico.

National Geodetic Satellites Program

Arrangements were made with Argentina, Australia, Brazil, Chad, Chile, Ecuador, Mexico, New Zealand, the Philippines, Senegal, Surinam, and the United Kingdom for temporary location of geodetic satellite observation equipment within their territories in support of the National Geodetic Satellite Program (NGSP).

Satellite Communications Experiments

A meeting of the international Ground Station Committee, consisting of representatives of countries with which arrangements exist for the conduct of experimental communications by satellite, was held in Washington March 6 and 7, 1967, to review prospects for participation in experiments with NASA's Applications Technology Satellite. Japan has been participating in tests with ATS I, stationed over the Pacific, and the airlines of a number of countries have plans for participating in VHF aircraft to ground tests.

Personnel Exchanges, Education and Training

During the first half of 1967, over 2,600 foreign nationals from 86 countries and separate jurisdictions visited NASA facilities for scientific and technical discussions or general orientation.

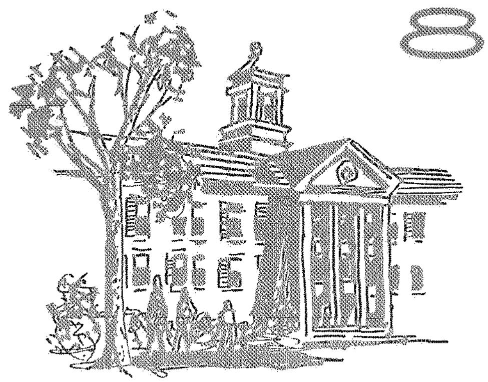
Under the NASA International University Fellowship Program, 51 students either entered the program or continued their studies. Thirteen countries and 19 universities participated in this program during the period. They were supported by their national space research sponsors or by the European Space Research Organization. This program is administered for NASA by the National Academy of Sciences.

Eighty-eight postdoctoral and senior postdoctoral associates from 22 countries carried on research at NASA centers, including the jet Propulsion Laboratory. This program is also administered by the National Academy of Sciences and is open to U.S. nationals.

Eight scientists, engineers, and technicians representing France and ESRO, here at their own expense, received training in space technology at the Goddard Space Flight Center in connection with cooperative projects.

International Conventions Relating to Space

At the end of the period the Legal Subcommittee of the United Nations Committee on the Peaceful Uses of Outer Space had before it for consideration an agenda aimed at drafting certain multilateral conventions. These conventions would be concerned with such matters as (a) assistance and return of astronauts and space vehicles; (b) liability for damage resulting from launches or attempted launches; (c) utilization of space; and (d) definition of outer space. The Legal Subcommittee met in Geneva, Switzerland, for some weeks starting on June 19, 1967. United States representation was provided through the Department of State. The General Counsel of NASA, serving as an alternate United States Representative to the Subcommittee, was principally concerned with the question of liability for damage resulting from launches or attempted launches.



8 GRANTS AND RESEARCH CONTRACTS ACTIVITIES

Research in space science and technology is sponsored selectively by NASA in response to unsolicited proposals. Although these proposals may receive support from any NASA program office having a scientific interest and available funds, the Office of University Affairs (chap. 10, p. 158) is the focal point for receiving, handling, and distributing the proposals, and for issuing the resultant grants and many of the research contracts to universities and nonprofit-scientific organizations. In addition, this office is responsible for the Sustaining University Program.

Sustaining University Program

The Sustaining University Program, which seeks to increase the participation of the university community in aeronautical and space science and to take advantage of the unique ability of the universities to conduct the broad multidisciplinary research required for the national space effort, continued to award grants under its training, research, and research facilities components.

Training

Under the training component, which was designed to ensure a continuing supply of highly trained scientists and engineers in the space program, 176 grants or contracts had been awarded to 152 institutions in every state in the Union, by the end of June 1967. During the year ending

June 30, 159 predoctoral training grants were made to support the training of 797 new predoctoral students at 152 institutions (app. P.) When these students enter the program in September 1967, the universities will select 764 for training in any fields in which the universities have space-related doctoral programs. Twenty-three of the trainees at 5 institutions will be selected specifically for training in engineering design and the remaining 10 at two institutions for training in public administration. When these new students join the 2,610 already in the program from the two previous years, the total number in the program during the school year 1967–68 will be 3,407.

By June 1, 1967, 578 Ph.D.'s had been earned by NASA trainees. Distribution was as follows: 302 in the physical sciences, 202 in engineering, 48 in the life sciences, 21 in the behavioral sciences, and 5 in other areas. The recipients of the doctorate made the following career choices: 249 in university research and/or teaching; 90 in postdoctoral fellowships or Fulbright awards; 37 in government laboratories; 182 in industry; and 20 serving military obligations.

To acquaint NASA trainees more directly with the Agency and its mission, trainee visits to the NASA research centers were continued. About 400 trainees and 50 faculty members visited NASA field research centers for intensive briefings on NASA research programs.

Early in 1967, seven contracts were awarded to twelve universities to continue the cooperative Summer Faculty Fellowship Program under which junior faculty members in engineering or science come to a NASA center for ten weeks of research and study. About 250 faculty members are scheduled to participate in this program during the summer of 1967, approximately one-fourth returning for a second, and terminal year.

Three contracts were awarded to conduct ten-week Summer Faculty Fellowship Programs in engineering design—one at Stanford University with the cooperation of the Ames Research Center; another at the University of Houston in cooperation with Rice University and the Manned Spacecraft Center; and the third at Auburn University in cooperation with the University of Alabama and the Marshall Space Flight Center. During the summer of 1967, 70 faculty members will work on a preliminary Voyager design project, an emergency orbital escape system, and a communications satellite system. In addition, the Agency sponsored summer institutes for advanced undergraduates at Columbia University, the University of Miami, the University of Southern California, and the University of California at Los Angeles; at the four institutions, about 165 senior undergraduates will receive six weeks of specialized training in space science and technology. Support of advanced training in aerospace medicine for a few selected physicians continued at Harvard University and Ohio State University.

In June the National Research Council-National Academy of Sciences administered program for advanced research at NASA centers, had 132 such advanced investigators on tenure at the following centers:

Goddard Space Flight Center		71
Institute for Space Studies N.Y.	19	
Greenbelt, Maryland	52	
Ames Research Center		35
Langley Research Center		9
Marshall Space Flight Center		7
Manned Spacecraft Center		2
Jet Propulsion Laboratory		6
Electronics Research Center		2
Total		132

Research fields include: astrophysics, airglow emission, high energy physics, geomagnetism, instrumentation for direct atmospheric measurements, applied mathematics, electron microscope, comparative biochemistry, hypersonic aerodynamics, plasma flow, materials, and meteorites.

Research

This component of the sustaining university program supported multidisciplinary space-related research at 56 educational institutions throughout the nation. The institutions holding research grants are:

Adelphi University
University of Alabama
University of Arizona
Brown University
University of California (Berkeley)
University of California (Los Angeles)
California Institute of Technology
University of Cincinnati
City University of New York
Colorado State University
Columbia University
University of Denver
Drexel Institute of Technology
Duke University
University of Florida
George Washington University
Georgia Institute of Technology
University of Houston
Howard University
University of Indiana
University of Kansas
Kansas State University
Louisiana State University
University of Louisville
University of Maine
University of Maryland
Massachusetts Institute of Technology
Miami University (Ohio)
University of Miami
University of Minnesota
University of Missouri (Columbia)
Montana State University
New Mexico State University
New York University
University of Oklahoma
Oklahoma State University
University of Pennsylvania
Pennsylvania State University
University of Pittsburgh
Purdue University
Rice University
University of Southern California
Southern Methodist University
Southwest Center for Advanced Studies
S.U.N.Y. (Stony Brook)
University of Tennessee
Texas A&M University
University of Vermont
University of Virginia

Virginia Polytechnic Institute
Washington University (St. Louis)
West Virginia University
College of William and Mary
University of Wisconsin
Yale University
Yeshiva University

By increasing the involvement of university researchers in the space program, the research component helps maintain a broad stable base of research competence in the university community to support NASA flight experiments; fill research gaps in areas complementary to NASA program office research; stimulate the growth and development of new talent; and, provide support to explore new research ideas and areas.

Research Facilities

One new building, the Radiophysics and Space Research Center at Cornell University, was completed and occupied by March 24, and dedication was scheduled for October 19. Three buildings already completed at the time of the 16th Semiannual Report were dedicated: The Space Sciences Building at the University of Arizona on January 26, The Space Sciences Center at the University of Maryland on April 26, and the Aerospace Sciences Building at New York University on May 12.

Ground-breaking ceremonies were held for the Space Research Laboratory at Case Institute of Technology on May 12 and for the Space Engineering Building at Stanford University on June 16. Construction was started on these buildings and the Space Sciences Center at the University of Rochester. One new facilities grant was awarded on May 22 to the University of Kansas for the construction of a space research and technology laboratory. The status of the twelve active grants is summarized in Table 8–1.

To date, 24 buildings have been completed under the Research Facili-

Table 8–1. Research Facilities in Progress—June 30, 1967

Fiscal year grant awarded	Institution	Topic	Area (1000 SF)	Percent complete	Cost ($1000)
1963	M.I.T.	Space sciences	75	65	$ 3,000
	Wisconsin	Theoretical chemistry	12	99	365
1964	Illinois	Space sciences	51	95	1,125
1965	Case Institute of Technology	Space engineering	69	5	2,226
	Rochester	Space sciences	35	5	1,000
	Florida	Space sciences	53	50	1,190
	Minnesota	Space sciences	70	35	2,500
	Denver	Space sciences	41	85	900
	Stanford	Space engineering	65	5	2,080
1966	Wisconsin	Space science and engineering	58	10	1,694
	Washington	Aerospace research	40	Design	1,500
	Kansas	Space research and technology	75	Design	1,800
Totals	----------------	----------------------------	644	-------	$19,380

Table 8–2. Completed Research Facilities—June 30, 1967

Fiscal year grant awarded	Institution	Topic	Area (1000 square feet)	Cost ($1000)
1962	RPI	Materials research	60	$ 1,500
	Stanford	Exobiology	15	535
	Chicago	Space sciences and astronautics	45	1,749
	Iowa	Physics and astronomy	24	536
	California (Berkeley)	Space sciences	44	1,990
	Harvard	Biomedicine	5	151
1963	Minnesota	Physics	17	542
	Colorado	Atmospheric and space physics	32	792
	California (Los Angeles)	Space sciences	69	2,000
	Michigan	Space sciences and engineering	56	1,436
	Pittsburgh	Space sciences	47	1,497
	Princeton	Propulsion sciences	26	625
	Lowell	Planetary sciences	9	237
1964	Texas A&M	Space sciences	34	1,000
	Maryland	Space sciences	77	1,500
	Southern California	Human centrifuge	4	160
	Cornell	Radiophysics and space research	38	1,350
	Rice	Space sciences	68	1,600
	Purdue	Propulsion sciences	4	840
	Washington (St. Louis)	Space sciences	25	600
	New York	Areonautics	13	582
	Georgia Tech	Space sciences and technology	51	1,000
	Arizona	Space sciences	51	1,200
	P.I.B.	Aerospace sciences	16	632
Totals	------------------------	----------------------------------	830	$24,054

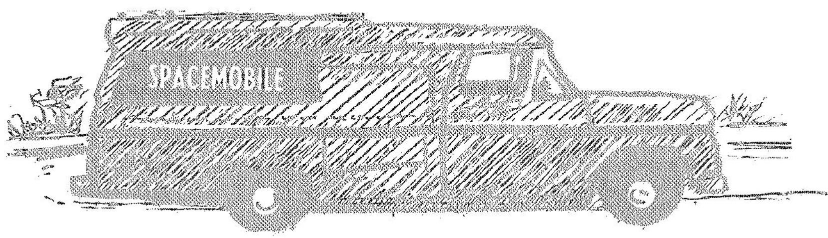
ties Program. They comprise a total of 830,000 gross square feet of research space and accommodate about 2,400 scientists, engineers, and other researchers engaged in multidisciplinary research in space-related science and technology. Table 8–2 provides detailed information on the completed laboratories.

Management of Grants and Research Contracts

It was decided to prepare the monthly *Status of Unsolicited Proposals* report ''in-house'' by utilizing the NASA Headquarters A.D.P. facilities. Plans were also being made to mechanize the *Status of Procurement* report and the *Grants and Research Contracts Obligated* appendix to the NASA Semiannual Report to Congress. These steps should result in a substantial cost reduction and a more realistic report distribution schedule.

Between January 1 and June 30, 1967, the Office of University Affairs received 1,571 unsolicited proposals; it processed 798 procurement requests totaling $61.6 million and 946 grants and research contracts totaling $83.1 million.

9 INFORMATIONAL AND EDUCATIONAL PROGRAMS



Reflecting an increasing interest in the Nation's space program, NASA responded to thousands of requests for educational publications and motion pictures from teachers, students, professionals, and the general public. Through educational television, radio, exhibits, and spacemobile lecture-demonstrations the Agency reached millions more. NASA's scientific and technical information services were being geared to supply information of interest to program managers. The Technology Utilization program was also expanding rapidly, with an estimated 1,000 or more inventions, discoveries, and innovations resulting from NASA research and development expected to be announced to industry this year.

Educational Programs and Services

NASA assisted colleges, universities, and school districts in planning, organizing, and conducting summer and in-service workshops and courses by supplying the Agency's publications, audiovisuals, exhibits, spacemobile lecturers, and other speakers. In addition, consultants, speakers, and specialists helped school authorities develop space related materials to enhance the curriculum.

To meet instructional needs of schools, colleges, and universities in space science and technology, NASA assisted in developing educational materials at all levels. These were being developed in cooperation with universities and a science teachers' organization. Among those published were: high school geometry (University of Vermont); use of planetariums by elementary schools (University of Bridgeport); and a revision of model spacecraft construction (California State College at Long Beach). Work continued on the following projects: life science (University of California, Berkeley); chemistry (Ball State University); industrial arts (South Florida and Western Michigan Universities); elementary school space science lexicon (Oregon State University); physical science (Columbia University); earth space science (National Science Teachers Association), and measurement (University of Akron). Projects begun during the first 6 months of 1967 were one on physics by Texas A & M University, and another in mathematics by Duke University.

A report on the Southern States Workshop Conference, *Meeting the Challenge of Space Exploration*, was published by the Texas Education Agency and a curriculum enrichment guide for the State of Massachusetts was being tested and reviewed for publication this fall. Both of these projects received assistance from NASA.

Spacemobiles

NASA's 26 spacemobile units provided lecture-demonstrations before 1,590,473 at schools throughout the country. Lecturers through local television and radio programs reached another 8,132,340. In addition, 449 teacher groups in workshops and seminars—an audience of 14,835—received lecture-demonstration at 175 colleges and universities. The Agency also provided publications, audiovisuals, and resource people to workshops in all of the States and in Puerto Rico. Spacemobile lecture-demonstration programs were carried out in Argentina, Brazil, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Australia, Guam, the Philippines, and France.

Youth Programs

In its youth service program NASA took part in 196 state and regional science fairs by providing certificates of outstanding achievement and judges for space-related projects. At the 18th International Science Fair in San Francisco, the Agency's judges selected six students to receive certificates of merit and two-day visits to a NASA field installation of their choice. Citations of honorable mention were also awarded.

Youth Science Congresses—a NASA innovation to encourage space-related research by high school students—were carried out in nine NASA Centers. During these Congresses 150 students who had conducted noteworthy scientific investigations met with scientists from NASA, industry and the universities to discuss their fields of specialization. The National Science Teachers Association assisted the Agency with this program.

Educational Publications and Films

NASA released six new publications, issued updated editions of a number of those previously published, and produced 12 new motion pictures. These are described in appendix K. Over 52,182 requests for publications and 1,185 for motion pictures were received from teachers, students, professionals, and the general public. Motion picture film catalogued and stored in the Agency's depository reached 7,329,355 feet, and 39,355 feet was made available to producers of educational and documentary motion pictures and telecasts.

Educational Television and Radio

To meet the increasing demand for information on aerospace research and development, NASA stepped up its programs for the ever-growing TV and radio audiences. (By the end of June, there were 732 television stations and an additional 189 authorized to begin telecasting soon. Also, the number of radio stations increased to 6,010 with an additional 331 authorized.)

The Agency continued to produce and distribute its monthly 5-minute television program, *Aeronautics and Space Reports,* to more and more stations. Telecasts included programs on communications satellites, lunar exploration through satellites, and new aeronautical concepts, as well as a short history of manned space flight marking the sixth anniversary of the flight of Astronaut Alan Shepard in May 1961. The *Science Reporter* series of half-hour television shows was also distributed. These programs reached an audience conservatively estimated at 8,425,300.

Production work was completed on a group of ten motion pictures for distribution to TV stations as *The Challenge of Space* series. Four of these motion pictures were produced originally for other audiences but found to be adaptable to television. Initial work also began on producing a group of short television films on various facets of Project Apollo. These were produced to permit various combinations, assuring wide use on television and in the classroom.

In addition to providing regular programs to stations, NASA furnished guidance, information, and visual materials on aeronautics and space research to a number of individual stations, networks, and producers in the U.S. and overseas.

The Agency continued production and distribution of its weekly 5-minute radio program, *Space Story.* The series covered many phases of NASA's activities, such as Saturn propulsion systems, the Lunar Orbiter spacecraft, sounding rockets, and the XB-70/SST aircraft research program. *NASA Special Report* (a 15-minute monthly program) was also continued, emphasizing such topics as extraterrestrial life and progress in manned space flight.

NASA's other continuing services to radio included *Audio News Features,* a series of interviews released periodically, and *NASA Space Notes,* a quarterly series of short informational features. In addition to regularly scheduled programs, a number of audio tapes were supplied to individual stations and networks for use in continuing programs.

Scientific and Technical Information

Traditionally, a scientific and technical information service processes information on the results of research and development, but these same processing techniques may be further refined and adapted to provide other types of information services in increasing demand today. To meet such a demand NASA has concentrated on expanding its services to supply information of interest to program managers.

Processing Information

A natural outgrowth of techniques for storing and retrieving bibliographic information are data banks on current research projects. The characteristics of research (for example, objectives, procedures, personnel involved, and costs) are indexed and stored on magnetic tape and computer-retrieved as lists or print-outs in answer to inquiries of research managers and research workers. This information may be used in reports on research conducted, in monitoring current developments, as well as in planning research programs.

NASA's Scientific and Technical Information Division cooperates with program managers to assure that documents in its information collection may be retrieved concurrently in response to management queries. This system was also designed to be compatible with comparable procedures used by the Department of Defense, in order to provide an efficient exchange of program management information.

Technical Publications

Space photography has provided data on the geological, oceanographic, and meteorological characteristics of the earth. Although primarily of interest to scientists, this information has its economic and social facets for commerce and industry. To serve these industrial and commercial interests, about 250 of the most significant pictures taken during several of the Gemini manned flights were compiled as an atlas of *Earth Photographs from Gemini III, IV, and V.* This is one of a selected list of NASA's scientific and technical publications released during the first half of 1967 and described in appendix L.

In addition, information guides were added to the materials available in the public information centers established by the Agency in accordance with the Public Information Act (Public Law 90–23). These guides help the public identify sources of information of specific interest. There are also general guides to NASA's entire collection of information in aerospace science and technology, and special guides to the Agency's research and development reports and to publications on technological advances and innovations which may have a variety of industrial applications.

Technology Utilization

Noteworthy progress was made in NASA's Technology Utilization Program designed to disseminate information generated by the Nation's space activities and bring about its rapid, effective use by the non-aerospace technical community.

Contractor reporting to the Agency of technology conceived or first put into practice during the course of work under contract—a requirement of the new technology clause incorporated into all NASA research and development contracts—increased significantly. More than 80 percent of the inventions and innovations announced to business and industry through NASA's *Tech Briefs* and by other compilations originated under contract. An estimated 1,000 or more inventions, innovations, and discoveries resulting from NASA research and development were expected to be announced during 1967 compared to the 714 during 1966.

In addition to an increasing number of these one-page *Tech Briefs* describing innovations, more state-of-the-art *Technology Surveys* were issued. Published were surveys on "High-Velocity Metalworking," "Solid Lubricants," and NASA's "Contributions to Cardiovascular Monitoring."

Tech Briefs and other technology utilization publications stimulated over 8,000 inquiries on NASA's innovations during 1966—an increase of 25 percent over 1965.

Biomedical Application Teams

The biomedical application teams continued to work toward a more effective coupling of aerospace science and technology with specific biomedical needs. Over 80 important medical problems were pinpointed for possible solution by applying innovations coming from this aerospace research and technology (*16th Semiannual Report*, p. 194).

Computer Software Management Information Center

COSMIC, the Computer Software Management Information Center, operated effectively to disseminate to businessmen and educators useful computer software developed by NASA. During its first five months of operation this Center at the University of Georgia answered 3,523 inquiries for additional information and sold 288 card decks and magnetic tapes.

Regional Dissemination Centers

NASA has established the New England Research Applications Center at the University of Connecticut. This is the ninth Regional Dissemination Center—each with somewhat different approaches to the interface between the storehouse of information and companies subscribing to its services.

Of the companies which were members of a Center for more than a year, 22 percent renewed their memberships for increased services at higher rates than in their first year. And more than 4 out of 5 companies renewed memberships. Small company membership increased to 37 percent of the total. This proved the effectiveness of the services rendered by the Regional Dissemination Centers and assured that the Centers will become self-supporting on the basis of industrial fees received for these services.

Interagency Cooperation

Interest in the technology transfer process and NASA's overall approach in this area continued to grow. During the first six months of 1967 the Agency maintained active cooperative projects with the Commerce Department's Office of State Technical Services; the Atomic Energy Commission; the Vocational Rehabilitation Administration; the Office of Law Enforcement Assistance of the Department of Justice; and the Small Business Administration. A joint effort with the Bureau of Reclamation of the Interior Department was started during this period.

Technology Utilization Conference

A technology utilization conference—sponsored by the Small Business Administration and NASA—was held at the Lewis Research Center in May. The representatives of the 400 companies attending learned how they might apply NASA-developed technology to their businesses. More conferences of this type are planned.

Technology Utilization Programs Overseas

The Agency also advised representatives from France, West Germany, Belgium, the United Kingdom, and India on how they could set up technology utilization programs in their countries.

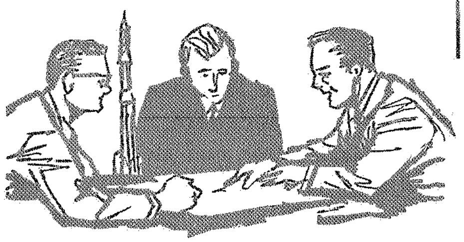
Historical Program

During the first six months of this year a number of major historical projects were under way. Included were a chronology of astronautical and aeronautical events for 1967; a 10-year historical data book on NASA; a bibliography of historical space and aeronautical literature; a history of Project Vanguard; and a detailed chronology of Project Gemini. Histories of most NASA centers were defined or continued in preparation.

Two publications went to press—*Astronautics and Aeronautics, 1966* (SP-4007) and *Venture Into Space: Early Years of Goddard Space Flight Center* (SP-4301).

Among other activities in NASA's historical program were planning and coordinating Agency-wide procedures for historical document retention and retirement; developing major projects including the history of Project Apollo; and supporting academic historians, as well as sponsoring a seminar on "History, Social Science, and Space" for select graduate students this summer.

10 PERSONNEL, MANAGEMENT, PROCUREMENT, AND SUPPORT FUNCTIONS



The personnel, management, procurement, and other non-technical support functions continued to receive major stress during the period. With its work force reaching a stable plateau and its management processes achieving maturity, NASA directed much attention to those innovations that would enhance program interfaces, make more efficient use of all its resources, and control expenditure of public funds without adversely affecting the Nation's long range space goals.

Personnel

Through its personnel program, NASA continued to stress training activities that would enable its employees to perform their duties more efficiently and to assure more effective management of its projects and resources. Employee-management cooperation received further emphasis, and the Agency recognized certain individuals for their outstanding contributions to the space program.

Training Activities

NASA continued to provide specialized seminars on an agency-wide basis to train members of program and project teams, to promote management improvement, and to assure uniform treatment of NASA policy. During the period 63 seminars were conducted in areas such as procurement management, contract cost management, PERT, contract administration, and incentive contracting. 1,172 employees attended these seminars. A new course in advanced incentive contracting, originally developed for DOD, was conducted at two major installations.

Eleven NASA employees completed a year of advanced university study as holders of various fellowship awards. These fellowship awards were the M.I.T. Alfred P. Sloan, the Stanford-Sloan, the National Institute of Public Affairs, the National Institute of Public Affairs Fellowship in Systematic Analysis, and the Princeton-Woodrow Wilson Fellowship in Public Affairs. The selected candidates were chosen on the basis of high potential for study in the fields of management and public administration.

Fourteen NASA employees were chosen to participate in the same fellowship programs during the coming school year, while one NASA candidate was selected to devote a year to advanced study in electrical engineering as a recipient of the Hugh L. Dryden Memorial Fellowship. These educational opportunities are part of NASA's career development program for promising young engineers, scientists, and managers.

Other training programs continued were graduate education, cooperative education, apprentice training, science and engineering lecture programs, and a wide variety of management and skills training.

Employee-Management Cooperation

NASA continued its participation in the government-wide program for Employee-Management Cooperation in the Federal Service (Executive Order 10988).

The collective bargaining agreement between the Langley Research Center and Lodge 892, International Association of Machinists and Aerospace Workers (AFL–CIO), was approved by the NASA Administrator.

Exclusive recognition within a wage board unit (599 employees), exclusive of pattern makers, was granted to Local 997, National Federation of Federal Employees at the Ames Research Center.

Key Executive Personnel Changes

During the period certain key executive personnel changes were made. These included four appointments, 14 reassignments, and six terminations.

Key Appointments.—On April 1, 1967, George S. Trimble, Jr. was appointed as Director, Advanced Manned Missions Program within the Office of Manned Space Flight, succeeding Edward Z. Gray. Mr. Trimble came from the Martin Company, Baltimore, with which he had been associated since 1937. From 1960 he had served as the Corporate Vice President (Advanced Programs) and had previously served as Vice President for Advanced Design (1951–1955) and Vice President for Engineering (1955–1960).

Charles R. Roderick, Major General, U. S. Air Force, Retired, was appointed on June 1, 1967, as Special Assistant to the Administrator. He had served as Deputy Assistant to the Secretary of Defense (Legislative Affairs) from January 1949 until his retirement, May 31, 1967.

George H. Hage was appointed (May 19, 1967) as Deputy Associate Administrator for Space Science and Applications (Engineering), succeeding Robert F. Garbarini. Mr. Hage reported for duty on July 5, 1967, and came from the Boeing Company, Seattle. At Boeing since 1947, he had served in a number of key leadership posts, including Engineering Manager of Boeing's staff at the Atlantic Missile Range on the Minuteman Program (1960–1962), principal systems engineer within the Advanced Space Systems Department in studies of the Lunar Excursion Module and the Lunar Orbiter (1962–1964), and Boeing's Engineering Manager for the Lunar Orbiter spacecraft development and the company's Voyager spacecraft proposals (1964–1967).

James W. Humphreys, Jr., Major General, USAF, MC, assumed the position of Director of Space Medicine, Office of Manned Space Flight, on June 1, 1967. He is serving in this capacity on detail from the U.S. Air Force. Prior to his assignment to NASA, General Humphreys was the Assistant Director for Public Health of the United States Agency for International Development in Vietnam.

Reassignments.—On February 10, 1967, John D. Stevenson was appointed as Director of Mission Operations within the Office of Manned Space Flight, succeeding Everett E. Christensen. Since October 1, 1966, General Stevenson (Major General, USAF, Retired) has served as a Special Assistant to the Associate Administrator for Manned Space Flight.

On January 15, 1967, Mr. Francis W. Kemmett was appointed Executive Secretary of the Inventions and Contributions Board, succeeding Dr. James A. Hootman, who had occupied the position since the inception of NASA. Mr. Kemmett had been previously assigned to NASA's Scientific and Technical Information Division.

Oran W. Nicks was appointed Director, Voyager Program, in the Office of Space Science and Applications (February 28, 1967). He also continues as Acting Director of Lunar and Planetary Programs.

A number of changes in assignments of key personnel were made on March 15, 1967, to implement a revised organization among the staff offices of the NASA Headquarters.

Harold B. Finger was appointed as Associate Administrator for Organization and Management with responsibility for coordinating and directing the Offices of Administration, Industry Affairs, Technology Utilization, and a new Office of University Affairs. Mr. Finger had been Director of the Nuclear Systems and Space Power Programs within the Office of Advanced Research and Technology (since November 1, 1961) and Manager of the joint AEC/NASA Space Nuclear Propulsion Project.

Francis B. Smith was appointed as Assistant Administrator for

University Affairs. The new Office of University Affairs assumed the responsibilities of the former Office of Grants and Research Contracts. Previously, Mr. Smith had been a Special Assistant to the Administrator (from February 12, 1967). Before then, he had been Chief, Instrument Research Division (1960–1964) and Assistant Director (Group 1), NASA Langley Research Center (1964–1967).

William E. Lilly was appointed as Assistant Administrator for Administration. He had previously been Director of Manned Space Flight Program Control within the Office of Manned Space Flight (from November 1, 1961). Mr. Lilly joined NASA in February 1960, coming from the U. S. Navy Bureau of Ordnance where he had been Director, Plans and Programs Division.

Jacob E. Smart was appointed Assistant Administrator for Policy Analysis, continuing also as a Special Assistant to the Administrator (the position to which he was appointed November 1, 1966). General Smart (U. S. Air Force, Retired) had served as Acting Assistant Administrator for Administration from January 1, 1967, to March 15, 1967.

John R. Biggs was appointed as Executive Secretary, NASA. He had served as Deputy Executive Secretary from March 5, 1967, and had previously been Director of the NASA Office at Downey, California (from May 1962).

On April 9, 1967, William H. Woodward was appointed Director of Space Power and Electric Propulsion Programs within the Office of Advanced Research and Technology. He had been Deputy Director of this program (division) since November 1961, and Chief, Power Plans Research Programs (NACA/NASA), since 1954.

Joseph F. Shea was appointed (April 10, 1967) as Deputy Associate Administrator for Manned Space Flight (Technical). He had been Manager of the Apollo Spacecraft Program Office at the NASA Manned Spacecraft Center, Houston, Texas, since December 1, 1963, and Deputy Director for Systems Engineering, Office of Manned Space Flight since January 8, 1962.

On April 10, 1967, George M. Low was appointed as Manager, Apollo Spacecraft Program Office, succeeding Dr. Shea. Mr. Low had been Deputy Director, NASA Manned Spacecraft Center since November 1, 1963; Deputy Director for Programs, Office of Manned Space Flight since February 20, 1963; and Director of Spacecraft and Flight Missions in that office since November 1, 1961.

Charles W. Harper was appointed as Deputy Associate Administrator for Advanced Research and Technology (Aeronautics) on May 5, 1967. He had been Director, Aeronautics Division, within OART since October 11, 1964, and Chief, Full-Scale and Systems Research Division, Ames Research Center, from September 1959 to October 1964.

On May 5, 1967, Albert J. Evans was appointed as Director of Aeronautical Vehicles (Division) within OART. He had served as Deputy Director (formerly "Aeronautics Division") from October 25, 1964, and as Technical Assistant to the Director from January 7, 1962.

Robert F. Allnutt was appointed Assistant Administrator for Legislative Affairs on June 18, 1967. He had been Assistant General Counsel for Patent Matters from September 13, 1965. He came to NASA from the Communications Satellite Corporation, Washington, D. C.

Terminations.—On February 17, 1967, Everette E. Christensen resigned from the position of Director of Mission Operations, Office of Manned Space Flight. He had held this position since December 20, 1964. Previously (since August 3, 1964), he had been Special Assistant to the Associate Administrator for Manned Space Flight.

Breene M. Kerr resigned from the position of Assistant Administrator for Policy Analysis on March 15, 1967. Mr. Kerr joined NASA in June 1964 as Deputy Assistant Administrator for Technology Utilization; he became Assistant Administrator for Technology Utilization on November 22, 1964.

Edward Z. Gray resigned (April 21, 1967) from the position of Director, Advanced Manned Missions Program, in the Office of Manned Space Flight. He had held this position since November 1, 1963. Mr. Gray joined NASA as Director of Advanced Studies, OMSF, October 14, 1963.

On April 29, 1967, Robert F. Garbarini resigned from the position of Deputy Associate Administrator for Space Science and Applications (Engineering) the position he had held since January 1965. Mr. Garbarini came to NASA June 27, 1963, as Director, Office of Applications, and on November 1, 1963, was made Director of Applications within the Office of Space Science and Applications.

Albert J. Kelley resigned from the position of Deputy Director, NASA Electronics Research Center on May 7, 1967. Earlier, he had been head of the Space Task Group, within the Office of Advanced Research and Technology, which developed the plans for the new Center. He became Center Deputy Director in September 1964. On detail from the U. S. Navy since March 1960, Dr. Kelley was formally appointed as Deputy (Center) Director in July 1965 when he retired from the Navy.

On June 18, 1967, Richard L. Callaghan resigned as Assistant Administrator for Legislative Affairs in which he had served from October 15, 1963. He joined the staff of NASA July 30, 1962, as a Special Assistant to the Administrator. His resignation became effective on July 3, 1967.

NASA Awards and Honors

Through the presentation of medals and top honor awards, NASA recognized individual contributions to the space program.

The Distinguished Service Medal was awarded to Walter D. Sohier, Headquarters, in recognition of his distinguished professional service and outstanding leadership as one of NASA's senior officials during the past eight years. As General Counsel since 1963, and as Deputy General Counsel prior to that time, he developed a highly effective legal staff and made major contributions to the advancement of government patent policy. As the senior responsible NASA official, he participated actively in the United Nations affairs, particularly in the negotiations which led to the 1967 United Nations Outer Space Treaty. His ability to resolve the novel and complex legal and policy matters which enabled the building of the NASA government-industry-university team to carry out the policies established in the 1958 National Aeronautics and Space Act was a source of great strength in the formative period of the National Aeronautics and Space Administration.

The Exceptional Scientific Achievement Medal was awarded to Richard V. Rhode, Headquarters, in recognition of pioneering research efforts and significant scientific contributions made to the National Advisory Committee for Aeronautics and the National Aeronautics and Space Administration in the development of research information, techniques, equipment, and design criteria essential to the construction of safe, reliable, and efficient aircraft and space vehicles.

The Exceptional Service Medal was awarded to Albert J. Kelley, Headquarters, for his contribution in creating the NASA-wide electronics research program and for the conceptual planning and establishment of the Electronics Research Center which has strengthened the Nation's ability to achieve and to sustain pre-eminence in space exploration.

The Exceptional Service Medal was awarded to Robert F. Garbarini, Headquarters, engineer and manager, for outstanding contributions in upgrading overall engineering standards and improving quality assurance practices on Space Science and Applications flight projects; and for particularly significant contributions to the success of the Ranger and Surveyor Programs.

The Exceptional Service Medal was awarded to Major General David M. Jones for outstanding technical and management contributions to the manned space flight programs of the National Aeronautics and Space Administration. As Deputy Associate Administrator for Manned Space Flight (Programs) and as Acting Director, Apollo Applications, he has played an important role in guiding the definition and development of future manned space missions.

Status of Personnel Force

The following figures represent total employment (including temporaries) as of December 31, 1966, and June 30, 1967:

	December 1966	*June 1967*
Headquarters	2274	2373
Ames Research Center	2232	2264
Electronics Research Center	619	791
Flight Research Center	618	642
Goddard Space Flight Center	3791	3997
Kennedy Space Center	2618	2867
Langley Research Center	4296	4405
Lewis Research Center	4825	4956
Manned Spacecraft Center	4688	5064
Marshall Space Flight Center	7434	7602
NASA Pasadena Office	87	91
NASA Office, Downey	127	—
Space Nuclear Propulsion Office	114	113
Wallops Station	538	576
Western Support Office	105	119
Total	34,366	35,860

Inventions and Contributions Board

NASA's Inventions and Contributions Board is responsible for three principal functions. First, it reviews and validates petitions for waiver of patent rights that have been submitted by NASA contractors and have then been analyzed and evaluated by the Board's secretariat. Upon completion of its review and deliberations, the Board makes a recommendation regarding the disposition of each petition and forwards all pertinent documents, together with its recommendation, to the Administrator of NASA for final decision.

Second, the Board recommends the granting of monetary awards to individuals responsible for inventions or other scientific and technical contributions which have proved to be of significant value in the advancement of an aeronautical or space program. Under the provisions of Section 306 of the National Aeronautics and Space Act of 1958, the Board may, after thoroughly evaluating the scientific and technical merits of an invention or contribution, recommend to the Administrator of NASA that a monetary award be granted. Application for a Space Act (Section 306) award may be submitted "by any person including any individual, partnership, corporation, association, institution, or other entity." The Government Employees Incentive Awards Act of 1954 provides the Board with another means for the granting of monetary awards for scientific and technical contributions. Under its provisions, the Board is authorized to make monetary awards in amounts not to exceed $5,000.00, but the recipients of these awards must be employees of the U. S. Government.

The third important function of the Board is performed by its secretariat and consists of responding to a large number of letters regularly received from a variety of sources outside of NASA. These letters normally contain suggestions or requests for specific information, and often offer solutions to problems associated with one of NASA's aeronautical or space programs.

In addition to its principal functions, the Board is also authorized to conduct hearings on matters that pertain to patent waivers and the granting of monetary awards. The Board's present membership is composed of nine voting members and a non-voting executive secretary. The current members and the executive secretary were appointed by the Administrator of NASA on January 25, 1967, and their names are listed in app. F.

Petitions for Patent Waivers

In general, there are two types of petitions for patent waivers. The first of these is the petition for waiver of patent rights to an individual invention conceived by a contractor's employee, and identified and reported after a contract has become effective. The second type is the petition for blanket waiver of patent rights to all inventions that may be made during the period that a contract is in existence. A petition for blanket waiver may be submitted within 60 days after a contract has been signed. A modification of the usual blanket waiver procedure is reserved for those special cases that require immediate attention. It utilizes the Advance Waiver Review Panel which is authorized to consider petitions for blanket waiver and make recommendations to the Administrator of NASA before a contract has been signed. The panel is composed of three members of the Inventions and Contributions Board.

During the period covered by this report, the Board considered 96 petitions for waiver of patent rights to individual inventions. Following a review of the Board's findings and recommendations, the Administrator granted 70 petitions for waiver and denied 26. (See listing of petitioners in app. G). Twenty-four petitions for blanket waiver of patent rights to all inventions were also evaluated by the secretariat, considered by the Board, and forwarded to the Administrator with recommendations for final decision. The Administrator granted 20 and denied 4. (See listing of petitioners in app. H). In addition, the Administrator granted 20 petitions for blanket waiver that were considered by the Advance Waiver Review Panel. (See listing of petitioners in app. H). Finally, the Board considered 9 additional petitions for waiver of patent rights, but final action was deferred on these petitions. (See listing of petitioners in app. H).

The secretariat of the Board also supervised the compilation and editing of a new supplement to the publication entitled "Petitions for Patent Waiver—Findings of Fact and Recommendations of the NASA Inventions and Contributions Board." (NHB 5500.1A)

Space Act (Section 306) Awards

The secretariat of the Board reviewed and evaluated 57 scientific and technical contributions that were submitted for monetary awards (Section 306 of the National Aeronautics and Space Act of 1958). The Board recommended that monetary awards be made in ten cases, and its recommendations were approved by the Administrator. A listing of the ten contributions for which monetary awards were made appears in app. I.

Government Employees Incentive Awards

Under the provisions of the Government Employees Incentive Awards Act of 1954, the secretariat of the Board also reviewed and evaluated 70 scientific and technical contributions. These contributions were considered by the Board and approved for monetary awards. A listing of the awards made under this authority appears in app. J.

Hearings Before the Board

During this reporting period, the Board held one hearing in response to a request from a contributor whose contribution had been found to be not qualified for a monetary award. The results of the hearing confirmed the original recommendation of the Board.

Organizational Improvements

On March 15, 1967, NASA announced the consolidation of several important functional offices into a new Office of Organization and Management, headed by an Associate Administrator.

This new office brought several existing offices and several new organizational elements into a new pattern aimed at evaluating and strengthening Agency-wide management policies and practices. The new pattern provides a more effective integration of all the Agency's activities in its own installations, with industry, and with the Nation's universities. Five major functional areas were established in the new groupings.

The *Office of Administration,* headed by the Assistant Administrator for Administration, includes a broad range of administrative and technical support functions such as management information systems, budget formulation and execution, facilities management, personnel, safety, security, transportation and logistics, property and supply, occupational medicine, and accounting.

A significant feature of the realignment was the transfer of the important Agency-wide budget and facilities management functions to the Office of Administration. This Office now contains the Agency-wide responsibility for allocation and control of all Agency resources—money, manpower, and facilities.

The *Office of University Affairs,* headed by an Assistant Administrator, has the responsibility for integrating and coordinating NASA's relationships with colleges and universities. This includes directing the Sustaining University Program. Previously this responsibility belonged to the Grants and Research Contracts Office, Office of Space Science and Applications.

The *Office of Industry Affairs,* headed by an Assistant Administrator, is responsible for developing smooth working relationships between NASA and industry. This Assistant Administrator carries out these responsibilities by establishing Agency-wide policies pertaining to procurement, labor relations, reliability and quality assurance, and cost reduction programs.

The *Office of Technology Utilization,* headed by an Assistant Administrator, is responsible for helping all segments of the economy make practical uses of the scientific and technological innovations resulting from NASA's research and development activities.

The *Office of Special Contracts Negotiation and Review* was established under an Assistant Administrator responsible for reviewing the totality of NASA's relationships with selected private contractors in special cases designated by the Administrator.

Additional offices under the Associate Administrator for Organization and Management include the Audit Division, the Inspections Division, the Organization and Management Planning Division, and Headquarters Administration.

In conjunction with the realignment of functions, the following organizational components were abolished: Office of Management Development, Office of Programming, Office of Administration, and the Grants and Research Contracts element of the Office of Space Science and Applications.

Several changes were made in other organizational elements of NASA in the first 6 months of 1967.

The *Office of Program Plans and Analsyis* was established, also under an Assistant Administrator. This office will analyze, evaluate, and synthesize the program planning activities of individual organizational units and will complement them with Agency-wide perspective. It provides an independent engineering, scientific, and technical staff capability for the Administrator and Deputy Administrator on technical requirements and related considerations.

A *Deputy Associate Administrator for Aeronautics* was appointed to coordinate and manage the aeronautics research and technology development activities conducted in the various divisions of the Office of Advanced Research and Technology.

A *Voyager Program Office* was established in NASA Headquarters, reporting directly to the Associate Administrator for Space Science and Applications. Previously, this program had been assigned to the Division of Lunar and Planetary Programs. As an initial field organization for project management, systems offices were established at the Langley Research Center, Marshall Space Flight Center, and the Jet Propulsion Laboratory, under the overall management of the Voyager Project Office located in Pasadena, California.

An *Apollo Applications Program Office* was established at the Kennedy Space Center for planning and executing the responsibilities for that program that are assigned to the Kennedy Center.

Financial Management

NASA's financial status, level of activities, and results of transactions for the six months ended June 30, 1967, are shown by the following tables.

Fiscal Year 1968 Program

Table 10–1 shows the level of effort in research and development, construction of facilities, and administrative operations for fiscal year 1968, as authorized by the National Aeronautics and Space Administration Authorization Act of 1968.

Financial Reports, June 30, 1967

Table 10–2 shows fund obligations and accrued costs incurred during the six months ended June 30, 1967. Appended to the table is a summary by appropriation showing current availability, obligations against this availability, and unobligated balances as of June 30, 1967.

Table 10–3 shows NASA's consolidated balance sheet as of June 30, 1967, as compared to that of December 31, 1966. Table 10–4 summarizes the sources and applications of NASA's resources during the six months ended June 30, 1967. Table 10–5 provides an analysis of the net change in working capital disclosed in Table 10–4.

Table 10–1. NASA Appropriation Authorizations
Fiscal Year 1968
[in thousands]

Research and development:	
Apollo	$2,521,500
Apollo applications	347,700
Advanced missions	2,500
Physics and astronomy	145,500
Lunar and planetary exploration	131,900
Voyager	42,000
Bioscience	41,800
Space applications	99,500
Launch vehicle procurement	157,700
Space vehicle systems	36,000
Electronics systems	39,200
Human factor systems	21,000
Basic research	21,465
Space power and electric propulsion systems	44,000
Nuclear rockets	73,000
Chemical propulsion	41,000
Aeronautics	66,800
Tracking and data acquisition	290,000
Sustaining university program	20,000
Technology utilization	5,000
Total, research and development	4,147,565
Construction of facilities	69,980
Administrative operations	648,206
Total	$4,865,751

Preprocurement Patent License Policy

An experimental procedure was put into effect this year under which a bidding patent owner may notify the Contracting Officer that a proposed procurement will infringe his patent. If it is determined that infringement will occur under the proposed procurement, and if the patent meets certain requirements of enforceability and commercial acceptance, NASA may acquire a license under the patent prior to contracting. The Agency will then consider the royalty payable thereunder in selecting the most advantageous bid or offer to the United States. Under this procedure the patent owner will receive a royalty for the use of his patent if neither he nor his licensee is awarded the procurement.

Since this experimental procedure could have been construed as varying somewhat from prior decisions of the Comptroller General, his opinion of the procedure was requested before its formal adoption by NASA. The Comptroller General responded in Opinion B-136916, dated September 12, 1966, that he had no objection to NASA's trial use of such a policy.

Table 10–2. Status of Appropriations as of June 30, 1967

[In thousands]

Appropriations	*Six months ended June 30, 1967* *Obligations*	*Accrued costs*
Research and development:		
Gemini	$3,909	$19,819
Apollo	977,720	1,279,071
Advanced manned missions	5,014	4,729
Apollo applications	78,894	54,613
Completed missions	120	125
Physics and astronomy	69,064	102,233
Lunar and planetary exploration	63,760	86,199
Sustaining university program	25,524	19,654
Launch vehicle development	22,296	18,630
Launch vehicle procurement (unmanned)	81,972	90,701
Bioscience	20,590	21,283
Space applications	28,765	42,133
Mission analysis program	1,434	638
Basic research program	10,419	12,180
Space vehicle systems	23,684	22,839
Electronics systems	23,670	17,279
Human factor systems	10,458	8,462
Nuclear rockets	26,318	26,714
Chemical propulsion	26,817	18,747
Space power and electric propulsion systems	32,852	21,579
Aeronautics	36,198	29,479
Technology utilization	3,846	1,849
Tracking and data acquisition	108,435	175,535
Operations	(19)	250
Reimbursable	50,256	40,606
Total, research and development	1,731,996	2,115,347
Construction of facilities	49,233	119,739
Administrative operations	307,815	322,004
Totals	$2,089,044	$2,557,090

Appropriation Summary	*Current availability* [1]	*Total obligations*	*Unobligated balance*
Research and development	$1,948,711	$1,731,996	$216,715
Construction of facilities	144,619	49,233	95,386
Administrative operations	308,713	307,815	898
Totals	$2,402,043	$2,089,044	$312,999

[1] The availability listed includes authority for anticipated reimbursable orders.

On January 18, 1967, Representative Morris introduced a bill, H.R. 2898, which would authorize all agencies of the Government to adopt a preprocurement licensing policy of this type. At the end of the period this bill was still in the originating committee.

Table 10–3. NASA Comparative Consolidated Balance Sheet, June 30, 1967 and December 31, 1966

[In millions]

ASSETS	*June 30, 1967*	*December 31, 1966*
Cash:		
Funds with U.S. Treasury	$2,132.4	$4,703.7
Accounts receivable:		
Federal agencies	26.2	36.1
Other	1.5	.8
	27.7	36.9
Inventories:		
NASA-held	39.1	32.7
Contractor-held	168.7	134.9
	207.8	167.6
Advances and prepayments:		
Federal agencies	10.1	6.9
Deposits on returnable containers	.1	.1
Other	31.4	33.9
	41.6	40.9
Fixed assets:		
NASA-held	2,591.1	2,167.8
Contractor-held	557.7	518.7
Construction in progress	890.0	1,148.0
	4,038.8	3,834.5
Total assets	$6,448.3	$8,783.6
LIABILITIES AND EQUITY		
Liabilities:		
Accounts payable:		
Federal agencies	$ 162.6	$ 219.2
Other	621.7	624.1
	784.3	843.3
Accrued annual leave	35.2	32.7
Total liabilities	819.5	876.0
Equity:		
Net investment	3,466.8	3,170.7
Undisbursed allotments	2,170.6	3,495.7
Unapportioned and unallotted appropriation	104.8	1,397.5
	5,742.2	8,063.9
Less reimbursable disbursing authority uncollected	(113.4)	(156.3)
Total equity	5,628.8	7,907.6
Total liabilities and equity	$6,448.3	$8,783.6

Table 10–4. Resources Provided and Applied Six Months Ended June 30, 1967

(In millions)

RESOURCES PROVIDED			
Revenues	-------	------	$ 38.3
Decrease in working capital (Table 10–5)	-------	------	2,480.6
Total resources provided	-------	------	$2,518.9
RESOURCES APPLIED	*Total costs six months ended June 30, 1967*	*Less costs applied to assets*	
Operating costs:			
Research and development	$2,115.4	$126.2	$1,989.2
Construction of facilities	119.7	73.2	46.5
Administrative operations	322.0	25.4	296.6
Total	$2,557.1	$224.8	-------
Total operating costs	-------	------	2,332.3
Increase in fixed assets:			
NASA-held	-------	------	423.3
Contractor-held	-------	------	39.0
Construction in progress	-------	------	(258.0)
Total increase in fixed assets	-------	------	204.3
Property transfers and retirements—net	-------	------	(20.5)
Increase in working capital (Table 10–5)	-------	------	2.8
Total resources applied	-------	------	$2,518.9

Table 10–5. Net Change in Working Capital Six Months Ended June 30, 1967

(In millions)

	June 30, 1967	*December 31, 1966*	*Increase or (decrease)*
Current assets:			
Funds with U. S. Treasury	$2,132.4	$4,703.7	$(2,571.3)
Accounts receivable	27.7	36.9	(9.2)
Inventories	207.8	167.6	40.2
Advances and prepayments	41.6	40.9	.7
Total current assets	2,409.5	4,949.1	(2,539.6)
Current liabilities:			
Accounts payable	784.3	843.3	(59.0)
Working capital	$1,625.2	$4,105.8	---------
Increase in working capital	-------	-------	$(2,480.6)

Cost Reduction

NASA's basic cost reduction policy remained unchanged. Separate programs continued to be maintained for the Agency's internal cost reduction activities and for its contractors. While separately kept and reported on, both are directed by the NASA Cost Reduction Board. The Associate Deputy Administrator chairs the Board, with day-by-day operations handled by the Headquarters Cost Reduction Office.

During fiscal year 1967, internal cost reduction savings amounted to $185,402,805, $10,402,805 more than the $175,000,000 goal established at the beginning of the year. During the period of this report, the savings amounted to $116,402,210.

NASA management periodically evaluates and recommends improvements in the organization for cost reduction at each principal Field Installation and the major Headquarters activities. Seven such evaluations were made by Headquarters Cost Reduction and Program Office representatives during this period.

These evaluations continue to emphasize that the cost reduction actions reported and claimed by NASA must be both quantitatively and qualitatively valid. There is a system to exchange ideas among NASA installations by direct participation of Center representatives at shirt-sleeve report review conferences, two of which were held during this period, and by the periodic publication of useful ideas emanating from local cost reduction improvements in *NASA BITS*. The third issue of *NASA BITS* was prepared and sent to the printer during this period.

Savings effected under the NASA-Contractor Cost Reduction Program during Fiscal Year 1967 amounted to $236.8 million. Thirty-nine contractors voluntarily reporting under this program have shown an increasing realization of their responsibilities to support the President's request for assistance. Beneficial effects of the program within their own organizations have caused corporate management to stress increasing participation by their employees since increased prestige and improved profits have results from cost-conscious attitudes.

The entire Cost Reduction Program of each contractor is reviewed annually with top management officials to insure that direction and support of the program stems from such officials. In addition, the NASA Cost Reduction Officer at the Field Installation assigned to work with the contractor in the Cost Reduction Program is required to review the actual operations of the program at those divisions and subsidiaries which conduct the bulk of the work under NASA contracts. The programs are evaluated, suggestions for improvement are offered, and reported items are validated during these visits. During this particular period, twenty evaluations were made at the corporate level and a considerably greater number of reviews were made at the operating locations. NASA's relationship with the participating contractors is excellent and the majority of the contractors have better than average Cos Reduction Programs.

Idea interchange is a most important factor in both programs and most contractors are willing to share their ideas through NASA's publication *TRIM* when proprietary rights are not impaired by such disclosure. An issue of *TRIM* was published during this period. Also during this period there were two working seminars in which a number of the contractors and NASA representatives shared ideas and sought solutions to problems which have arisen in connection with improving the program.

Procurement

NASA's procurement efforts during the period were concentrated chiefly on improved management of contracts and contracting procedures. It became a full participant in the Contractor Performance Evaluation Program, it expanded its use of DOD Contract Administration Services, it modified certain policies related to unsolicited proposals, and it placed further stress on incentive contracting. Generally speaking, the Agency's procurement actions remained at the plateau indicated in the *16th Semiannual Report* (ch. 10).

NASA Contractor Performance Evaluation Program

NASA became a full participant with the Department of Defense in the Contractor Performance Evaluation Program (CPE). The program provides systematic and formal means for evaluating and recording the cost, schedule, and technical performance of a contractor, as specified by the terms of the contract. Under the program, development type contracts with a projected annual cost of $2 million or a projected total cost of $10 million may be placed in evaluation. Production contracts which are concurrent or follow-on to those development contracts in the program, and which have a projected annual cost of $5 million or a projected total cost of $20 million are also eligible for inclusion. At period's end, NASA had 18 major contracts with 13 separate corporations under evaluation. It was placing those new contracts which meet the established criteria into the evaluation system.

In support of the total Contractor Performance Evaluation Program, the Department of Defense made available to NASA the CPE training capability of the Army Management Engineering Training Agency (AMETA). Since February, 1967, AMETA has trained over 450 NASA personnel in the details of the CPE system.

This joint training effort, as well as the entire Contractor Performance Evaluation Program, illustrates the excellent interagency coordination which exists between NASA and the DOD.

Use of DOD Contract Administration Services

It is NASA policy to make maximum use of the DOD contract administration services that are available at or near NASA contractor plants. These services include quality assurance, property administration, reviews of contractors' business systems, as well as many other individual services.

For such services performed during FY 1967, NASA reimbursed DOD $29 million. This amount is considerably less than would be expended each fiscal year had NASA established its own field contract management organization. This arrangement conserves NASA funds, avoids duplication of resources, and provides for greater specialization in each of the contract administration skills, with more effective on-site surveillance of NASA contracts.

To make certain that these services are being performed satisfactorily by DOD, NASA actively participates in selected DOD contract management reviews of contract administration offices. Through such participation and by being a part of a larger DOD effort, NASA is able to assess overall DOD contract administration performance on NASA contracts with minimum expenditure of manpower.

NASA also participates in the DOD sponsored Customer Relations Program. In this program, the DOD and NASA jointly explore contract administration problems at the NASA procurement centers as they pertain to contracts delegated to the DOD for administration. The results of the Agency's first efforts in this program proved to be very beneficial, especially in resolving common problems and further improving communication between the two agencies.

Independent Research and Development Costs Allowance on Unsolicited Proposals

NASA procurement policy was revised to allow the costs of independent research and development (IR&D) as overhead chargeable to contracts which result from unsolicited proposals from commercial organizations. NASA's previous policy denying such costs differed in this respect from the Armed Services Procurement Regulation. Industry had long criticized the NASA policy as inequitable and, in view of the ASPR, uneconomical to administer. The differences in NASA and DOD policy were also found to be troublesome to Government contract administrators and auditors at the plants of the many contractors who have both NASA and DOD contracts since accounting segregation was required for relatively small increments of costs.

Unsolicited Proposals

NASA issued a new Part 4, Subpart 4, to its procurement regulation entitled "Unsolicited Proposals." This issuance stated NASA's policy to encourage submission of unsolicited proposals containing relevant new ideas.

The regulation provides detailed guidance concerning the format to be used in submitting an unsolicited proposal. It calls for a "preliminary review" of all submissions to determine whether they contain sufficient information to warrant a more detailed analysis. If they do, they are then subjected to a comprehensive evaluation which requires that consideration be given to the proposal's overall scientific and technical merit; its potential contribution to NASA's program objective(s); the proposer's unique capabilities, experience, and techniques; and any unique qualifications, capabilities, and experience of the proposed principal investigator and/or key personnel.

The regulation provides, in regard to any potential procurement stemming from an unsolicited proposal, that it is NASA's policy to obtain competition whenever possible. Therefore, if the substance of a proposal is available without restriction from another source, NASA shall not negotiate a non-competitive contract with the unsolicited proposer. However, if an unsolicited proposal receives a favorable technical evaluation, and if sufficient justification for accepting that proposal is established, the substance of the proposal may be procured from the proposer on a noncompetitive basis. To establish such justification, the regulation requires preparation of a "Justification for Acceptance of Unsolicited Proposal," which includes findings according to the criteria set forth in the regulation.

Improved Procurement, Supply and Property Management

From the inception of the President's program in September, 1966, NASA has made all its procurement, supply and property management activities responsive to its objectives. Procedures were improved, supply inventories were reduced, spare parts on contract were re-examined and reduced or cancelled wherever possible, and greater use was made of excess government property.

As a specific example, the Manned Spacecraft Center established a task group to provide for the rapid and orderly disposition of approximately $150,000,000 worth of Government property held by the Gemini prime contractor and his subcontractors. As of March 31, 1967, $139,000,000 of the property had been authorized for shipment to other NASA Centers for use on space programs, or to the Air Force and Navy.

Extension of Service Contract Act of 1965 to Option Renewals

The Congress enacted the "Service Contract Act of 1965," (Public Law 89–286, 79 Stat. 1034), to provide labor standards to protect employees of contractors and subcontractors that furnish services to the Federal Government. By its terms the Act does not apply to contracts in existence on January 20, 1966, the effective date of the Act. However, it is silent regarding its application to options for renewal or extension of service contracts. A number of NASA service contracts are written for a period of one year with a unilateral option in the Government to renew the contract for several additional one-year periods.

To carry out the Act's intent more efficiently, NASA recently revised certain regulations, extending its application to option renewals in both existing and new service contracts. The regulation makes the exercise of an option to renew a service contract subject to the current minimum wages and fringe benefits as determined by the Secretary of Labor to be prevailing in the locality. It also provides for adjustment in the contract price for resulting increases or decreases in the determined minimum wages and fringe benefits applicable to each option period, exclusive of overhead and of both general and administrative costs or profit. NASA believes this policy will promote stability in labor relations throughout the service industry and should promote the objectives of the Service Contract Act of 1965.

Procurement Management Surveys

During the period of this report three additional NASA buying centers were surveyed and final reports prepared. These surveys provided increased management insight into the effectiveness of field procurement organizations. They also provided evidence of the soundness of Agency procurement policies and procedures in actual operation.

Incentive Contracting

The significant growth in NASA's use of incentive contracts and the corresponding decrease in the use of cost-plus fixed fee contracts is reflected in the fact that the Agency had more than 200 incentive contracts in effect as of June 30, 1967. The target values of these contracts is about $6.2 billion, an increase of one billion dollars in incentive contracting during the past year.

NASA continued its efforts to develop new incentive contracting techniques. One of its newer contract management tools involves the use of subjective type incentives called Cost Plus Award Fee Contracts, (CPAF). As of June 30, NASA had in effect nearly 90 CPAF contracts with a total contract value of over $1.2 billion. The management disciplines of the new contract type generate benefits for both the Government and the contractor. The award fee or earned profit is determined subjectively, based on after-the-fact evaluation of the contractor's performance, his technical and business management, and utilization of resources. The evaluation criteria include quality, timeliness, and economy of performance.

During this reporting period NASA developed comprehensive guidelines for structuring and administering Cost Plus Award Fee Contracts. These guidelines are to be printed and distributed during the third quarter of 1967. Nearly every major aerospace contractor is now involved with CPAF Contracting, and the new guidelines will serve as an important training and administration tool.

NASA's periodic reporting of incentive contracts was expanded to include information concerning the timeliness of processing and definitizing contract changes. This addition to the reporting procedures makes it possible to identify management improvement goals for incentive contract administration. Late definitization of changes to incentive contracts adversely affects the integrity of the incentive contract structure and reduces risk-sharing on the part of the contractor. During the past year NASA's emphasis in this area reduced the average age of undefinitized changes by nearly sixty percent. This is considered to be an outstanding accomplishment in a relatively new procurement management program.

Summary of Contract Awards

NASA's procurement for the last 6 months of Fiscal Year 1967 (FY) (this report period) totaled $1,866.2 million. This is $386.3 million less than was awarded during the corresponding period of FY 1966.

Approximately 80 percent of the net dollar value was placed directly with business firms, 6 percent with educational and other nonprofit institutions, 4 percent with the California Institute of Technology for operation of the Jet Propulsion Laboratory, and 10 percent with or through other Government agencies.

Contracts Awarded to Private Industry

Ninety percent of the dollar value of procurement requests placed by NASA with other Government agencies resulted in contracts with industry awarded by those agencies on behalf of NASA. In addition, about 77 percent of the funds placed by NASA under the Jet Propulsion Laboratory contract resulted in subcontracts or purchases with business firms. In short, about 92 percent of NASA's procurement dollars was contracted to private industry.

Sixty-seven percent of the total direct awards to business represented competitive procurements, either through formal advertising or competitive negotiation. An additional 9 percent represented actions on follow-on contracts placed with companies that had previously been selected on a competitive basis to perform the research and development on the applicable project. In these instances, selection of another source would have resulted in additional cost to the Government by reason of duplicate preparation and investment. The remaining 24 percent included contracts for facilities required at contractor's plants for performance of their NASA research and development effort, contracts arising from unsolicited proposals offering new ideas and concepts, contracts employing unique capabilities, and procurements of sole-source items.

Small business firms received $125 million, or 8 percent of NASA's direct awards to business. However, most of the awards to business were for large continuing research and development contracts for major systems and major items of hardware. These are generally beyond the capability of small business firms on a prime contract basis. Of the $413 million of new contracts of $25,000 and over awarded to business during the six months, small business received $59 million, or 14 percent.

In addition to the direct awards, small business received substantial subcontract awards from 84 of NASA's prime contractors participating in its Small Business Subcontracting Program. Total direct awards plus known subcontract awards aggregated $264 million, or 18 percent of NASA's total awards to business during the last half of FY 1967.

Geographical Distribution of Prime Contracts

Within the United States, NASA's prime contract awards were distributed among 50 States and the District of Columbia. Business firms in 4 States and the District of Columbia, and educational institutions and other nonprofit institutions in 50 States and the District of Columbia, participated in the awards. Two percent of the awards went to labor surplus areas located in 14 States.

Subcontracting

Subcontracting effected a further distribution of the prime contract awards. NASA's major prime contractors located in 26 States and the District of Columbia reported that their larger subcontract awards on

NASA effort had gone to 1,515 subcontractors in 43 States and the District of Columbia, and that 61 percent of these subcontract dollars had crossed state lines.

Major Contract Awards

Among the major research and development aggregate contract awards by NASA during the last six months of FY 1967 were the following:

1. North American Aviation, Inc., Downey, Calif. NAS9–150. Design, develop and test Apollo command and service module. Awarded $186 million; cumulative awards $2,596 million.

2. Grumman Aircraft Engineering Corp., Bethpage, N.Y. NAS9–1100. Development of Apollo lunar module. Awarded $123 million; cumulative awards $1,225 million.

3. McDonnel Douglas Corp., Santa Monica, Calif. NAS7–101. Design, develop and fabricate the S-IVB stage of the Saturn V vehicle and associated ground support equipment and provide launch suport services. Awarded $69 million; cumulative awards $795 million.

4. The Boeing Company, New Orleans, La. NAS8–5608. Design, develop and fabricate the S-IC stage of the Saturn V vehicle, construct facilities in support of the S-IC stage and provide launch support services. Awarded $61 million; cumulative awards $965 million.

5. North American Aviation, Inc., Downey, Calif. NAS7–200. Design, develop, fabricate and test the S-II stage of the Saturn V vehicle and provide launch support services. Awarded $59 million; cumulative awards $918 million.

6. General Electric Company, Huntsville, Ala. NASw-410. Overall integration, checkout and reliability of Apollo space vehicle system. Awarded $45 million; cumulative awards $532 million.

7. Aerojet General Corp., Sacramento, Calif. SNP-1. Design, develop, and produce a nuclear powered rocket engine (NERVA). Awarded $39 million; cumulative awards $398 million.

8. North American Aviation, Inc., Canoga Park, Calif. NAS8–19. Develop and procure 200,000-pound thrust J-2 rocket engine with supporting services and hardware. Awarded $32 million; cumulative awards $529 million.

9. Chrysler Corporation, New Orleans, La. NAS8–4016. Fabricate, assemble, checkout and static test Saturn S-IB stage; provide product improvement program and spare parts support; modify areas of Michoud Plant assigned to contractor; provide launch support services. Awarded $24 million; cumulative awards $396 million.

10. International Business Machines Corp., Huntsville, Ala. NAS8–14000. Fabrication, assembly and checkout of Instrument Units for

Saturn I and V vehicles. Awarded $23 million; cumulative awards $181 million.

11. Bendix Corporation, Kennedy Space Center, Fla. NAS10–1600. Apollo launch support services at Kennedy Space Center. Awarded $15 million; cumulative awards $43 million.

12. International Business Machines Corp., Houston, Texas. NAS9–996. Design, develop and implement real time computer complex for Integrated Mission Control Center at the Manned Spacecraft Center. Awarded $15 million; cumulative awards $89 million.

13. General Motors Corp., Milwaukee, Wisc. NAS9–497. Guidance computer subsystem for Apollo command and service module. Awarded $15 million; cumulative awards $295 million.

14. General Dynamics Corp., San Diego, Calif. NAS3–8711. Management and engineering services in support of Centaur Program for CY 1967. Awarded $14 million; (new contract).

15. Bendix Corporation, Ann Arbor, Mich. NAS9–5829. Apollo lunar surface experiments package. Awarded $13 million; cumulative awards $31 million.

16. General Electric Company, King of Prussia, Pa. NAS2–1900. Design, fabricate, deliver and provide operational support for Biosatellites. Awarded $12 million; cumulative awards $60 million.

17. McDonnell Douglas Corp., Santa Monica, Calif. NAS7–537. Prepare for launch and launch Delta Space Research Vehicles at the Eastern and Western Test Ranges. Awarded $11 million; (new contract).

18. Trans World Airlines, Kennedy Space Center, Fla. NAS10–1242. Provide base support services at Kennedy Space Center. Awarded $11 million; cumulative awards $57 million.

19. TRW, Inc., Houston, Texas. NAS9–4810. Gemini—Apollo mission trajectory and Apollo spacecraft systems analysis programs. Awarded $11 million; cumulative awards $46 million.

20. McDonnell Douglas Corp., St. Louis, Mo. NAS9–6555. Airlock module for use with the orbital workshop experiment and trainers spare parts and GSE. Awarded $11 million; (new contract).

Major Contractors

The 25 contractors receiving the largest direct awards (net value) during the last six months of FY 1967 were as follows:

	Contractor and place of contract performance	*Thousands*
1.	North American Aviation, Inc., Downey, Calif.*	$301,021
2.	Grumman Aircraft Engineering Corp., Bethpage, N.Y.	124,382
3.	McDonnell Douglas Corp., Santa Monica, Calif.*	104,936
4.	Boeing Co., New Orleans, La.*	85,577
5.	General Electric Co., Huntsville, Ala.*	74,690

6.	International Business Machines Corp., Huntsville, Ala.*	55,819
7.	Aerojet-General Corp., Sacramento, Calif.*	53,671
8.	Bendix Corp., Owings Mill, Md.*	49,011
9.	General Dynamics Corp., San Diego, Calif.*	36,978
10.	TRW Inc., Redondo Beach, Calif.*	28,738
11.	Radio Corporation of America, Princeton, N.J.*	27,393
12.	LTV Aerospace Corp., Dallas, Texas*	25,178
13.	Chrysler Corp., New Orleans, La.*	25,049
14.	United Aircraft Corp., West Palm Beach, Fla.*	23,887
15.	Lockheed Aircraft Corp., Houston, Texas*	18,019
16.	Sperry Rand Corp., Huntsville, Ala.*	15,717
17.	General Motors Corp., Milwaukee, Wisc.*	15,107
18.	Philco Ford Corp., Houston, Texas*	14,365
19.	Honeywell, Inc., St. Petersburg, Fla.*	11,889
20.	Trans World Airlines, Inc., Kennedy Space Center, Fla.	11,012
21.	General Precision, Inc., Houston, Texas*	9,569
22.	Brown Engineering Co., Inc., Huntsville, Ala.*	9,343
23.	Bell Aerospace Corp., Buffalo, N.Y.*	8,225
24.	Garrett Corp., Los Angeles, Calif.*	7,683
25.	Martin Marietta Corp., Denver, Colo.*	7,017

* Awards during the period represent awards on several contracts which have different principal places of performance. The place shown is that which has the largest amount of the awards.

Labor Relations

Significantly fewer mandays were lost as a result of work stoppage on NASA construction projects during the first six months of 1967 than were lost during the preceding six months. Time lost resulting from strikes on construction projects at all NASA Centers was reduced to 2,316 mandays during the first half of 1967, compared to 18,243 mandays during the last half of 1966.

However, there was an increase in mandays lost because of work stoppages of industrial contractor employees at NASA Centers during the first half of 1967. Industrial service contractor employees accounted for 1,456 mandays lost because of strike at all NASA Centers during the first half of 1967, compared to 50 mandays lost during the last half of 1966.

The most significant improvement in labor-management relations was experienced at the John F. Kennedy Space Center and Cape Kennedy, where all projects were completely free of strike activity from September 8, 1966, through the end of this period.

The NASA Office of Labor Relations continued to increase and intensify planning for preventive labor relations programs at all NASA Centers.

Relationships with Other Government Agencies

NASA continued to work with other government agencies, particularly the Department of Defense, to promote economy and efficiency in those matters that are of interest to both. A major area of effort was the work done through the Aeronautics and Astronautics Coordinating Board.

The Aeronautics and Astronautics Coordinating Board

NASA continued its close working relationship with the Department of Defense in matters of common interest. Direct contact, interagency coordinating groups, and special briefings and program reviews are maintained for the exchange of information and coordination of NASA and DOD activities and programs. As in the past, the principal mechanism for this activity was the Aeronautics and Astronautics Coordinating Board (AACB) and its six specialized Panels.

Results of the AACB efforts during the six month period were significant.

The FY 1968 facilities budgets of NASA and DOD were reviewed with respect to new construction or expansion of research facilities. No unwarranted duplication of aeronautical and space facilities was identified in the final phase of this review process.

NASA and DOD studied the economic aspects of reusable launch vehicles. The principal conclusions were that the initiation of a major development effort on fully reusable launch vehicle stages is not currently warranted, but that partially reusable personnel/cargo spacecraft appear attractive as a next development step.

The coordination of the DOD-NASA Space Science Programs was reviewed by the Unmanned Spacecraft Panel and accepted by the Board.

An ad hoc sub-panel on Security Classification Practices reviewed the NASA-DOD application of security guidelines and determined that the classification policies of the two Agencies are consistent. However, some disparities in application exist in certain areas of technology. A coordinating mechanism to review specific classification guides in selected fields of technology would reduce or eliminate inconsistencies. Action to this end is to be taken.

The AACB approved a proposal to conduct a comprehensive review of existing aerospace test facilities and anticipated future needs in order to establish a long-term national guideline plan. A detailed outline for the conduct of this study—covering industry, university, and government facilities—was being prepared by the Aeronautics Panel.

Other interagency coordinating groups such as the Manned Space Flight Policy Committee, the Space Applications Coordinating Committee, and the NASA-FAA Coordinating Committee continued to exchange information and consider matters of mutual interest.

Interagency Agreements

Agreements between NASA, DOD, and the individual Military Services provide a basis of understanding on some very complex interrelationships. New agreements were reached on the operation of the unified S-Band tracking facilities on Grand Bahama Island; on loans to NASA of Naval and Air Force aircraft for flight research programs; on the logistic support plan for aircraft at Wallops Station, Virginia; and on arrangements for the Air Force 1st Strategic Aerospace Division at Vandenberg Air Force Base to provide base support facilities and services to the NASA Western Test Range Operations Division.

Some revisions and updating of agreements were also being accomplished. Those related to NASA and Army tests at the White Sands Missile Range; an agreement with the Air Force to cover procedures in the investigation of aircraft accidents wherein the interests of both Agencies are involved; and the use of the AF Nuclear Aerospace Research Facility at Fort Worth, Texas.

NASA-Navy-Air Force coordination resulted in a simplified format to be used in the preparation or extension of aircraft loan agreements.

NASA and the Air Force agreed on the transfer of management responsibilities for the XB-70 Flight Research Program from the Air Force to NASA. The program is to continue as a joint activity, and the Air Force will continue to provide administrative, operational, and logistic support on a nonreimbursable basis. A reduced flight rate was established, with future flights concentrating on the investigation of inflight dynamics, handling qualities, stability and control, systems technology, and propulsion of large supersonic aircraft.

Personnel Affairs

Early in the year, NASA's policy regarding the use of military detailees was reaffirmed by the Administrator. However, because the manpower needs of the Military Services became more pressing and the NASA organization was able to generate within itself its needed skills, efforts were initiated to reduce the number of detailees. Nevertheless, a minimum number of detailees will be required for orientation and for the interchange of information in national aeronautical and space program needs and activities. These tours of duty of military personnel with NASA benefit not only the parent Service and NASA, but also the career development of the individual detailees.

As of the end of the period, 325 military personnel were assigned to NASA. Of these, 79 were from the Army, 33 from the Navy, 4 from the Marine Corps, and 209 from the Air Force. Thirteen NASA employees were assigned to the Defense Department, all but two of whom are assisting in the MOL program. One Army civilian employee is on detail to NASA Headquarters.

Exchange of Information

The Administrator's Program Reviews, repeated for the benefit of interagency groups, are attended by senior civilian officials of DOD, flag and general officers of the Military Services, and by high-level officials of other government agencies having an interest in the national aerospace program. Such repeated Program Reviews during the period covered Launch Vehicles, Nuclear Space Power and Rockets, Electric Propulsion, Aeronautics, Lunar and Planetary Exploration, Space Vehicle Systems, Life Sciences, Space Applications, and ground based Tracking and Data Acquisition Systems.

The Air Force (AFSC) gave NASA a special briefing on the Objective Force Structure of the Air Force through 1976. NASA gave a reciprocal briefing which described its programs in areas of technology wherein advances are needed to support the development of the planned weapon systems. Exchanges such as this were supplemented by periodic visits of senior DOD officials to NASA laboratories.

Information was exchanged on geodetic, meteorological, and communications satellites; space flight secondary payload capabilities; and success rates of launch vehicles, spacecraft, and missions.

NASA served as sponsor, along with DOD and other government agencies, in joint symposiums. Plans were underway for the sponsorship of a joint symposium by NASA, DOD, and FAA on manned flight simulation requirements and techniques. The symposium is to cover such areas as performance characteristics of aeronautical and manned space systems in the conceptual stage, aircraft and spacecraft crew trainers, and air-to-air combat simulators. Also being planned was a joint government conference of microelectronics applications and development trends.

Mutual Support

The Department of Defense provided specific support to NASA on a reimbursable basis in several categories. These included: air-sea search to locate Biosatellite I when its orbit decayed near Australia; a study by the Navy on the use of stable ocean platforms as mobile tracking and communications facilities; training by the Air Force of NASA pilots in the operation of F-106 type aircraft being used in flight research work; and airlift of astronauts on geological field trips in Iceland. NASA in turn has continued to provide support to DOD in space and aeronautical research, development, and testing.

Appendix A

Congressional Committees on Aeronautics and Space

(January 1–June 30, 1967)

Senate Committee on Aeronautical and Space Sciences

CLINTON P. ANDERSON, New Mexico, *Chairman*
RICHARD B. RUSSELL, Georgia
WARREN G. MAGNUSON, Washington
STUART SYMINGTON, Missouri
JOHN STENNIS, Mississippi
STEPHEN M. YOUNG, Ohio
THOMAS J. DODD, Connecticut
HOWARD W. CANNON, Nevada
SPESSARD L. HOLLAND, Florida
WALTER F. MONDALE, Minnesota
MARGARET CHASE SMITH, Maine
BOURKE B. HICKENLOOPER, Iowa
CARL T. CURTIS, Nebraska
LEN B. JORDAN, Idaho
EDWARD W. BROOKE, Massachusetts
CHARLES H. PERCY, Illinois

House Committee on Science and Astronautics

GEORGE P. MILLER, California, *Chairman*
OLIN E. TEAGUE, Texas
JOSEPH E. KARTH, Minnesota
KEN HECHLER, West Virginia
EMILIO Q. DADDARIO, Connecticut
J. EDWARD ROUSH, Indiana
JOHN W. DAVIS, Georgia
WILLIAM F. RYAN, New York
THOMAS N. DOWNING, Virginia
JOE D. WAGGONNER, JR., Louisiana
DON FUQUA, Florida
GEORGE E. BROWN, JR., California
LESTER L. WOLFF, New York
WILLIAM J. GREEN, Pennsylvania
EARLE CABELL, Texas
JACK BRINKLEY, Georgia
BOB ECKHARDT, Texas
ROBERT O. TIERNAN, Rhode Island
JAMES G. FULTON, Pennsylvania
CHARLES A. MOSHER, Ohio
RICHARD L. ROUDEBUSH, Indiana
ALPHONZO BELL, California
THOMAS M. PELLY, Washington
DONALD RUMSFELD, Illinois
EDWARD J. GURNEY, Florida
JOHN W. WYDLER, New York
GUY VANDER JAGT, Michigan
LARRY WINN, JR., Kansas
JERRY L. PETTIS, California
DONALD E. LUKENS, Ohio
JOHN E. HUNT, New Jersey

Appendix B

National Aeronautics and Space Council

(January 1–June 30, 1967)

HUBERT H. HUMPHREY, *Chairman*
Vice President of the United States

DEAN RUSK
Secretary of State

ROBERT S. MCNAMARA
Secretary of Defense

JAMES E. WEBB, *Administrator*
National Aeronautics and Space Administration

GLENN T. SEABORG, *Chairman*
Atomic Energy Commission

Executive Secretary
EDWARD C. WELSH

Appendix C

Principal NASA Officials at Washington Headquarters

(June 30, 1967)

James E. Webb	Administrator
Dr. Robert C. Seamans, Jr.	Deputy Administrator (and Associate Administrator)
Willis H. Shapley	Associate Deputy Administrator
Harold B. Finger	Associate Administrator for Organization and Management
William E. Lilly	Assistant Administrator for Administration
Dr. Bernhardt L. Dorman	Assistant Administrator for Industry Affairs
Bernard Moritz	Assistant Administrator for Special Contracts Negotiation and Review
Dr. Richard L. Lesher	Assistant Administrator for Technology Utilization
Francis B. Smith	Assistant Administrator for University Affairs
DeMarquis D. Wyatt	Assistant Administrator for Program Plans and Analysis
Jacob E. Smart	Assistant Administrator for Policy
Adm. W. Fred Boone, USN (Ret.)	Assistant Administrator for Defense Affairs
Paul G. Dembling	General Counsel
Arnold W. Frutkin	Assistant Administrator for International Affairs
Robert F. Allnutt	Assistant Administrator for Legislative Affairs
Julian Scheer	Assistant Administrator for Public Affairs
Dr. George E. Mueller	Associate Administrator for Manned Space Flight
Dr. Homer E. Newell	Associate Administrator for Space Science and Applications
Edmond C. Buckley	Associate Administrator for Tracking and Data Acquisition
Dr. Mac C. Adams	Associate Administrator for Advanced Research and Technology

(Telephone information: 963–7101)

Appendix D

Current Official Mailing Addresses for Field Installations

(June 30, 1967)

Installation and telephone number	Official	Address
Ames Research Center; 415-961-1111.	Dr. H. Julian Allen, Director.	Moffett Field, Calif. 94035.
Electronic Research Center; 617-491-1501.	Mr. James C. Elms, Director.	575 Technology Square, Cambridge, Mass. 02139.
Flight Research Center; 805-258-3311.	Mr. Paul Bikle, Director	Post Office Box 273, Edwards, Calif. 93523.
Goddard Space Flight Center; 301-474-9000.	Dr. John F. Clark, Director	Greenbelt, Md. 20771.
Goddard Institute for Space Studies; 212-UN6-3600.	Dr. Robert Jastrow, Director.	2880 Broadway, New York, N.Y. 10025.
Jet Propulsion Laboratory; 213-354-4321.	Dr. W. H. Pickering, Director.	4800 Oak Grove Dr., Pasadena, Calif. 91103.
John F. Kennedy Space Center; 305-867-7110.	Dr. Kurt H. Debus, Director.	Kennedy Space Center, Fla. 32899.
Langley Research Center; 703-722-7961.	Dr. Floyd L. Thompson, Director.	Langley Station, Hampton, Va. 23365.
Lewis Research Center; 216-433-4000.	Dr. Abe Silverstein, Director.	21000 Brookpark Rd., Cleveland, Ohio 44135.
Manned Spacecraft Center; 713-HU3-0123.	Dr. Robert R. Gilruth, Director.	Houston, Tex. 77058.
George C. Marshall Space Flight Center; 205-877-1100.	Dr. Wernher von Braun, Director.	Huntsville, Ala. 35812.
Michoud Assembly Facility; 504-255-3311.	Dr. George N. Constan, Manager.	Post Office Box 26078, New Orleans, La. 70126.
Mississippi Test Facility; 601-688-2211.	Mr. Jackson M. Balch, Manager.	Bay St. Louis, Miss. 39520.
KSC Western Test Range Operations Division; 805-866-1611.	Mr. H. R. Van Goey, Chief	Post Office Box 425, Lompac, Calif. 93436.
Plum Brook Station; 419-625-1123.	Mr. Alan D. Johnson, Director.	Sandusky, Ohio 44871.
Wallops Station; 703-VA4-3411	Mr. Robert L. Krieger, Director.	Wallops Island, Va. 23337.
Western Support Office; 213-451-7411.	Mr. Robert W. Kamm, Director.	150 Pico Blvd., Santa Monica, Calif. 90406.

Appendix E

NASA's Historical Advisory Committee

(June 30, 1967)

Chairman: Prof. MELVIN KRANZBERG, Case Institute of Technology and Executive Secretary of the Society for the History of Technology

MEMBERS

Prof. JAMES LEA CATE, Department of History, University of Chicago

Dr. A. HUNTER DUPREE, Department of History, University of California (Berkeley)

Prof. WOOD GRAY, Department of History, George Washington University

Dr. LAURENCE KAVANAU, Executive Vice President, Space and Information Division, North American Aviation, Inc.

Mr. MARVIN W. MCFARLAND, Chief, Science and Technology Division, Library of Congress

Dr. ALAN T. WATERMAN, Former Director, National Science Foundation

Executive Secretary: Dr. EUGENE M. EMME, NASA Historian

Appendix F

NASA's Inventions and Contributions Board

(June 30, 1967)

Chairman	ERNEST W. BRACKETT
Vice Chairman	ROBERT F. ALLNUTT
Executive Secretary	FRANCIS W. KEMMETT
Members	J. ALLEN CROCKER
	MELVIN S. DAY
	C. GUY FERGUSON
	HARVEY HALL
	ARTHUR D. HOLZMAN
	ROBERT E. LITTELL
	JOHN B. PARKINSON

Appendix G

Patent Waivers Granted and Denied for Separate Inventions Upon Recommendation of the Agency's Inventions and Contributions Board

(January 1–June 30, 1967)

Invention	Petitioner	Action on petition
Automatic power shut-off brazed fluid system stub union removal tool.	McDonnell Aircraft Corp.	Granted.
High temperature generating fuse salt battery power supply.	TRW Inc./TRW Systems	Denied.
Airstretcher inflatable patient restraint	Martin-Marietta Corp.	Do.
Orthopedic stretcher	Francis X. Lothshuetz, M.D., (Employee of Mason-Rust).	Do.
Particle parameter analyzing system (electronic X-Y plotter).	TRW, Inc.	Granted.
Control apparatus	Honeywell, Inc.	Do.
Brushless direct current motor and torquer	General Electric Co.	Do.
Wide angle, long eye relief eyepiece	Kollsman Instrument Corp.	Denied.
Tantalum-base alloys	Westinghouse Electric Corp.	Granted.
Load current limiter for a direct coupled amplifier.	The Bendix Corp.	Do.
Method of maintaining the activity of a hydrogen sensing platinum electrode.	Beckman Instruments, Inc.	Denied.
Polymers of amines and anhydrides	Quantum, Inc.	Granted.
Dicyanoacetylene polymers	California Institute of Technology.	Do.
Thrust measurement	North American Aviation, Inc.	Granted.
Anti-resonant mass spectrometer	California Institute of Technology.	Do.
Burrowing apparatus	do	Do.
Control apparatus	Honeywell, Inc.	Do.
Spherical tank gauge	United Aircraft Corp.	Denied.
Electrolytically prepared reference electrode	Institute of Research and Instrumentation.	Do.
Pressed—disc type reference electrode	do	Do.
Stable superconducting magnet	North American Aviation, Inc.	Granted.
Iridium slurry coating for tungsten	Ill. Institute of Technology Research Institute.	Do.
Method and apparatus for vibration analysis utilizing the Mossbauer effect.	North American Aviation, Inc.	Do.
Improved ear oximeter	Beckman Instrument, Inc.	Denied.
Shoulder joint	Litton Systems, Inc.	Do.
Waist joint	do	Do.
Hip joint	do	Do.
Rotational control for controlling reaction jets on a space vehicle.	Honeywell, Inc.	Do.
Portable hermetic work chamber	Herbert M. Goldstein and Joseph L. LeBlanc, (Employees of Grumman Aircraft Engineering Corp.).	Do.
Tantalum-base alloys	Westinghouse Electric Corp.	Granted.
Precipitation-hardened tantalum-base alloy	do	Do.

Patent Waivers Granted and Denied for Separate Inventions Upon Recommendation of the Agency's Inventions and Contributions Board—Continued

(January 1–June 30, 1967)

Invention	Petitioner	Action on petition
Fluid amplifier serial digital adder logic circuit	General Electric Co.	Do.
Fluid amplifier serial digital complementer circuit.	do	Do.
Fluid amplifier shift register circuit	do	Do.
Liquid-metal arc cathode	Hughes Aircraft Co.	Do.
Electrical contract assembly for compression bonded electrical devices.	Westinghouse Electric Corp.	Do.
Squeeze film bearing utilizing double film	The Bendix Corp.	Do.
Charging method and apparatus for nickel-cadmium cells.	TRW Inc.	Denied.
D. C. power amplifier	General Precision Inc.	Do.
Low inertial tape storage	Ampex Corp.	Do.
Aluminum welding rod	North American Aviation, Inc.	Granted.
Brazing alloy composition	do	Do.
Heterogeneous rigid urethane foams of superior physical properties.	Monsanto Research Corp.	Do.
Momentum transducer for impacting particles	Ling-Temco-Vought, Inc.	Do.
Static switching circuit	Westinghouse Electric Corp.	Do.
A linear actuator and quadruple redudant type fail operative actuation system.	Bendix Corp.	Granted.
Browning inhibitor	Schwatz Bioresearch, Inc.	Do.
Apparatus for making computer memory	Massachusetts Institute of Technology.	Do.
Jig saw attachment with zero reaction feed mechanism.	Martin-Marietta Corp.	Do.
Zero reaction drill (hole saw) attachment	do	Do.
Gauge calibration by diffusion	National Research Corp.	Do.
Sight switch	Spaco, Inc.	Denied.
Touch starting of power arc with consumable electrode.	Air Reduction Co.	Granted.
Cascade aperture multiplier photo-tube	International Telephone and Telegraph Corp.	Do.
Research in realization of threshold logic circuit techniques.	The Bunker-Ramo Corp.	Do.
Reinforced thermal shock resistant ceramics	TRW, Inc.	Do.
Balanced modulator	Sylvania Electric Products, Inc.	Denied.
Time multiplexing of antenna position and polarization signals for processing by a single signal channel.	do	Do.
Soil penetrometer	California Institute of Technology.	Granted.
Ablative resins for poly-alkaline earth metal acrylates.	TRW, Inc.	Denied.
Polyimide-ethers—a new class of polymers	TRW, Inc.	Denied.
Polyimide-esters—a new class of polymers	do	Do.
Improved lead telluride thermoelectric elements	Hittman Associates, Inc.	Granted.
Noise suppression system and device	Douglas Aircraft Co., Inc.	Denied.
Fuel cell design	American Cyanamid Co.	Do.
Gas leak detection system	Drury K. Mitchell (Employee of Boeing Co.).	Granted.
Pressure switch	Norman J. Smith (Employee of Boeing Co.).	Do.
Solid state battery	California Institute of Technology.	Do.
Combined series regulator and magnetic core multivibrator.	General Electric Co.	Do.

Patent Waivers Granted and Denied for Separate Inventions Upon Recommendation of the Agency's Inventions and Contributions Board—Continued

(January 1–June 30, 1967)

Invention	Petitioner	Action on petition
Electron multiplier array for image intensifier tubes.	The Bendix Corp.	Do.
Interlocking collapsible boom	Melpar, Inc.	Do.
Electric current producing cell	Livingston Electronic Corp.	Do.
Preferential edge coating of flat ribbon wire	G. T. Schjeldahl Co.	Do.
Air particle analyzer	Block Engineering, Inc.	Denied.
Tracking receiver	International Telephone and Telegraph Corp.	Do.
Method of fabricating flat conductor cable	G. T. Schjeldahl Co.	Granted.
Method of treating precipitation hardened alloys.	North American Aviation, Inc.	Do.
Thermoplastic rubber	California Institute of Technology.	Do.
Preparation of alkali metal dispersions	do	Do.
Closed-loop feedback for machining	North American Aviation, Inc.	Do.
Brazing alloy binder	do	Do.
Method for eliminating second harmonic ripple current from the DC input lines in static inverters.	TRW, Inc.	Do.
Simultaneous message framing and error detection.	International Business Machine Corp.	Do.
Movable electrode for arc heater	Westinghouse Electric Corp.	Do.
Load current and power dissipation limiter for a direct current coupled amplifier.	The Bendix Corp.	Do.
Control apparatus	Honeywell, Inc.	Do.
Method for one dimensional storage of two dimensional information.	Stanford University	Do.
Solid state scanning apparatus	General Electric Co.	Do.
Solid state image converter system	do	Do.
Connector separators for sub-miniature rectangular connectors.	B. H. Greenspan, (Employee of R.C.A.).	Do.
Polyimide resin bonded solid film lubricant	Midwest Research Institute	Granted.
Combination automatic-starting electrical plasma torch and gas shutoff valve.	Giannini Scientific Corp.	Do.
Contacts for semiconductive devices, particularly integrated circuits, and methods for making the same.	Westinghouse Electric Corp.	Do.
Production of porous materials	Electro-Optical Systems, Inc.	Do.
Radiation sensitive semiconductive system	Westinghouse Electric Corp.	Do.
Cyclized polydiene resin-rubber vylcanizates	TRW, Inc.	Do.

Appendix H

Patent Waivers Granted and Denied for All Inventions Made During Performance of Contract Upon Recommendation of the Agency's Inventions and Contributions Board

(January 1–June 30, 1967)

Contract description	Petitioner	Action on petition
To develop an oil lubricated, rolling element bearing system for Brayton cycle turbomachinery.	United Aircraft Corp.	Granted.
Study of lunar worm planetary roving vehicle concept.	Philco Corp.	Denied.
Analytical and experimental program to determine effect of spin on hybrid rocket internal ballistics.	United Technology Center, Division of United Aircraft Corp.	Granted.
Design, fabricate, test and deliver hermetically sealed toggle switches for the LEM, command and service modules of the Apollo spacecraft.	Texas Instruments, Inc. Metals & Controls Inc. Division.	Do.
A study to determine the accuracy requirement for a small energetic (kick) stage for use as an upper stage with present and future launch vehicles with respect to the relationship between accuracy requirements, weight, and space design.	United Aircraft Corp.	Denied.
Research on critical computational problems concerning strapdown inertial navigation systems.	do	Do.
Improved fuel cell electrical power system for Apollo extension system missions.	Allis-Chalmers Mfg. Co.	Granted.
Design, development, fabrication, and test of a spacecraft teleprinter.	The National Cash Register Co.	Do.
Development of fuel cell electrodes	Union Carbide Corp.	Do.
Studies of variable-pitch supersonic inflow compressor.	The Garrett Corp.	Granted.
Development of a thermionic space power supply	Radio Corp. of America	Denied.
Development of high performance light weight electrodes systems of hydrogen-oxygen fuel cells.	American Cyanamid Co.	Granted.
Design & develop computer equipment in the nature of flight data storage subsystems and associated operational support equipment.	Texas Instruments, Inc.	Do.
Feasibility study of prototype thin film tunnel cathode.	Arthur D. Little, Inc.	Do.
Design of a process and formulation for producing ferrite toroids and design of integrated ferrite structure for an eight-stage ring-counter.	Ampex Corp.	Do.
Design and develop a flight telemetry system, operational support equipment and ground telemetry system.	Texas Instruments, Inc.	Do.
A study to determine the feasibility of employing nuclear radiation techniques to measure the propellant mass in the tank of an orbiting space vehicle.	Industrial Nucleonics Corp.	Do.

Patent Waivers Granted and Denied for All Inventions Made During Performance of Contract Upon Recommendation of the Agency's Inventions and Contributions Board—Continued

(January 1–June 30, 1967)

Contract description	Petitioner	Action on petition
Study to determine the effects of radiation on the acid etch rate of silicon nitride coating and a comparison of the effect of radiation on the stability of metal nitride semiconductor and metal oxide semiconductor.	Hughes Aircraft Co.	Do.
Experimentation program for development of phosphor for cathode ray tube.	PanAura Corp.	Do.
A study covering the various methods and techniques of recording digital data on magnetic tape and the methods of recovering these data.	Ampex Corp.	Granted.
Development of improved carbon dioxide control systems for manned spacecraft.	Esso Research and Engineering Co.	Do.
Microelectronic S-band receiver	General Dynamic Electronics Division.	Do.
R&D thin film space charge limiter triode devices.	Hughes Aircraft Co.	Do.
Improved fuel cell electrical power systems for advanced space mission application.	Allis Chalmers Mfg. Co., Research Division.	Do.

Contract description [1]	Petitioner	Action on petition
Research, develop, design, fabricate, test and deliver one Test Model Gyro Assembly utilizing a hydrodynamic fluid-film self-sealing grease or oil bearing for the Gyro Spin Axis.	Ampex Corp.	Granted.
Perform research and development to determine feasibility of new techniques for sensing pressures.	Electro-Optical Systems, Inc.	Do.
Design and develop a high-density memory system.	Ampex Corp.	Do.
Research, development and evaluation of light weight high strength magnesium-scandium alloys.	The Dow Chemical Co.	Do.
Research and development of fuel cell catalysts	General Electric Co.	Do.
Beta fiber material fabrication and consulting services.	Owens-Corning Fiberglas Corp.	Do.
Study and design of deposition of single-crystal silicon, silicon dioxide, silicon nitride on cold-substrate silicon.	Space Sciences Inc.	Do.
Determine overall feasibility of a Servoactuator having the characteristics of an inner loop integrator.	Hydraulic Research and Mfg. Co.	Do.
Design, fabrication, and testing of a laminated ferrite memory system.	Radio Corp. of America Astro-Electronics Division	Do.
Study of Ions in the presence of strong fields within a quadrupole mass spectrometer.	Consolidated Electrodynamics Corp.	Do.
Research for development of a space environment power amplifier.	Varian Associates	Do.
A study of methods and structures for reducing bit creep in continuous film memory elements.	Honeywell, Inc., Aero Division	Do.
Study to determine design concept of instrumentation record/reproduce systems for stadan.	Radio Corp. of America (RCA) Defense Electronics Products.	Granted.

[1] Waiver before execution of contract.

Patent Waivers Granted and Denied for All Inventions Made During Performance of Contract Upon Recommendation of the Agency's Inventions and Contributions Board—Continued

(January 1–June 30, 1967)

Contract description [1]	Petitioner	Action on petition
Development of improved vibration tests of spacecraft assemblies.	Bolt, Beranek and Newman, Inc.	Do.
Total temperature transducer	Honeywell, Inc.	Do.
Laminated ferrite integrated MOS memory	Radio Corp. of America	Do.
Research leading to the development of a high performance short take off and landing (STOL) jet transport.	DeHavilland Aircraft of Canada, Limited.	Do.
Study, design, fabrication, and delivery of jet pipe servovalves.	Hydraulic Research and Manufacturing Co.	Do.
Read-write memory (RWM) unit	General Precision, Inc. Librascope Group.	Do.
Design, development, and fabrication of a hydrogen slush, mass/quality flowmeter.	Engineering Physics Co.	Do.

[1] Waiver before execution of contract.

Petitions deferred
United Aircraft Corp. (BW-649)
North American Aviation, Inc. (BW-669)
Esso Research and Engineering Co. (BW-670)
Radio Corporation of America (BW-680)
Honeywell, Inc. (BW-691)
Pennsylvania Research Associates, Inc. (BW-702)
Esso Research and Engineering Co. (BW-761)
Honeywell, Inc. (BW-755)
Aeronautical Division of Philco Corp. (BW-773)

Appendix I

SCIENTIFIC AND TECHNICAL CONTRIBUTIONS RECOGNIZED BY THE AGENCY'S INVENTIONS AND CONTRIBUTIONS BOARD

(January 1–June 30, 1967)

Awards Granted Under Provisions of Section 306 of the Space Act of 1958

Contribution	Inventor(s)	Employer(s)
Alkali-metal silicate protective coating.	John B. Schutt Charles M. Shai	Goddard Space Flight Center. Electro Mechanical Research, Inc.
Locking device for turbine rotor blades.	Joseph A. Goodrich Kenneth T. Ingham	North American Aviation, Inc.
A thermocouple assembly	Richard C. Turner	Jet Propulsion Laboratory.
Temperature control system for circulating fluids.	Dr. Richard A. McKay	Do.
Constant lift device	Irwin Baker	Hughes Aircraft Co.
Catalyst for monopropellant decomposition of hydrazine.	Warren E. Armstrong Donald S. LaFrance Carroll Z. Morgan Lloyd B. Ryland Hervey H. Voge	Shell Development Co. A Division of Shell Oil Co.
Three component optically pumped magnetometer.	Kenneth A. Ruddock Robert C. Rempel	Spectra-Physics, Inc.
Connector strips-positive, negative and "T" tabs	Charles R. Peek Lewis E. Boodley	Astro-Electronics Division, Radio Corporation of America.
Inorganic thermal control pigment.	G. Richard Blair	Hughes Aircraft Co.
Low-noise single aperture multimode monopulse antenna feed system.	Paul A. Jensen	Do.

Appendix J

Awards Granted NASA Employees Under Provisions of the Incentive Awards Act of 1954

(January 1–June 30, 1967)

Contribution	Inventor(s)
GODDARD SPACE FLIGHT CENTER:	
Tunnel diode clipper circuit	Edgar G. Bush.
Strain gauge	Frank J. Cepollina.
Digitally controlled frequency synthesizer	Rodger A. Cliff.
Polarization diversity monopulse tracking receiver	Ralph E. Taylor.
Spacecraft battery seals	Karl F. Plitt and Carroll H. Clatterbuck.
Bi-polar phase detector and corrector for PCM data signals	James W. Bailey, Donald F. McAfee, and Louis A. Koschmeder.
Signal detection and tracking apparatus	David H. Schaefer.
Spacecraft attitude detection system (SCADS)	Irving B. Lowen and Marvin S. Maxwell
Tunnel diode binary coupling circuit	Edgar G. Bush
Friction measuring apparatus	Warren G. Clement [1] and Pleasant T. Cole
Segmenting lead telluride—Silicon germanium thermoelements	Martin Weinstein,[2] Herbert E. Bates,[2] and Joseph Epstein.
Regulated D.C. to D.C. Converter	Joseph C. Thornwall.
Computing apparatus	David H. Schaefer.
Automatic Formation Cycler and Controller for Electrochemical cells.	Floyd E. Ford,[3] Thomas J. Hennigan, Nelson Potter, and Kenneth Sizemore.
LANGLEY RESEARCH CENTER:	
Calibrating device	Edward F. Manestar.
Ladder polymers and their preparation	Vernon L. Bell, Jr.
Automatic fatigue test temperature programer	Eugene C. Naumann and Patrick L. Corbin.
Ellipsograph	LaVern E. Winn
Ring wing vehicle	John S. Mixson
Collision negator	Willard S. Blanchard, Jr.
Light shield and infrared reflector for fatigue testing	Walter Illg and Fred F. Eichenbrenner
Means for temperature compensating semiconductor strain gages.	Chris Gross.
Low profile clamping band	Joseph D. Pride, Jr. and James W. Mayo.
Radiometer	George E. Sweet, William W. Anderson, Jr., and Howard B. Miller.
Frangible insert	James W. Mayo.
Dosimeter for high levels of absorbed radiation	George F. Pezdirtz and Vernon L. Bell, Jr.

[1] Employed by Jet Propulsion Laboratory.
[2] Employed by Tyco, Inc.
[3] Employed by the Department of the Navy.

Awards Granted NASA Employees Under Provisions of the Incentive Awards Act of 1954—Continued

(January 1–June 30, 1967)

Contribution	Inventor(s)
LANGLEY RESEARCH CENTER: Continued	
Plasma diagnostic technique	William L. Grantham.
Slosh alleviator	Wallace J. Nelson.
Bidirectional binary rate multiplier	William G. Batte
Binary accumulator with roundoff	Do.
Flared tube strainer	Otis J. Parker.
LEWIS RESEARCH CENTER:	
Foil seal	Lawrence P. Ludwig.
Slug flow magnetohydrodynamic	Yih-Yun Hsu and John W. Dunning, Jr.
High temperature ferromagnetic cobalt-base alloy	John C. Freche, Richard L. Ashbrook, Gary D. Sandrock, and Robert L. Dreshfield.
Improved connection for solar cell arrays	Russell D. Shattuck.
Rocket engine injector	Samuel Stein.
Magnetic brake system	Heinrich G. Kosmahl.
Supercharged topping rocket propellant feed system	Warner L. Stewart, Ambrose Ginsburg, and Melvin J. Hartmann.
Capillary radiator	Alex Vary.
Induction heater	Henry J. Geringer.
Low level signal limiter	Irving G. Hansen and Victor S. Peterson.
Flow angle sensor and read out system	Victor S. Peterson and Irving G. Hansen.
MANNED SPACECRAFT CENTER:	
Tension measurement device	Thomas M. Grubbs.
Signal monitor system	William E. Zrubek.
Amplitude modulated laser transmitter	Robert R. Bilderback.
Method of improving heat transfer characteristics in a nucleate boiling process.	Lou D. Allen.
Discrete local altitude sensing device	Carlisle C. Campbell, Jr. Joseph A. Chandler, and Thomas M. Grubbs.
Aligning and positioning device	Alphonse M. Thiel.
Amplifier drift tester	David Cree, Guss E. Wenzel.
Angular accelerometer	Richard R. Richard.
Soft frame adjustable eyeglasses	Robert O. McBrayer.
Flow test device	Bernard J. Rosenbaum, Mike Oberschmidt, John J. Fitzgerald.
Method for forming plastic materials	Joseph F. Naples.
Shorting plug	William H. Simmons.
Cryogenic storage system	William A. Chandler, Robert R. Rice.
Hand-held self-maneuvering unit	Harold I. Johnson, William C. Huber.
Digital output cardiotachometer system	Howard A. Vick.
Light intensity modulator controller	Herbert K. Strass, Hoyt E. Maples.
Blood pressure reprogramming system	Howard A. Vick.
Phonocardiograph transducer	William J. Young.
Machining of geometric cones	John H. Allen, Jr., Orrin A. Wobig.
GEORGE C. MARSHALL SPACE FLIGHT CENTER:	
Electronic components lead forming tool	C. G. Glenn.
Energy absorbing device	Georg F. von Tiesenhausen.

Awards Granted NASA Employees Under Provisions of the Incentive Awards Act of 1954—Continued

(January 1–June 30, 1967)

Contribution	Inventor(s)
GEORGE C. MARSHALL SPACE FLIGHT CENTER: Continued	
Process for chemical milling of copper-rich and zinc-rich aluminum alloys.	Max H. Sharpe.
Method for leakage testing of tanks	Ernst E. Seiler.
Hybrid welding torch and methods	Gilbert V. Allen.
High pressure helium purifier	John A. Hauser.
Method and apparatus for fabricating electronic circuitry and components.	George D. Adams.
WALLOPS STATION:	
Method of plating copper on aluminum	James C. McConnell.

Appendix K

EDUCATIONAL PUBLICATIONS AND MOTION PICTURES

(June 30, 1967)

NASA released the following new educational publications during the first 6 months of 1967. They are available to the public without charge from the Media Development Division, Code FAD-1, National Aeronautics and Space Administration, Washington, D.C. 20546. Other publications are listed in a folder supplied from the same address.

Booklets and Folders

Guide to Apollo.—A booklet of audiovisual resource material on Project Apollo for television stations. 12 pp.

Space, The New Frontier.—An illustrated booklet introducing the reader to space exploration and the programs of the National Aeronautics and Space Administration. 96 pp.

NASA Facts

Issues are illustrated and describe NASA programs (such as Project Apollo, Lunar Orbiter, Mariner) or discuss the Agency's techniques (The Laser, Living in Space). Some are wall display sheets.

Lifting Bodies.—Describes the design, testing, and flying of powered and unpowered lifting bodies, and includes a brief illustrated, technical description of various types. 8 pp.

Manned Space Flight (Apollo).—Description of the Project Apollo program for placing men on the moon before the end of this decade and returning them safely to earth. There are illustrations of the Saturn V launch vehicle, the Apollo spacecraft, and the Lunar Module which will land on the moon. 12 pp.

Saturn V.—Wall sheet in color of America's largest rocket vehicle (21 by 32 inches).

Motion Pictures

NASA also released 12 new motion pictures. These may be borrowed—without charge other than return mailing and insurance costs—from the Media Development Division, Code FAD-2, National Aeronautics and Space Administration, Washington, D.C. 20546, or from any NASA Center. (Other films are listed in a brochure supplied from the same address.)

Legacy of Gemini.—27:30 min., color. Documentary summary of the major accomplishments of NASA's two-man Gemini Program and their relationship to the three-man Apollo Program. Includes the best of Gemini photography.

Space Navigation.—21 min., color. Film uses animation and live-action photography to illustrate the equipment, techniques, and mathematics of space navigation between the earth and the moon and the earth and the planets.

Electric Power Generation in Space.—26:30 min., color. Describes the problems and methods of generating sufficient power in space for various needs—includes the solar cell, fuel cell, Rankine cycle, Brayton cycle, and other experimental systems.

Doorway to Tomorrow.—28 min., color. A documentary portrait of the new John F. Kennedy Space Center with emphasis on the Complex 39 ''moonport'' from which Project Apollo astronauts will be launched. Shows the vehicle assembly building in detail, assembly of a Saturn V, the mission launch control center, and a crawler transporter moving the Saturn launch vehicle to the launch pad.

The Big Challenge.—28 min., color. Produced jointly by NASA and the Corps of Engineers. The story of the planning and construction of the vehicle assembly building, crawler transporter, mobile service structure, and other buildings and support facilities of the John F. Kennedy Space Center.

Lunar Landing.—15 min., color. Documentary of the Surveyor I mission to soft land a spacecraft on the moon and send back its close-up photographs. Film shows the launching of the spacecraft and the method by which the photographs were received.

View of the Sky.—27:40 min., color. Symbolic photography used to explain various historical theories of the universe from Copernicus to Einstein. Also a brief look at present-day space exploration.

Universe on a Scratch Pad.—28:20 min., black and white. A candid study of the work of a modern astrophysicist and his method of studying the universe. Features a commentary by Dr. Robert Jastrow, Director, and Dr. Patrick Thaddeus, NASA's Goddard Institute for Space Studies, New York. (Companion film to a *View of the Sky,* but each may be viewed separately.)

Skyward the Great Ships.—27:20 min., black and white. A report on the chemical, nuclear, and electrical propulsion systems being developed for space missions. The film covers research on these propulsion systems and points out the applications and advantages of each.

The Guaymas Story.—27:05 min., color. A visit to the tracking station at Guaymas, Mexico, and a study of the relationship between the community and this station in NASA's manned space flight tracking and data acquisition network.

The Poetry of Polymers.—19 min., color. The story of Dr. Frank d'Alelio, research scientist at the University of Notre Dame, which illustrates the role of basic research in the space program. (One in a series of films for career guidance in science).

It's You Against the Problem.—26 min., color. A study of the research on ablative materials being carried on by Dr. Simon Ostrach and his colleagues at Ohio State University. (Another film in the science career guidance series.)

Appendix L

TECHNICAL PUBLICATIONS

(January 1–June 30, 1967)

The following special publications, issued during the report period by NASA's Scientific and Technical Information Division, are sold by the Superintendent of Documents, U.S. Government Printing Office (GPO), Washington, D.C. 20402, or by the Clearinghouse for Federal Scientific and Technical Information (CFSTI), Springfield, Va., 22151, at the prices listed.

Spacecraft Sterilization Technology (NASA SP–108).—Papers presented at a conference in Pasadena, California on November 16–18, 1965 by representatives from academic institutions, the aerospace industry, and NASA. Discussion includes NASA sterilization requirements, microbiological control and monitoring, and sterilization techniques applicable to spacecraft components, payloads, and facilities. Index. 630 pp. GPO $2.25.

Second Symposium on the Role of the Vestibular Organs in Space Exploration (NASA SP–115).—A collection of 23 papers presented at a conference held at Ames Research Center, Moffett Field, California, January 25–27, 1966. The proceedings discuss gravitoinertial receptor mechanisms and related systems in aerospace flight, practical problems posed by weightlessness and subgravity, current articles in this field, and brief reports on current investigations in progress. 312 pp. GPO $2.00.

Electronic Densities and Scale Heights in the Topside Ionosphere: Alouette I Observations Over the American Continents. Vol. III: June, July, September, and October 1963 (NASA SP–3033). By Kwok-Long Chan, Lawrence Colin, and John O. Thomas. The third of four volumes presenting data on electron density and plasma scale height at various heights and times in the topside ionosphere. The measurements were made over the American continents by the Alouette I satellite at a sunspot minimum epoch of the solar cycle. The first two volumes (NASA SP–3027 and NASA SP–3032) contain tabulations for winter and summer. Tabulations for the equinox period are presented in the third volume. Vol. III. 584 pp. CFSTI $6.25.

Additional Stopping Power and Range Tables for Protons, Mesons, and Electrons (NASA SP–3036).—By Martin J. Berger and Stephen M. Seltzer. This report is a supplement to earlier tabulations appearing in NASA SP–3012 and NASA SP–3013. It extends earlier tabulations of stopping power and range for protons, mesons, and electrons. Data are given for liquid H_2, LiF, Si, Ge, propane, and freon. In addition, tables for electrons in muscle and bone from the earlier volumes are corrected. 40 pp. CFSTI $2.00.

Selected Electronic Circuitry (NASA SP–5046).—A report which summarizes specific innovations in electronic-circuit technology which were derived from the space program, and which appear to be useful for general industrial application. Information includes data on amplifier circuits; oscillator circuits, multivibrator circuits, wave shaping circuits, temperature compensation circuits, control circuits and specialized computer circuits. 100 pp. GPO $0.70.

Mathematical Computer Programs (NASA SP-5069).—This publication outlines several mathematical programs and programming techniques for digital computers which are available through the NASA Technology Utilization program. Although the functions which the programs perform are not new, and similar programs are available in many large computer center libraries, this collection may be useful to centers with limited systems libraries and for instructional purposes for new computer operators. 26 pp. CFSTI $1.00.

Space Technology. Volume IV, Spacecraft Guidance and Control (NASA SP-68).—By J. R. Scull; *Space Technology. Volume V, Telecommunications* (NASA SP-69).—By J. J. Stiffler; *Space Technology. Volume VI, Space Sciences* (NASA SP-114).—By T. A. Farley. Basic texts for the upper-level college engineering student. Volume IV discusses the guidance of lunar and planetary spacecraft and covers the tradeoffs among injection, midcourse, and terminal guidance, as well as ways of mechanizing these systems by radio, inertial, or celestial techniques. Volume V presents techniques for improving components and data handling and modulation systems in telecommunications. The mathematical fundamentals are summarized, and component designs for increased signal power are described. Volume VI discusses the geometric field configurations close to Earth and at a distance. Details are given on the Van Allen radiation belt charged particle motion, trapped proton distribution, and energy spectra. Vol. IV 143 pp. GPO $0.55; Vol. V 142 pp. GPO $0.55; Vol. VI 84 pp. GPO $0.35.

The Dynamic Behavior of Liquids in Moving Containers, With Applications to Space Vehicle Technology (NASA SP-106).—Edited by H. Norman Abramson. This monograph, prepared for NASA by the Southwest Research Institute, presents a comprehensive view of the general subject of the behavior of liquids as it specifically relates to space technology applications. It covers lateral sloshing in moving containers, vehicle stability and control, liquid impact on tank bulkheads, liquid propellant behavior at low and zero g, etc. Index. 467 pp. GPO $2.70.

Ariel I: The First International Satellite—Experimental Results (NASA SP-119).—The Ariel I project summary includes descriptions of experimental results, spacecraft design and performance, tracking, data acquisition, and data reduction of the first international satellite. The structure of design of the spacecraft is examined. Extensive discussions on such experiments as the energetic particle measurements and the use of the Langmuir probe to measure electron temperatures and density are presented. 158 pp. GPO $1.50.

Second Annual NASA-University Conference on Manual Control (NASA SP-128).—Proceedings of a conference held at MIT, Cambridge, Mass. On February 28–March 2, 1966. The 29 papers include discussions of discrete and continuous models, adaptive control, information theory, multivariable control, display, motion and stress, optimal control, and analysis and design methods. 417 pp. GPO $2.50.

Aerospace Measurement Techniques (NASA SP-132).—Gene G. Mannella, Editor. Results of a symposium held July 7–8, 1966 at the Massachusetts Institute of Technology presenting the latest findings in critical areas of interest to those research scientists working in the fields of measurement and instrumentation, with a view to exploring the application of new physical principles. 261 pp. GPO $1.00.

Significant Achievements in Space Applications, 1965 (NASA SP-137).—This volume describes the significant scientific progress made in 1965 in the scientific disciplines involved in the United States space program. Discussion is directed to the following disciplines: communications, geodesy, and meteorology. 85 pp. GPO $0.45.

Commercial Potentials of Semipermeable Membranes (NASA SP–5061).—By Sidney B. Tuwiner, Ernest J. Henley, and H. Kenneth Staffin. A survey of research which focuses on advances in semipermeable membrane technology, and which has possible industrial application. Presented are data on new techniques and principles; membrane application in batteries; advances in material science; level control in batteries; fuel cells; and separation processes. 47 pp. GPO $0.35.

NASA Contributions to Metals Joining (NASA SP–5064).—By W. J. Reichenecker and J. Heuschkel. This Technology Survey covers developments between 1962 and mid-1965 in joining metals by mechanical fasteners, soldering, brazing, welding, and plasma spray bonding. The material reviewed is related to solving hardware problems. Included are data on novel tooling, process development and applications, base metal and filler metal relationships, and advances in joining mechanisms. 141 pp. GPO $0.60.

Adhesives, Sealants, and Gaskets (NASA SP–5066).—By R. B. Perkins and S. N. Glarum. A survey is presented on adhesives, sealants, and gaskets developed to operate in the extreme environments encountered in space work. Emphasis is on reliability of materials that can be used in a liquid oxygen environment. The following are described in detail: polymeric fillers in adhesives, elastomeric films in glue lines; epoxy ester adhesives; sealants for low-temperature service; gasket design; and measurement of stress in gaskets. 63 pp. GPO $0.25.

Astronomy in Space (NASA SP–127).—By Homer E. Newell, Henry J. Smith, Nancy G. Roman, and George E. Mueller. Four papers provide information on present and future results of placing astronomical instruments in space. The first paper provides a view in perspective; the second covers solar astronomy; the third discusses stellar and galactic astronomy; and the fourth paper presents the results of the manned space flight program and the opportunities provided by the developing manned flight capability. 67 pp. GPO $0.45.

Significant Achievements in Space Science, 1965 (NASA SP–136).—One of a series summarizing achievements made in the scientific and technical disciplines involved in the Space Science and Applications Program, the volume describes scientific progress made in 1965 in the fields of Astronomy, Ionospheres and Radio Physics, Particles and Fields, Planetary Atmospheres, Planetology, and Solar Physics. 218 pp. GPO $1.00.

Models of the Trapped Radiation Environment. Vol. III: Electrons at Synchronous Altitudes (NASA SP–3024).—By James I. Vette and Antonio B. Lucero. The third volume of a multi-volume compilation of the results of a program sponsored by NASA and the USAF for the purpose of defining a model of the radiation environment of the Earth. Volumes I and II contained model environments for the lower altitude regions where trapping is relatively stable. The present volume presents a model of the earth synchronous orbit at 19,300 n. miles near the boundary of stable trapping where the particle fluxes vary through several orders of magnitude. 107 pp. CFSTI $3.00.

Electron Densities and Scale Heights in the Topside Ionosphere: Alouette I Observations Recorded at Hawaii, Winter 1962–1963, Summer 1963 (NASA SP–3038).—By Lawrence Colin and Kwok-Long Chan. Tabulations and graphs of electron density and plasma scale height data computed from Alouette topside sounder ionograms are presented. Ionograms selected for analysis in this volume were telemetered to the South Point, Hawaii, tracking station during November and December 1962, and May, June, October, and November 1963. 286 pp. CFSTI $3.00.

Vacuum Switchgear (NASA SP-5063).—By W. S. Emmerich. A survey of the literature and NASA-sponsored reports on vacuum switchgear citing studies dealing directly with the basic technology underlying ultrahigh vacuums suitable for application as vacuum interrupters; studies of adhesion mechanisms and the effect of surface preparation; pressure measurements; cathode and arc phenomena; and hardware developments. An analysis of unsolved switching problems is also included. 36 pp. GPO $0.35.

An Introduction to the Evaluation of Reliability Programs (NASA SP-6501).—By D. S. Liberman and A. J. Slechter. A basic orientation to the task of evaluating the effectiveness of a reliability program is presented. Primary emphasis is devoted to discussing the assurance task as it relates to project requirements and resources, and to describing the factors which determine effectiveness in program implementation. The general fundamentals which apply to the treatment of reliability program objectives, the criteria for judging task effectiveness, and the approach to evaluating the various tasks for meaningful accomplishment are discussed. 67 pp. CFSTI $3.00.

Space Cabin Atmospheres. Part III: Physiological Factors of Inert Gases (NASA SP-117).—Literature Review by Emanuel M. Roth. A summary of the literature on the physiological effects of chemically inert gases are presented. Discussion of these gases as they relate to decompression sickness, biological systems, and engineering aspects in space cabin systems are included. Parts I and II were published in 1964 as NASA SP-47 and NASA SP-48. 136 pp. GPO $1.00.

A Survey of Space Applications . . . "for the benefit of all mankind" (NASA SP-142).—This document analyzes the real and potential applications of space technology. Sections include communications, earth resources geodesy, meteorology, navigation and future applications. Work to date is summarized and present and future program plans are discussed. The report was prepared as a guide for a 1967 summer study on space applications. 135 pp. GPO $0.70.

Venus and Mars Nominal Natural Environment for Advanced Manned Planetary Mission Programs (NASA SP-3016).—2nd Edition. By Dallas E. Evans, David E. Pitts, and Gary L. Kraus. Numerical values for a nominal natural environment for application in studies of advanced planetary missions to Venus and Mars. The data compiled here provide a standard environment so that various mission and preliminary design studies will all be based on realistic data and have a common basis for comparison of results. The data in this revised edition differ from those of the first edition mainly as a result of the Mariner IV Mars flyby experimental results. 52 pp. CFSTI $3.00.

Tables of Interference Factors for Use in Correcting Data from VTOL Models in Wind Tunnels with 7 by 10 Proportions (NASA SP-3039).—By Henry H. Heyson. The publication presents tables of the interference factors for models whose span is parallel to either the long or the short side of the wind tunnel. Instructions for the use of these values for semispan models are included. 649 pp. CFSTI $3.00.

Brazing and Brazing Alloys. A Bibliography (NASA SP-5026).—A bibliography designed to identify the current literature on brazing and brazing alloys in order to provide industry with summarizing information on innovations contained in NASA and other space technology literature. 52 pp. CFSTI $1.00.

Properties and Current Applications of Magnesium-Lithium Alloys (NASA SP-5068).—By R. J. Jackson and P. D. Frost. This Technology Report presents a compilation of engineering information on magnesium-lithium alloys. Mechanical properties and metallurgical characteristics for standard and developmental alloys are included. Various processing techniques including cleaning and finishing, fabrication, casting, and joining are discussed. 54 pp. GPO $0.40.

Handling and Use of Fluorine and Fluorine-Oxygen Mixtures in Rocket Systems (NASA SP–3037).—By Harold W. Schmidt. The technology necessary for the practical application of fluorine as a rocket propellant is presented based on applied research, development experience, and experimental test data. The physical and chemical characteristics peculiar to fluorine are considered in relation to specific areas in design and development of rocket systems, and in testing and launch operations. 279 pp. GPO $1.50.

High-Velocity Metalworking (NASA SP–5062).—By Michael C. Noland, Howard M. Gadberry, John B. Loser, and Eldon C. Sneegas. This Technology Survey gathers and evaluates the current practical information available on working metals at high velocities. The four major areas covered are: electro-hydraulic, explosive, magnetic, and mechanical-pneumatic methods. Examples of parts made by each method and equipment presently available are included. 183 pp. GPO $1.25.

Selected Machining and Metal Fabricating Technology (NASA SP–5065).—A compilation of shop hints on metal fabricating, and machining tools, and techniques originally devised for the space industry. This publication includes articles on fastening devices, assembly tools and techniques, layout and inspection devices, and machine techniques helpful to machinists. 26 pp. GPO $0.25.

Nondestructive Testing: Trends and Techniques (NASA SP–5082).—The proceedings of the Second Technology Status and Trends Symposium held at Marshall Space Flight Center, Huntsville, Ala., October 26–27, 1966 presents nine technical papers which discuss nondestructive testing for multilayer printed wiring circuits, adhesive bonded composite materials, and aluminum. Methods discussed include X-ray television techniques, infrared microscope, ultrasonic testing, and laminography. 123 pp. GPO $0.55.

Communications Satellites (NASA SP–7004(03)).—A Continuing Bibliography with Indexes. Annotated listing of report and journal literature on the subject introduced into the NASA information system during the period February 1966–March 1967. Subject and author indexes. 47 pp. CFSTI $3.00.

Previously issued under the same title: NASA SP–7004(02) containing references acquired February 1965–January 1966 (39 pp. CFSTI $1.00), NASA SP–7004(01), May 1964–January 1965 (56 pp. CFSTI $1.00), and NASA SP–7004, January 1962–April 1964 (90 pp. CFSTI $1.00).

Earth Photographs from Gemini III, IV, and V (NASA SP–129).—A selection of color photographs taken by the astronauts during the first three Gemini missions. The pictures were taken as a part of synoptic terrain and weather experiments and are useful to oceanographers, meteorologists, geographers, geologists, mapmakers, and scientists in related fields of interest. 266 pp. GPO $7.00.

A Review of the Mariner IV Results (NASA SP–130).—By Oran W. Nicks. The publication attempts to highlight the great volume of interpretative analysis elicited by the seven and one-half month long Mariner IV journey. The spacecraft was launched in November 1964 and returned useful data until October 1965 when its distance from earth and antenna orientation halted interpretation of its signal, which is still functioning. The more important engineering advances are summarized including design and testing. 39 pp. GPO $0.25.

First Compilation of Papers on Trajectory Analysis and Guidance Theory (NASA SP–141).—Seven technical papers on NASA-sponsored studies in the area of trajectory analysis, astrodynamics, and celestial mechanics are presented. The studies are being carried on by several universities and industrial companies.

The first paper discusses trajectory analysis and guidance theory; the second supplies approximations to functions where only numerical values are available. The third paper contributes to mission design; the fourth will be useful for trajectory analysis on mission design. The last three papers concern celestial mechanics, specifically orbit determination or prediction. 215 pp. CFSTI $3.00.

Handbook of the Physical Properties of the Planet Jupiter (NASA SP–3031).—By C. M. Michaux, et al. This document summarizes the present observational knowledge of Jupiter through December 1965 and briefly outlines the results of a great many theoretical studies of the planet. Areas covered include: orbital elements, mass, diameter and shape, rotation, mean density, surface gravity, internal structure, temperature, radio-frequency radiation, atmospheric composition, structure, circulation, and satellites. 142 pp. GPO $0.60.

Thermodynamic Equilibrium in Prebiological Atmospheres of C, H, O, N, P, S, and Cl (NASA SP–3040).—By M. O. Dayhoff, E. R. Lippincott, R. V. Eck, and G. Nagarajan. The book presents the mathematical methods used, and describes the computer program from which the tables were derived. Also, a survey of thermodynamic equilibrium states of ideal gas systems containing C, H, O, N, P, S, and Cl are discussed. Two appendixes give applications of the survey to research problems: Appendix I discusses applications with regard to the thermodynamic equilibria in planetary atmospheres; Appendix II discusses application with regard to the role of thermodynamic equilibrium in the inorganic origin of organic matter. 257 pp. CFSTI $3.00.

High Energy Propellant, A Continuing Bibliography with Indexes (NASA SP–7002(03)).—Annotated references to report and journal literature on the subject introduced into the NASA information system January–December 1966. Emphasis is given to research and development studies on solid, liquid, and hybrid propellants and oxidizers, but the bibliography also covers such related topics as propellant handling and storage, combustion characteristics, toxicity, and hazards and safety measures. Subject and author indexes. 68 pp. CFSTI $3.00.

Previously issued under the same title: NASA SP–7002(02), containing references to NASA acquisitions January–December 1965 (48 pp. CFSTI $3.00), NASA SP–7002(01) April–December 1964 (98 pp. CFSTI $3.00), NASA SP–7002, January 1962–March 1964 (65 pp. CFSTI $3.00).

Lunar Surface Studies. A Continuing Bibliography With Indexes (NASA SP–7003(03)).—A selection of annotated references to reports and journal articles introduced into the NASA information system during the period February 1966–January 1967. Subjects include the theory of the lunar origin, the lunar atmosphere, and physical characteristics of the Moon. Techniques and instrumentation for lunar observation, measurement, and analysis are also covered. Subject and author indexes. 71 pp. CFSTI $3.00.

Previously issued under the same title: NASA SP–7003(02) reflecting NASA acquisitions February 1965–January 1966 (36 pp. CFSTI $3.00), NASA SP–7003(01), April 1964–January 1965 (54 pp. CFSTI $3.00), and NASA SP–7003, January 1962–March 1964 (98 pp. CFSTI $3.00).

Appendix M

Major NASA Launches

(January 1–June 30, 1967)

Name, date launched, mission	Vehicle	Site[1]	Results
Intelsat II-B, January 11. Commercial communications satellite launched by NASA for ComSat. Will also support the Agency's Apollo lunar landing program.	Thrust-augmented Thor-Delta.	ETR	Placed in 22,300-mile synchronous orbit over the Marshall Islands in the Pacific Ocean on January 14. Nicknamed "Lani Bird," the 192-pound satellite became available for commercial service on January 27.
ESSA IV (TOS-B), January 26. Weather satellite orbited by NASA for the Environmental Science Services Administration (ESSA) to assure world wide continuous Automatic Picture Transmission (APT) coverage.	Thrust-augmented Thor-Delta.	WTR	APT system providing pictures of good quality to simple ground receivers in 35 countries. Satellite's orbit—894-mile apogee and 822-mile perigee.
Lunar Orbiter III, February 4. Photographic probe of the Moon to obtain additional detailed pictures to confirm the suitability of providing landing sites for Surveyor spacecraft and Project Apollo astronauts identified by Lunar Orbiter I and II pictures.	Atlas-Agena B.	ETR	Placed in lunar orbit on February 8, then into close-in orbit of the Moon. Photographed 12 primary potential Apollo and Surveyor landing sites. Provided pictures of other areas on the front and far sides. Also measured the micrometeoroid flux and radiation levels in the near lunar environment.
OSO III (Orbiting Solar Observatory III), March 8. Scientific satellite of the earth to provide more data on solar disturbances and their effects on the earth's atmosphere, and information on hazards to manned flight from solar flares.	Thor-Delta.	ETR	Placed in circular orbit between 335 and 355 miles. All 9 experiments operated as planned to supply detailed data on X- and ultraviolet radiation.
Intelsat II-C, March 22. Another commercial communications satellite launched by NASA for ComSat. Like Intelsat II-B, it will support Apollo lunar landings.	Thrust-augmented Thor-Delta.	ETR	Placed into a 22,300-mile synchronous orbit over the west coast of Africa on March 25. Nicknamed "Canary Bird," it provides commercial services to countries bordering the Atlantic Basin.

See footnotes at end of table.

Major NASA Launches—Continued

(January 1–June 30, 1967)

Name, date launched, mission	Vehicle	Site[1]	Results
ATS-II, April 6. The second Applications Technology Satellite (the first three-axis gravity gradient stabilized spacecraft) carrying communications and scientific experiments.	Atlas-Agena D.	ETR	Planned for a 6,900-mile circular orbit, the Agena stage failed to ignite for a second burn causing the satellite to stay in a highly elliptical orbit (apogee 5,805 miles, perigee 108 miles).
Surveyor III, April 17. NASA's second spacecraft to soft land on the Moon to photograph its surface and its environment, also the first carrying a soil surface sampler instrument to manipulate the lunar soil.	Atlas-Centaur	ETR	Soft-landed inside a crater in the Sea of Storms (Oceanus Procellarum) on April 20. Transmitted 6,315 TV pictures of the lunar surface (some in color). Surface sampler and landing gear strain gages calculated the surface bearing strength to be 3 to 8 pounds per square inch—able to support the Apollo manned spacecraft and astronauts walking on the surface.
ESSA V (TOS-C), April 20. The second TIROS operational meteorological satellite, with an Advanced Vidicon Camera system, launched for the Environmental Science Services Administration.	Thrust-augmented Thor-Delta.	WTR	The two cameras were providing 24-hour global weather coverage. Instruments on board were also transmitting data on radiation to help chart the global heat balance. Satellite's orbit—840 miles to 883 miles.
Lunar Orbiter IV, May 4. To make a systematic photographic survey of as much of the surface of the Moon as possible.	Atlas-Agena D.	ETR	Spacecraft provided detailed pictures of 99 percent of the Moon's front face at least ten times clearer than any ever made from earth. Also photographed part of the hidden side. The four Lunar Orbiters in the series of five have photographed about 75 percent of this side.
Explorer XXXIV (IMP-F), May 24. Fifth in the Interplanetary Monitoring Platform series. Spacecraft's 11 experiments will supply data for use in studying sun-earth relationships, particularly effects of solar events on earth's environment during present period of increasing solar activity.	Thrust-augmented Delta.	WTR	Satellite was operating as designed in its planned orbit ranging between 154 and 131,187 miles from the earth.

See footnotes at end of table.

Major NASA Launches—Continued

(January 1–June 30, 1967)

Name, date launched, mission	Vehicle	Site [1]	Results
Mariner V, June 14 Scientific probe of Venus (fly-by scheduled for October 19.)	Atlas-Agena D.	ETR	Obtained interplanetary scientific data and will pass by Venus at a distance of about 2,500 miles. Significant new information on the planet expected.

Non-NASA Missions

Name, date launched, mission	Vehicle	Site [1]	Results
San Marco II, April 26 Italian satellite, launched by NASA, to determine air density at satellite's height of several hundred miles and investigate ionospheric disturbances to radio transmissions.	Scout [2]	San Marco facility off the coast of Kenya, Africa	First launching from an anchored launch platform and first made from near the equator. (Apogee 465 miles; perigee 136 miles.) All experiments working as planned.
Ariel III, May 5 British satellite, orbited by NASA, carrying 5 experiments in electron density and temperature, radio noise, and distribution of molecular oxygen.	Scout [2]	WTR	Launched into nearly circular orbit over the earth (306 to 373 miles). All experiments working as planned.
ESRO II, May 29 International satellite, launched by NASA for the European Space Research Organization (ESRO), to study processes taking place within the sun and investigate cosmic rays.	Scout [2]	WTR	Unsuccessful launch.

[1] ETR—Eastern Test Range, Cape Kennedy, Fla.
WTR—Western Test Range, Point Arguello, Calif.
[2] NASA provided launch vehicle.

Appendix N

NASA Launch Vehicles

Vehicle	Stages	Payload in pounds			Principal use
		345-mile orbit	Escape	Mars/ Venus	
Scout	4	245 to 305			Launching small scientific satellites, reentry experiments, and probes (Explorer XXX, SERT Ion engine, SECOR V, French-built FR-1).
Delta	3	880	150	120	Launching scientific, meteorological, and communications satellites TIROS IX, Orbiting Solar Observatories—OSO I and II, Ariel, Telstar I, Relay, Syncom II, Interplanetary Monitoring Platforms (Explorers XXI and XXVIII), Energetic particles satellite (Explorer XXVI).
Thrust Augmented Delta (TAD).	3	1,300	250	220	Launching scientific, meteorological, communications, and Bioscience satellites, and lunar and planetary probes (Pioneer VI, TIROS M, TIROS operational satellites OT-3 and OT-2, Syncom III, Commercial Communications Satellite Early Bird I, Radioastronomy Explorers, Biosatellites A—F, INTELSAT I and II communications satellites, international satellites for ionospheric studies—ISIS).
Thor-Agena	2	1,600			Launching scientific, communications, and applications satellites (Echo II, Nimbus I, Polar Orbiting Geophysical Observatory, Orbiting Geophysical Observatory II).
Thrust Augmented Thor-Agena (TAT)	2	2,200			Launching geophysics and astronomy and applications satellites (OGO C, D, and F, and Nimbus B).
Atlas-Agena	2½	6,000	950	600	Launching heavy scientific satellites, and lunar and planetary probes (Rangers VII, VIII and IX, Mariners III and IV, Orbiting Geophysical Observatory—OGO-I, OAO-A).
Atlas-Centaur	2½	9,900	2,700	1,700	Launching heavy unmanned spacecraft as lunar soft landers (Surveyor, Mariner).
Saturn IB	2	28,500			Launching Project Apollo spacecraft.
Saturn V	3	220,000	98,000	70,000	Do.

Appendix O

Grants and Research Contracts Obligated*

(January 1–June 30, 1967)

ALABAMA

NGR 01-001-003 S 2	Alabama A&M College, C. LEE Radiation effects on the Metabolism of Phospholipide in the Central Nervous System of Albino Rats.	$15,402
NsG-381 S 4	Alabama, University of, R. HERMAN Research in the Aerospace Physical Science.	425,000
NsG(T)-30 S 4	Alabama, University of, E. RODGERS Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	142,200
NGR 01-002-035	Alabama, University of, E. W. GROHSE Advanced Electrochemical Technology.	30,000
NGR 01-002-036	Alabama, University of, H. MOTT Study of Inexact Modeling Techniques.	38,000
NGR 01-002-045	Alabama, University of, O. R. AINSWORTH Study of Gyroscopic Stability.	22,880
NSR 01-002-033	Alabama, University of, R. M. HOLLUB Contract for a Summer Institute in Space-Related Engineering.	133,900
NsG(T)-18 S 4	Auburn, University of, W. V. PARKER Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	138,200
NGR 01-003-008 S 1	Auburn, University of, W. A. SHAW Computer Techniques for Multivariant Function Model Generation, Emphasizing Programs Applicable to Space Vehicle Guidance.	26,774
NSR 01-003-025	Auburn, University of, R. I. VACHON A Summer Program in Systems Design Engineering.	93,600

ALASKA:

NsG-201 S-6	Alaska, University of, S. CHAPMAN A Theoretical Study of the Ring Current and Geomagnetic Field Phenomena.	59,736
NsG-459 S 3	Alaska, University of, P. MORRISON Experimental Studies in Physiological Adaptation to Environmental Extremes.	49,950
NsG(T)-131 S 3	Alaska, University of, K. M. RAE Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	43,200
NSR 02-001-035 S 2	Alaska, University of, K. B. MATHER Construct and operate Image Orthicon Television Systems to Detect artificial auroras.	114,176

ARIZONA:

NsG(T)-32 S 4	Arizona State University, W. J. BURKE Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	61,800

* The grants listed in this appendix are reported to the Congress in compliance with the requirements of the grants statute, 42 U.S.C. 1891–93 (72 Stat. 1793).

Contracts have prefix NASr or NSR; grants have prefix NsG or NGR; transfer of funds to Government agencies have prefix R. Earlier grants and contracts are listed in appendices of previous NASA Semiannual Reports to Congress.

ARIZONA—Continued

NGR 03-001-034	Arizona State University, J. STAUDHAMMER. Applications of Approximate Models in Solid State Circuit Analysis and Design.	$14,921
NsG-580 S 2	Arizona, University of, T. L. VINCENT. A Study of the Calculus of Variations, Especially as Related to Aerospace Engineering Problems.	15,282
NsG-161 S 7	Arizona, University of, G. P. KUIPER. Planetary Spectroscopic Studies and Selenodetic and Physical Studies of the Lunar Surfaces.	207,131
NsG-732 S 3	Arizona, University of, W. G. TIFFT. Photographic and Photoelectric Signal Detection.	75,000
NsG(T)-33 S 4	Arizona, University of, H. D. RHODES. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	127,500
NGR 03-002-071 S 1	Arizona, University of, T. BOWEN. Cosmic Ray Investigations of Elementary Particle Phenomena at Very High Energies.	140,000
NGR 03-002-081 S 1	Arizona, University of, A. M. J. GEHRELS. Photometry & Polarimetry of Minor Planets.	22,900
NGR 03-002-091 S 1	Arizona, University of, H. D. CHRISTENSEN. Multidisciplinary Research Program in Space Science and Technology.	200,000
NGR 03-002-115	Arizona, University of, L. E. WEAVER. Research In and Application of State Variable Feedback Design of Guidance Control Systems for Aerospace Vehicles.	19,000
NGR 03-002-116	Arizona, University of, F. J. LOW. Scanning and Mapping the Lunar Surface at $\lambda =$ 20 Microns.	25,991
NGR 03-002-122	Arizona, University of, E. ROEMER. Astrometric and Astrophysical Investigation of Comets, Minor Planets, and Satellites.	41,080
NASr-138 A 6	Arizona, University of, A. M. J. GEHRELS. Develop and Test Photo-Polarimeter for Space Vehicles.	50,006
NSR 03-002-123	Arizona, University of, M. D. KELLER. Case History of the Langley Research Center 1917–1947.	14,970
NsG-451 S 2	Lowell Observatory, J. S. HALL. Studies in Planetology, Including Collection and Interpretation of Planetary Information.	216,836

ARKANSAS:

NsG(T)-12 S 4	Arkansas, University of, V. W. ADKISSON. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	97,600
NGR 04-002-004	Harding College, H. D. OLREE. Methods of Achieving and Maintaining Physical Fitness for Prolonged Space Flight.	46,440

CALIFORNIA:

NASr-17 A 3	Beckman Instruments, Inc. A Feasibility and Design Study of a Gas Chromatograph for Analysis of Closed Atmospheres.	904
NsG-18 S 4	California Institute of Technology, E. E. SECHLER. Study of Cylindrical and Conical Shells with Large Radius to Thickness Ratios.	29,451
NsG-40 S 5	California Institute of Technology, H. LIEPMANN. Investigation of Rarefied Gas Flow.	65,000
NsG-56	California Institute of Technology, H. BROWN. Investigation of Problems of Lunar and Planetary Exploration.	172,206

CALIFORNIA—Continued

NsG–426 S 5	California Institute of Technology, R. B. LEIGHTON. Space Related Research in Selected Fields of Physics and Astronomy, Including Cosmic Rays, Interplanetary Magnetic Fields, Solar Physics, Theoretical Astrophysics, Planetary Spectroscopy and Infrared Astronomy.	$260,006
NsG(T)–37 S 4	California Institute of Technology, F. BOHNENBLUST. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	155,900
NGR 05–002–036 S 2	California Institute of Technology, J. E. McKEE. Investigation of Biochemical Stabilization of Aqueous Solutions of Organic Compounds by Unsaturated Flow Through Porous Media.	25,000
NGR 05–002–044 S 1	California Institute of Technology, G. J. WASSERBURG Geochemical Investigations of Lunar Materials.	145,112
NGR 05–002–069	California Institute of Technology, D. L. ANDERSON. Theoretical Investigation of Planetary Interiors.	25,000
NSR 05–002–071	California Institute of Technology, H. ZIRIN. Feasibility Study for Large Aperture Solar Telescope to Fly on Apollo Telescope Mount (ATM) System.	19,880
NGR 05–002–084	California Institute of Technology, L. T. SILVER. Investigations in the Isotopic Systems of Uranium, Thorium and Lead in Lunar Material.	150,000
NGR 05–002–085	California Institute of Technology, S. EPSTEIN. Stable Isotope Abundance Measures of Lunar Materials.	150,000
NsG–101 S 5	California, University of (Berkeley), M. CALVIN. Studies of Reflection Spectra, Meteorite Analysis, Paleobiochemistry, and Biochemical Evolution as Bases for Studying Extraterrestrial Life.	250,000
NsG–243 S 6	California, University of (Berkeley), S. SILVER. Interdisciplinary Space-Oriented Research in the Physical, Biological, Engineering and Social Sciences.	1,200,000
NsG–243 S 7	California, University of (Berkeley), D. H. CALLOWAY Interdisciplinary Space-Oriented Research in The Physical, Biological, and Engineering and Social Sciences.	102,000
NsG–243 S 8	California, University of (Berkeley), S. SILVER. Interdisciplinary Space-Oriented Research in the Physical, Biological, Engineering and Social Sciences.	20,000
NsG–274 S 3	California, University of (Berkeley), E. POPOV. Investigation of Stresses and Deformations in Thin Shells of Revolution.	33,000
NsG–387 S 5	California, University of (Berkeley), K. A. ANDERSON. Study of High Energy Radiation Associated with Solar Flares and Auroral Zone Phenomena.	88,333
NsG–513 S 5	California, University of (Berkeley), N. PACE. Primate Hemodynamics and Metabolism Under Conditions of Weightlessness, for the Purpose of Defining and Verifying an Experiment Suitable for Use in a Biosatellite.	100,000
NsG–702 S 2	California, University of (Berkeley), A. K. OPPENHEIM. Gas-Wave-Dynamic Studies of Spray Combustion.	70,000
NsG–707 S 2	California, University of (Berkeley), H. WEAVER. An Experimental Study of Advanced Infrared Detectors for Use in Planetary Spectroscopy.	33,000
NsG(T)–117 S 3	California, University of (Berkeley), S. S. ELBERG. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	178,800

CALIFORNIA—Continued

NGR 05-003-067 S 2	California, University of (Berkeley), W. B. N. BERRY. Study of Growth in Recent and Fossil Invertebrate Exoskeletons and Its Relationship to Tidal Cycles in the Earth-Moon System.	$11,833
NGR 05-003-068 S 3	California, University of (Berkeley), S. MARGEN. Clinical Nutritional Study of Minimal Protein and Caloric Requirements.	50,000
NGR 05-003-080 S 2	California, University of (Berkeley), R. W. COLWELL. Multispectral Photographic Terrain Analyses, Based on Statistical Analysis of Spectrometric Data.	34,800
NGR 05-003-089 S 1	California, University of (Berkeley), D. H. CALLOWAY. Investigations of the Nutritional Properties of Hydrogenomonus Eutropha.	19,426
NGR 05-003-115 S 1	California, University of (Berkeley), C. A. TOBIAS. Conference on Space Radiation Biology.	5,750
NGR 05-003-143 S 1	California, University of (Berkeley), D. SAKRISON. Optimization of Design of Space Experiment from the Standpoint of Data Processing.	30,000
NGR 05-003-172	California, University of (Berkeley), A. N. KAUFMAN. Atomic Physics: Scattering and Bound States.	20,988
NGR 05-003-220	California, University of (Berkeley), A. N. KAUFMAN. Plasma Kinetic Theory.	20,633
NGR 05-003-228	California, University of (Berkeley), S. MARGEN. Calcium and Magnesium Metabolism as Related to Dietary Protein Intake.	50,000
NGR 05-003-243	California, University of (Berkeley), R. S. MULLER. Field Effect Transistor Stress Transducers.	19,200
NASr-220 A 4	California, University of (Berkeley), M. CALVIN. Scanning System for Mariner Space Vehicle.	96,471
NSR 05-003-189	California, University of (Berkeley), J. K. MITCHELL. Studies of Materials Related to Lunar Surface Exploration.	63,500
NGR 05-004-008 S 2	California, University of (Davis), A. H. SMITH. Investigation of the Physiological Effects of Chronic Acceleration.	80,000
NGR 05-004-010 S 1	California, University of (Davis), A. SMITH & E. BESCH. Effect of Changes in Apparent Weight on the Efficiency of Synthetic Steroids to Alter Calcium Metabolism, Emphasizing Indexes of Calcium Metabolism Amenable to Instrumental Analysis and Telemetry.	41,000
NGR 05-004-014 S 1	California, University of (Davis), F. H. KRATZER. Effect of Changes in Apparent Weight on the Efficiency of Synthetic Steroids to Alter Calcium Metabolism, Emphasizing Quantitative Aspects of Hormone Admin. and Various Dietary Constituents on Calcium Accretion and Resorption.	47,000
NGR 05-004-028	California, University of (Davis), L. Z. MCFARLAND. Pineal Mechanism and Avian Photoperiodicity.	34,400
NGR 05-004-031	California, University of (Davis), L. D. CARLSON. A Systems Analysis Study of the Properties Veins.	37,273
NsG-322 S 2	California, University of (La Jolla), H. E. SUESS. An Investigation of the Cosmic Abundance of the Elements.	51,998
NsG-216 S 3	California, University of (Los Angeles), W. M. KAULA. Theoretical Evaluation of the Internal Structures and Atmosphere of Planets and the Moon.	10,000

CALIFORNIA—Continued

NsG–237 S 8	California, University of (Los Angeles), W. F. LIBBY. Interdisciplinary Space-Oriented Research in the Physical, Biological, and Engineering Sciences.	$642,000
NsG–249 S 4	California, University of (Los Angeles), W. F. LIBBY. Theoretical and Experimental Investigations of Particles and Fields in Space, Including Construction of Prototype Instrumentation.	183,634
NsG–314 S 3	California, University of (Los Angeles), G. C. KENNEDY. Studies on the High Pressure Solid Phases of Inert Gases, Particularly as They Might Relate to Planetary Interiors.	27,997
NSG–423 S 2	California, University of (Los Angeles), F. R. SHANLEY. Theoretical and Experimental Studies of Optimum Structural Design for Space Structures.	70,000
NsG(T)–4 S 5	California, University of (Los Angeles), W. F. LIBBY. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	177,400
NGR 05–007–041 S 3	California, University of (Los Angeles), Z. SEKERA. Feasibility Studies of Coordinated Radiation Experiments from Meteorological Satellites.	20,000
NGR 05–007–046 S 1	California, University of (Los Angeles), L. H. ALLER. Solar Elements, Their Physical Parameters and Abundances.	59,987
NGR 05–007–065 S 1	California, University of (Los Angeles), P. J. COLEMAN. Reduction and Analysis of Data from the Mariner IV Magnetometer Investigations.	64,282
NGR 05–007–066 S 2	California, University of (Los Angeles), A. Y. WONG. Investigation of Interaction Between Ion Beams and Plasmas.	29,768
NGR 05–007–122	California, University of (Los Angeles), A. V. BALAKRISHNAN. *Time Domain Analysis of System Identification* Problems.	27,000
NGR 05–007–138	California, University of (Los Angeles), W. M. KAULA. To Develop Tidal Theory and To Determine Tidal Parameters from Artificial Satellite Orbit Perturbations.	24,035
NSR 05–007–089	California, University of (Los Angeles), J. D. FRENCH. Summer Institute In Mammalian Physiological Functions In A Space Environment.	37,500
NSR 05–007–094 A 2	California, University of (Los Angeles), P. J. COLEMAN. A Feasibility Study of a Small Satellite to Investigate the Interplanetary Medium, the Magnetosphere, and the Transition Region between the Magnetosphere and the Interplanetary Medium.	57,935
NsG(T)–130 S 3	California, University of (Riverside), R. B. MARCH. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	39,000
NGR 05–008–005 S 1	California, University of (Riverside), J. CALLAWAY. Atomic Scattering Theory.	17,000
NsG–317 S 2	California, University of (San Diego), G. ARRHENIUS. Condensation of Metastable Gases in Space, and the Nature of Resulting Solids.	72,000
NsG–318 S 5	California, University of (San Diego), L. E. PETERSON. Studies for X-ray and Gamma Ray Astronomy.	130,000
NsG–321 S 4	California, University of (San Diego), J. B. ARNOLD. An Investigation of the Cosmogenic Radioactivity and Origin of Meteorites, and the Geochemistry of Solar Nebula.	75,000

CALIFORNIA—Continued

NsG–357 S 5	California, University of (San Diego), G. R. BURBIDGE. Theoretical Studies in Astrophysics.	$55,000
NsG–534 S 1	California, University of (San Diego), J. R. ARNOLD. Study of Lunar Gamma Ray Emission.	110,000
NsG–731 S 1	California, University of (San Diego), J. ARNOLD. Collection and Analysis of Cosmic Dust in the Stratosphere.	44,114
NsG(T)–95 S 3	California, University of (San Diego), F. T. WALL. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	108,100
NGR 05–009–020 S 2	California, University of (San Diego), J. H. TAYLOR. Investigation of Sensitivity of the Central and Peripheral Visual Fields of Normal Human Observers.	53,332
NGR 05–009–043 S 1	California, University of (San Diego), B. NAGY & H. UREY. Study of Techniques for Organic Geochemical Analysis of Lunar Sample Materials.	74,043
NGR 05–009–059	California, University of (San Diego), S. Q. DUNTLEY. Experimental Techniques for Analyzing Visual Detection Probability of Objects in Space.	100,000
NGR 05–009–062	California, University of (San Diego), I. M. JACOBS. Coding Studies for Deep Space Communication.	15,000
NASr–116 A 13	California, University of (San Diego), C. E. MCILWAIN. Conduct Analytical, Theoretical and Experimental Studies of Geomagnetically Trapped Particles.	64,000
NSR 05–009–046	California, University of (San Diego), C. E. MCILWAIN. Auroral Particle Experiment.	64,448
NsG–91 S 5	California, University of (San Barbara), W. C. WALKER. Investigation of the Optical Parameters of Certain Solids in the Spectral Region Between 3000 and 300 Angstroms.	35,000
NsG(T)–146 S 3	California, University of (Santa Barbara), E. L. GRIGGS. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	37,100
NGR 05–010–010 S 1	California, University of (Santa Barbara), W. C. GOGEL. Interrelations of Perceived Size and Distance.	26,168
NGR 05–010–019	California, University of (Santa Barbara), A. C. WATERS. Maar Volcanoes, and the Role of Water in Their Origin.	22,435
NGR 05–059–001	Children's Hospital Medical Center, S. ABRAHAM. Dietary Factors Affecting Eoxgenous and Eondogenous Sources of Fat and Carbohydrate for Energy Production and Synthesis.	33,260
NGR 05–060–001	Humboldt State College, J. D. LONGSHORE. Chemical and Petrological Investigation of the Medicine Lake Calders.	15,965
NsG–289 S 4	Institute for Medical Research, C. M. AGRESS. A Study of Measurement Techniques for Determining Cardiac Performance, Including Consideration of Methods for Vibro-Cardiogram Interpretation and of Physiological Stress Effects on Man.	50,000
NGR 05–024–003 S 1	Institute of Medical Sciences, K. H. FINLEY. Study of the Role of the Vascular System of the Brain on Causation of Damage from Stresses of Radiation and Oxygen Excess.	28,000

CALIFORNIA—Continued

NsG–30 S 7	Leland Stanford University, O. G. VILLARD Electron Content Distribution and Temporal Variation of the Ionosphere by Means of Scintillation and Faraday Rotation of Satellite Radio Transmissions, Including Consideration of Latitudinal Effects of Magnetic Storms.	$64,730
NsG–81 S 7	Leland Stanford University, J. LEDERBERG Cytochemical Studies of Planetary Microorganisms.	448,850
NsG–133 S 5	Leland Stanford University, R. H. CANNON Space Vehicle Attitude Control Systems.	80,000
NsG–215 S 4	Leland Stanford University, F. MORRELL Investigation of the Electrophysiological Correlates of Vigilance and Learning, Including Consideration of Periodic Phenomena Related to the Adaption of Humans to Monotonous Environments.	31,966
NsG–377 S 4	Leland Stanford University, V. R. ESHLEMAN Theoretical and Experimental Radio and Radar Studies of Lunar and Planetary Ionospheres, Atmospheres, and Surfaces, the Sun, and the Interplanetary Medium.	200,000
NsG–378 S 4	Leland Stanford University, W. M. FAIRBANK Gravitational and Resonance Experiments on Very Low Energy Free Electrons and Positrons.	70,000
NsG–582 S 5	Leland Stanford University, R. H. CANNON Investigation, Theoretical and Experimental Analyses for a Zero-G Satellite Development, and Schiff Gyro Test of General Theory of Relativity.	180,000
NsG–622 S 3	Leland Stanford University, A. S. TETELMAN Mechanisms of Strengthening and Fracture in Composite Materials.	15,000
NsG(T)–76 S 4	Leland Stanford University, H. HEFFNER Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	170,400
NsG(T)–157	Leland Stanford University, J. M. PETTIT Supporting the Training of Predoctoral Graduate Students in the Field of Engineering Design.	108,000
NGR 05–020–036 S 2	Leland Stanford University, R. C. ATKINSON Study of Decision Making and Information Processing.	60,000
NGR 05–020–073 S 2	Leland Stanford University, R. E. KALMAN Research on Stability and Stochastic Optimal Control.	35,084
NGR 05–020–084 S 2	Leland Stanford University, O. D. SHERBY Mechanical Behavior of Polycrystalline Non-Metallics At Elevated Temperatures.	10,000
NGR 05–020–089 S 1	Leland Stanford University, O. G. VILLARD Analysis of Topside Ionograms.	20,000
NGR 05–020–091 S 2	Leland Stanford University, D. BERSHEDER Experimental and analytical studies of plasma transport properties.	60,000
NGR 05–020–102 S 1	Leland Stanford University, K. KARAMCHETI Theoretical Studies of Some Nonlinear Aspects of Hypersonic Panel Flutter.	27,230
NGR 05–020–137 S 1	Leland Stanford University, L. STRYER Structure and Function of Proteins and Nucleic Acids.	63,000
NGR 05–020–165 S 1	Leland Stanford University, M. CHODOROW Theoretical and experimental investigations of collective microwave phenomena in solids.	100,000
NGR 05–020–176	Leland Stanford University, F. W. CRAWFORD Investigation of Space Related Whistler Propagation Phenomena in Laboratory Plasmas.	25,000
NGR 05–020–180	Leland Stanford University, C. WHITCHER Analysis of Human Korotkov Sounds.	29,800

CALIFORNIA—Continued

NGR 05-020-209	Leland Stanford University, T. R. KANE Dynamics of the Human Body in Free Fall.	$35,148
NGR 05-020-214	Leland Stanford University, R. H. BUBE Mechanism of the Photovoltaic Effect in II–VI Compounds.	46,000
NGR 05-020-232	Leland Stanford University, R. L. KOVACH Examination of Lunar Scientific Objectives and Evaluation and Developmental Studies for Possible Active Seismic Experiments During the Post-Apollo Period.	28,130
NGR 05-020-237	Leland Stanford University, R. VICKERS, R. LYON Fundamental Studies Relating Particle Size Effects to Infrared Spectra.	29,029
NSR 05-020-088 A 3	Leland Stanford University, M. ANLIKER A Summer Institute in Space-Related Engineering.	135,400
NSR 05-020-151 A 1	Leland Stanford University, W. BOLLAY A Summer Program in Systems Design Engineering.	107,100
NASr-21(02) A 10	Rand Corporation, J. L. HULT Studies of Operational and Technological Factors of Communication Satellites.	350,000
NASr-21(07) A 9	Rand Corporation, S. GREENFIELD Research on Scientific Utilization of Meteorological Satellite Data.	60,000
NASr-21(12) A 3	Rand Corporation, A. M. MARGOLIA Development of Procedures for Examining the Economic Implication of Manned Space Exploration.	140,000
NASr-21(12) A 5	Rand Corporation Development of Procedures for Examining the Economic Implication of Manned Space Exploration.	259,400
NASr-21(13) A 1	Rand Corporation, S. DOLE Conduct a Contingency Planning for Space Emergencies Study.	4,135
NGR 05-017-010	Santa Clara, University of, D. D. DILJAK Extension of Mitrovic's Method for the Analysis and Design of Dynamic Systems.	39,410
NGR 05-017-012	Santa Clara, University of, R. C. DORF Analysis and Design of Solid-State Circuits Utilizing the NASA Analysis Computer Program.	10,000
NGR 05-017-013	Santa Clara, University of, D. A. OLIVER Nonuniformities and instabilities in Electrically Conducting Partially Ionized Gases in the Presence of a Magnetic Field.	11,616
NGR 05-042-001 S 1	Scripps Clinic and Research Foundation, D. FRANKLIN. Applications of Ultrasonic Doppler Sonar Techniques to Cardiovascular Instrumentation in Humans.	40,000
NsG-343 S 3	Southern California, University of, R. SIMHA The Mechanism and Interpretation of Glass Transition Phenomena in Polymers.	29,561
NsG-433 S 4	Southern California, University of, J. P. HENRY An Experimental Investigation of the Role of Experiences in the Etiology of Animal and Human Physiological and Behavioral Responses to Situational Stress in later Life.	54,948
NsG(T)-75 S 4	Southern California, University of, M. C. KLOETZEL Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	139,300

CALIFORNIA—Continued

NsG(T)-162	Southern California, University of, H. REINING. Supporting the Training of Five Predoctoral Graduate Students in Public Administration with Emphasis on Policy Development, Management and Administration of Large Scientific & Technological Program.	$105,000
NGR 05-018-022 S 2	Southern California, University of, G. A. BEKEY. Study of New Techniques for the Analysis of Manual Control Systems.	47,443
NGR 05-018-044 S 1	Southern California, University of, H. BICHSEL. Multidisciplinary Research in the Space-Related Engineering, Physical, Biological and Social Sciences.	200,000
NGR 05-018-056	Southern California, University of, M. P. BIENIEK. Impact Stresses and Deformations in Spherical Shells.	21,551
NGR 05-018-065	Southern California, University of, T. C. JAMES. *Investigation of Molecules of Interest in Stellar* and Planetary Atmospheres.	35,000
NGR 05-018-079	Southern California, University of, W. T. KYNER. Qualitative Properties of the Orbits of Near Earth Satellites.	39,539
NGR 05-018-083	Southern California, University of, W. G. SPITZER. Theoretical and Experimental Investigation of Defects Associated with Lithium in Silicon.	39,962
NSR 05-018-055 S 1	Southern California, University of, R. H. EDWARDS. *Summer Institute in Space Technology.*	43,500
NSR 05-018-067	Southern California, University of, D. L. JUDGE. Conduct a Rocket Experiment to Measure Pre-Extreme Ultraviolet Dayglow.	13,747
NSR 05-018-071	Southern California, University of, A. K. OULIE. Establishment and Operation of Western Research Applications Center.	289,454
NASr-49(07) A 6	Stanford Research Institute, F. T. SMITH. Conduct Theoretical Research on Low Energy *Electronic, Ionic, and Atomic Impact Phenomena.*	40,937
NASr-49(24) A 1	Stanford Research Institute, T. J. AHRENS. An Investigation of the Shock-Induced Transformation of Plagioclases, Olivines, and Pyroxenes.	2,000
NASr-49(24) A 2	Stanford Research Institute, T. J. AHRENS. An Investigation of the Shock-Induced Transformation of Plagioclases, Olivines, and Pyroxenes.	52,280
NASr 49(26)	Stanford Research Institute. Development and Testing of an Image Tube Camera and Spectroscopic System.	37,381
NASr-49 (27)	Stanford Research Institute, W. E. EVANS. Remote Probing of High Cloud Cover via Satellite-Borne Lidar.	47,539
NASr-49(28)	Stanford Research Institute, D. L. DOUGLASS.	51,400
NASr-49(30)	Stanford Research Institute, H. WISE. Research Related to Measurements of Atomic Species in the Earth's Upper Atmosphere.	47,940
NSR 05-019-187	Stanford Research Institute, N. K. HIESTER. An International Symposium on High Temperature Technology.	4,000
R-104(02) A 5	U.S. Atomic Energy Commission, C. A. TOBIAS. Continue Studies Related to Cellular and Whole Body Irradiation with Protons, Alpha Particles, and Heavy Ions.	250,000
R-104(02) A 6	U.S. Atomic Energy Commission, C. A. TOBIAS. Conduct Studies Related to Cellular and Whole Body Irradiation with Protons, Alpha Particles and Heavy Ions.	200,000

CALIFORNIA—Continued		
R–104(06) A 4	U.S. Atomic Energy Commission, J. V. SLATER. Conduct a Feasibility Study for an Experiment Suitable for Use in a Biosatellite, to Determine the Effect of the Space Environment Complex on Insect Growth and Development.	$73,836
R–104(12)	U.S. Atomic Energy Commission, J. H. LAWRENCE. Heme Catabolism as Measured by Exhaled Carbon Monoxide.	77,748
R 05–030–001 A 2	U.S. Navy-Naval Ordnance Test Station, E. BAUER. Theoretical and Experimental Research to Provide Quantitative Knowledge on the Influence of Surface Energy and Structure on the Electron Emission Properties of Materials.	10,000
R 05–030–001 A 3	U.S. Navy-Naval Ordnance Test Station, E. BAUER. Theoretical and Experimental Research to Provide Quantitative Knowledge on the Influence of Surface Energy and Structure on the Electron Emission Properties of Materials.	30,000
R 05–038–001 A 2	U.S. Navy—Pacific Missile Range, F. E. WHITTENBERG. Install Precision Instrument No. PI-200 Tape Deck, Special Reel, Universal Mounting Board and Megacycler in PMR Safety Van, and Make Available to UCLA for Ionosphere Disturbance Experiments.	2,200
COLORADO:		
NsG(T)–92 S 3	Colorado School of Mines, A. R. JORDAN. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	35,000
NsG(T)–45 S 4	Colorado State University, W. H. BRAGONIER. Supporting the Traning of Predoctoral Graduate Students in Space-Related Science and Technology.	63,900
NGR 06–002–032 S 1	Colorado State University, W. R. MICKELSEN. Advanced Electric Propulsion Research.	249,212
NsG(T)–46 S 4	Colorado, University of, E. J. ARCHER. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	117,700
NGR 06–003–052 S 1	Colorado, University of, C. A. BARTH. Theoretical and Experimental Research Program in Physics of Planetary Atmospheres.	342,959
NsG–518 S 3	Denver, University of, S. A. JOHNSON. Multidisciplinary Research in Space-Related Science and Technology.	160,000
NsG(T)–49 S 4	Denver, University of, W. C. MILLER. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	41,200
NSR 06–004–039 A 1	Denver, University of, J. WELLES. Analysis of the NASA Technology Utilization Program and External Communication Network of Commercial Industry.	7,342
R 06–012–006 A 1	Environmental Science Services Adm., J. W. WRIGHT. Ionospheric Electron Density Studies and Computations.	92,900
R 06–012–008	Environmental Science Service Admin., D. T. FARLEY. Partial Support of Observations and Experiments at the Jicamarca Radar Observatory, Emphasizing Incoherent Backscatter Studies of the Magnetosphere.	150,000
R 06–012–010	Environmental Science Service Admin., J. W. WRIGHT Height Profiles of Electron Density and Wind Velocity from Ionospheric Radio Soundings.	37,400
R 06–012–013	Environmental Science Services Adm., R. G. MERRILL. To Process Data Taken from Beacon Explorer Signals as Received on the Ground and to Study Therefrom the Variations of Electron Content and Large Scale Irregularities.	20,000

COLORADO—Continued

R–102 A 3	Environmental Science Service Admin., R. B. SCOTT Conduct Research Aimed at Increasing the Basic Understanding of the Production Mechanisms and Physical Processes of Solar Activity.	$100,000
NASr–185 A 5	University Corporation for Atmospheric Research, K. O. KIEPENHEUER. Development of Improved Means of Scientific Ballooning and the Conduct of Scientific Balloon Flights.	32,000
NASr–224 A 3	University Corporation for Atmospheric Research, E. A. MARTELL. Develop and Construct Cryogenic Air Samplers for Aerobee Rocket and Analyze Samples after Flight and Recovery by NASA.	100,000
NASr–213 A 3	Western State College of Colorado, T. D. VIOLETT Provide for the Flight of a Rocket Spectrograph to Examine the Lyman-Beta Line of Solar Emission.	6,410

CONNECTICUT:

NsG(T)–47 S 4	Connecticut, University of, N. L. WHETTEN Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	71,500
NSR 07–002–029	Connecticut, University of, Establishment and Operation of New England Research Applications Center.	254,230
NSR 07–002–015 A 1	Connecticut, University of, R. O. HARVEY Study of the Feasibility of Establishing a Regional Dissemination Center in the New England Area.	23,500
NGR 07–006–003	Wesleyan University, H. OGDEN Search for Faint Comets near the Sun during Totality of November 12, 1966, Solar Eclipse.	6,000
NsG–138 S 6	Yale University, R. C. BARKER Low-Power, Low-Speed Data Storage and Processing Techniques.	51,819
NsG–163 S 5	Yale University, V. W. HUGHES AND D. R. BRILL Theoretical Research in Relativity, Cosmology and Nuclear Astrophysics.	40,000
NsG–208 S 3	Yale University, H. J. MOROWITZ A Determination and Analysis of the Properties and Characteristics of Extremely Small Free-living Self-Replicating Cells.	20,670
NsG(T)–34 S 4	Yale University, J. P. MILLER Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	144,800
NGR 07–004–028 S 2	Yale University, I. B. BERNSTEIN Plasma Physics in Planetary and Solar Environments.	63,894
NGR 07–004–035 S 2	Yale University, W. E. LAMB Investigation of the Basic Foundation of Masers and Lasers.	30,000
NGR 07–004–049 S 1	Yale University, V. SZEBEHELY The Gravitational N-Body Problem.	7,000
NGR 07–004–055	Yale University, T. H. WATERMAN Study of Retinal Fine Structure and Visual Orientation.	17,180
NGR 07–004–067	Yale University, S. R. LIPSKY Analysis of Organic Compounds in Returned Lunar Material.	153,000
NGR 07–004–068	Yale University, B. J. SKINNER Determining the Composition of Volcanic Emanations Through Study of Lunar Samples.	10,000
NGR 07–004–083	Yale University, V. SZEBEHELY Applications of Celestial Mechanics to Space Research.	24,993

DELAWARE:		
NsG(T)–29 S 4	Delaware, University of, C. E. BIRCHENALL. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	$66,400
NGR 08–001–016	Delaware, University of, E. J. PELLICCIARO. A Nonlinear Integral Equation of the Abel Type Arising from the Theory of Absorption Kinetics.	12,286
DISTRICT OF COLUMBIA:		
NASr–132 A 9	American Institute of Biological Sciences, J. R. OLIVE. Symposium on the Minimum Ecological Systems for Man.	240,000
NsG–586 S 2	Catholic University, C. C. CHANG. Theoretical, Analytical and Experimental Investigation of Hydrodynamics of Gaseous-Core Ring-Vortex and Cylindrical Cavity Reactors.	70,000
NsG–649 S 3	Catholic University, T. TANAKA. Analysis of Radiation Damage in Solar Cells.	28,000
NsG(T)–39 S 4	Catholic University, J. P. O'CONNOR. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	84,400
NGR 09–005–022	Catholic University, B. T. DECICCO. Genetic Studies of Hydrogen Bacteria and Their Application to Biological Life Support Systems.	28,164
NGR 09–005–035 S 2	Catholic University, S. C. LING. Experimental Study of a Weak Turbulent Field.	22,000
NGR 09–134–001 S 1	Children's Hospital (Research Foundation) J. C. HOUCK. Investigation of the Effect of Stress on the Chemistry, Metabolism and Biophysics of Collagen.	28,729
NsG(T)–98 S 3	Georgetown University, J. B. HORIGAN. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	70,800
NsG–603 S 4	George Washington University, N. FILIPESCU. Synthesis and Spectroscopic Properties of Rare Earth Chelates in Solvents and Polymers for Optical Masers.	31,673
NsG(T)–51 S 4	George Washington University, A. E. BURNS. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	59,700
NSR 09–010–027 A 1	George Washington University, C. W. SHILLING. Scientific Communication Research in Space Biology.	150,000
NSR 09–010–027 A 2	George Washington University, C. W. SHILLING. Scientific Communication Research in Space Biology.	50,921
NSR 09–010–035	George Washington University, C. W. SHILLING. Design and Management of Biomedical Applications Systems for NASA.	81,136
NSR 09–150–001	Green and Lomask, History of Project Vanguard.	25,800
NSR 09–150–001 A 1	Green and Lomask, History of Project Vanguard.	4,000
NsG(T)–110 S 3	Howard University, C. L. MILLER. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	62,500
NGR 09–011–006 S 1	Howard University, F. SENFTLE. Investigation of Infra-Red Absorption and Low Angle X-Ray Scattering of Tektites.	13,000
NGR 09–012–910	National Academy of Sciences, N. E. PROMISEL. Advisory Services on Materials Research and Development.	5,000
NGR 09–012–911	National Academy of Sciences, H. HESS. A Study of Medical, Physiological, Behavioral Effects on Success of Long-Term Manned Space Mission.	30,000

DISTRICT OF COLUMBIA—Continued

NSR 09-012-901 A 6	National Academy of Sciences, C. J. LAPP. Postdoctoral Fellowship Program.	$50,000
NSR 09-012-901 A 7	National Academy of Sciences, C. J. LAPP. Postdoctoral and Senior Postdoctoral Resident Research Associateship Program in Space Sciences and Technology.	200,000
NSR 09-012-903 A 2	National Academy of Sciences, H. ODISHAW. Space Science Board.	275,000
NSR 09-012-906 A 2	National Academy of Sciences, Astrometric Survey of the Southern Sky.	48,775
NSR 09-012-908	National Academy of Sciences, To Conduct a Biogravitational Symposium.	2,500
NSR 09-012-909	National Academy of Sciences. A Study and Report on the Probable Future Usefulness of Satellites in Practical Earth-Oriented Applications.	100,000
NSR 09-012-909 A 1	National Academy of Sciences. A Study and Report on The Probable Future Usefullness of Satellites in Practical Earth-Oriented Applications.	26,000
NSR 09-012-912	National Academy of Sciences, H. K. WORK. Support of an Aeronautics and Space Engineering Board.	186,500
NSR 09-012-913	National Academy of Sciences. A Study of Postdoctoral Education in The United States.	25,000
NSR 09-012-914	National Academy of Sciences, L. SAYLES. A Study of Management of Complex Technological Systems.	150,000
NSR 09-125-002 A 3	National Art Education Association. Development of Two 40-Frame Sound Color Film-Strips of Art Work on Space-Related Subjects.	360
NsG-87 S 18	Smithsonian Institution, F. L. WHIPPLE. Optical Satellite Tracking Program.	3,651,500
NsG-87 S 19	Smithsonian Institution, F. L. WHIPPLE. Optical Satellite Tracking Program.	1,854,923
NsG-291 S 3	Smithsonian Institution, R. E. MCCROSKY. Systematic In-Flight Photography and Subsequent Recovery of Meteorites.	201,256
NGR 09-015-047	Smithsonian Institution, N. CARLETON. Study of the Carbon Dioxide Spectrum of Mars.	46,845
NSR 09-015-018 A 2	Smithsonian Institution, R. HAEFNER. Data Aanalysis in Connection with the National Geodetic Satellite Program.	30,000
NSR 09-015-018 A 3	Smithsonian Institution, LUNDQUIST. Data Analysis in Connection With The National Geodetic Satellite Program.	124,480
NSR 09-015-022 A 1	Smithsonian Institution, G. G. FAZIO. A High Energy Gamma-Ray Astronomy Experiment for High-Altitude Balloons.	21,045
NSR 09-015-033 A 3	Smithsonian Institution, R. B. SOUTHWORTH. A Meteor Research Program.	304,681
NSR 09-015-039	Smithsonian Institution, F. L. WHIPPLE. Providing Capability to Update a Baker-Nunn Satellite Tracker to Track to One Meter or Better Accuracy Using Laser Techniques.	100,000
NSR 09-015-044	Smithsonian Institution, S. R. GALLER. Interdisciplinary Communications Program Conferences.	120,000
NSR 09-015-054	Smithsonian Institution. Research Studies in the Application of Geodetic Satellite Techniques to the Earth Sciences and Oceanography.	69,388

DISTRICT OF COLUMBIA—Continued

NSR 09-015-058	Smithsonian Institution, F. C. DURANT Custody and Management of NASA Historical Artifacts.	$199,672
NsG-35 S 7	Society of Photographic Scientists & Engineers, N. GOODWIN. Independent Tracking Coordination Program.	40,948
R 09-019-040 A 2	U.S. Atomic Energy Commission, H. D. SIVINSKI Support of the Planetary Quarantine Activities of Bioscience Programs.	51,000
R 09-038-002 A 1	U.S. Department of Agriculture Studies Leading to Identification of Agriculture/Forestry Experiments Utilizing Manned-Orbiting Space Stations.	550,000
R-66 A 7	U.S. Department of Interior (Geological Survey) F. E. SENFTLE. Perform Studies of the Lunar Surface Including Lunar Geologic Mapping, Cratering and Crater Impact Mechanisms.	822,000
R 09-020-011 A 1	U.S. Department of Interior (Geological Survey) W. T. PECORA. Continue Scientific Technical Experiment Program for Geology & Hydrology Leading to Space Flight Experiments for Earth Orbital Flights. Geoscience Applications—Manned Earth Orbital Program.	850,000
R 09-020-013 A 4	U.S. Department of Interior (Geological Survey) L. CLARK. Conduct Studies, Evaluation and Analyses Relating to the Planning and Development of Scientific Operations (and supporting equipment and facilities) for Apollo Lunar Missions.	60,000
R 09-020-024 A 1	U.S. Department of Interior (Geological Survey) A. GERLACH. Studies for Geography and Cartography Leading to the Formulation of Spaceflight Experiments for Manned Earth Orbital Flights.	300,000
R 09-020-041	U.S. Department of Interior (Geological Survey) Photometric Investigations.	100,000
R 09-040-001 A 2	U.S. Dept. of Interior/Bureau of Mines, T. C. ATCHESON. Continued Research Program Leadnig to the Utilization of Extraterrestrial Resources.	300,000
R-141 A 5	U.S. Library of Congress, P. L. BERRY Scanning, Selecting, Abstracting and Indexing Services of Current Literature in the Field of Aerospace Medicine, Biology, and Related Subjects.	52,600
R-56 A 5	U.S. National Bureau of Standards, L. A. WALL Study the Thermal Degradation of Aromatic and Heterocyclic polymers with emphasis on the Solid State Reactions occurring at High Temperature and the manner in which these reactions are modified by the presence of oxygen and other active agents.	31,000
R-64 A 4	U.S. National Bureau of Standards, A. M. BASS An Investigation of the Vacuum Ultraviolet Spectra of Atoms and Low Molecular Weight Molecules.	35,000
R-80 A 5	U.S. National Bureau of Standards, M. J. BERGER Conduct a Study of the Penetration of High Energy Radiation Through Matter.	57,000
R-130 A 2	U.S. National Bureau of Standards, H. L. LOGAN Study of the Mechanism of Stress-Corrosion of Titanium Alloys Exposed to Sodium Chloride at Elevated Temperatures.	5,964

DISTRICT OF COLUMBIA—Continued

R–127 A 3	U.S. National Bureau of Standards, C. M. TCHEN. Conduct the Investigations of Electrohydrodynamics and Statistical Dynamics as Applied to Plasma Propulsion.	$25,000
R 09–022–029 A 3	U.S. National Bureau of Standards, W. HAMER. For Continuation of Compilation of Critically Evaluated Data of Electrochemical Properties of Solutions, Including Activities and Activity Coefficients, Standard Electrical Potentials, Electric Conductivities, Ionic Mobilities and Heats of Solution.	45,000
R 09–022–033 A 2	U.S. National Bureau of Standards, H. P. R. Frederikse. Conduct Theoretical and Experimental Investigations of the Electronic Energy Band Structure of Solids.	30,000
R 09–022–039 A 2	U.S. National Bureau of Standards, J. A. CUNNINGHAM. Research and Development in Selected Areas of Computer Sciences and Related Disciplines.	50,000
R 09–022–075	U.S. National Bureau of Standards. Constitution of Alloys.	28,000
R–42 A 5	U.S. Navy—Office of Naval Research, C. TOLHURST. Partial Support of the National Research Council Committee on Hearing and Bio-Acoustics and the National Research Council Committee on Vision.	70,000
R–48 A 9	U.S. Navy—Office of Naval Research, F. B. ISAKSON. Provide Balloons, Helium and Launch Support Services to NASA Sponsored Scientists During CY 1967.	412,550
R–122 A 3	U.S. Navy—Office of Naval Research, H. W. HAYS. Continued Support of the Advisory Center on Toxicology.	15,000
R–129 A 3	U.S. Navy—Office of Naval Research, L. A. JEFFRESS. Conduct Studies of Auditory Information Processing, Emphasizing the Application of Signal Detectability Theory to Auditory Sensory Responses.	35,000
R 09–030–027 A 1	U.S. Navy—Office of Naval Research, H. ENGSTROM. To Provide Detailed Anatomical Information of the Vestibular System Needed to Access Changes or Damage to that System from Prolonged Weightlessness or Excessive Stimulation.	17,000
R 09–030–042	U.S. Navy—Office of Naval Research, H. WACHMAN. Sixth International Symposium on Rarefied Gas Dynamics.	4,000
R–55 A 5	U.S. Weather Bureau. Partial Support of the Severe Storms Study Program to Include Obtaining Information on the Relation of Gust Intensity Level with Radar Reflectivity and the Erosion Effects of Atmospheric Particles on Aircraft at High Mach Numbers.	74,800

FLORIDA:

NsG–224 S 4	Florida State University, C. H. BARROW. A Study of Polarization of the Decameter-Wave Radiation from Jupiter, With Particular Emphasis on the Correlation Between Jupiter and Solar Activity.	99,798
NsG(T)–50 S 4	Florida State University, R. J. KEIRS. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	94,400
NGR 10–004–018 S 2	Florida State University, H. GAFFRON. Specific Effect of Blue Light on Plant Metabolism.	32,500
NGR 10–004–029 S 2	Florida State University, R. G. CORNELL. Space-Related Biostatistical Studies, Emphasizing Microbiology and Sterilization.	6,400

FLORIDA—Continued

NGR 10-004-041	Florida State University, W. SCHWARTZ Microbial Activity in Non-aqueous Systems.	$32,425
NsG-542 S 3	Florida, University of, L. E. GRINTER Multidisciplinary Program of Research in Space-Related Sciences and Technology.	335,000
NsG(T)-13 S 4	Florida, University of, L. E. GRINTER Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	101,100
NGR 10-005-039 S 1	Florida, University of, J. J. HREN Investigation of Structure with the Field Ion Microscope.	28,667
NGR 10-005-049 A 1	Florida, University of, R. T. SCHNEIDER Investigation of Spectra in the Vacuum UV and Soft X-Ray Region.	12,000
NGR 10-005-054 S 1	Florida, University of, R. T. SCHNEIDER Investigation of Material Release and Electric Current Emission from Electrodes, Particularly in High Vacuum.	23,794
NsG-424 S 3	Miami, University of, A. H. STENNING Instabilities in the Flow of Boiling Liquid.	400
NsG(T)-126 S 3	Miami, University of, J. A. HARRISON Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	53,100
NGR 10-007-010 S 1	Miami, University of, E. H. MAN Multidisciplinary Research in Space Sciences.	200,000
NGR 10-007-012 S 2	Miami, University of, M. L. KEPLINGER Investigation of the Toxic Effects of Fluorine.	12,021
NGR 10-007-044	Miami, University of, S. W. FOX Techniques for Determining Organized Elements in Returned Lunar Materials.	50,000
NSR 10-007-032 A 3	Miami, University of, K. P. CHOPRA A Summer Institute on Fundamental Concepts in Environmental and Planetary Sciences.	52,058
R 10-009-013 A 3	U.S. Navy—School of Aviation Medicine, A. GRAYBIEL Ground Based Investigations toward a Long Duration Primate Experiment.	110,000
R 10-009-027 A 1	U.S. Navy—School of Aviation Medicine, D. E. BEISCHER. Study of the Effects of Space Vehicle Vibrations on Chromosomes and Cellular Structure of Tradescantia, Drosophila and Neurospora, which are being Flown in the Biosatellite.	38,000

GEORGIA:

NGR 11-001-009 S 2	Emory University, V. P. POPOVIC Cardiovascular Adaptation During Long-Term Weightlessness.	50,000
NsG-545 S 3	Emory University, T. FORT Difference Equations with Varying Difference Interval and Difference and Differential Equations with almost Periodic Coefficients.	6,263
NsG(T)-123 S 3	Emory University, C. T. LESTER Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	38,400
NsG-337 S 2	Georgia Institute of Technology, J. A. KNIGHT Chemical Reactivity of Hydrogen, Nitrogen and Oxygen Atoms at Temperatures below 100°K:	40,000
NsG-657 S 3	Georgia Institute of Technology, V. CRAWFORD Multidisciplinary Research in the Space Sciences and Technology.	300,000
NsG(T)-1 S 5	Georgia Institute of Technology, T. W. JACKSON Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	130,000

GEORGIA—Continued

NsG(T)–158	Georgia Institute of Technology, T. W. JACKSON Supporting the Training of Predoctoral Graduate Students in the Field of Engineering Design.	$96,000
NsG(T)–125 S 3	Georgia, University of, G. B. HUFF Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	115,200
R–137 A 4	U.S. Dept. of Health, Education & Welfare, S. W. SIMMONS. Research on Microbiological Sterilization Problems Involving the Safety of Earth and Other Planets of this Galaxy from the Effects of Intra-Spatial Transmission of Potentially Virulent Microorganisms.	168,500

HAWAII:

NsG–135 S 2	Hawaii, University of, W. R. STEIGER Research on Selected Lines in the Airglow Spectrum.	70,341
NsG–676 S 4	Hawaii, University of, J. L. WEINBERG Photoelectric Study of the Night-Sky Radiation From Zodiacal Light, Airglow and Starlight.	24,000
NsG(T)–108 S 3	Hawaii, University of, W. GORTER Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	40,700
NGR 12–001–011 S 2	Hawaii, University of, J. T. JEFFERIES Coronal and Chromospheric Physics.	428,000
NGR 12–001–020 S 1	Hawaii, University of, T. A. ROGERS Physiological Studies of Highly Motivated Subjects in Severe Environments.	80,000
NGR 12–001–031	Hawaii, University of, J. L. WEINBERG International Symposium on the Zodiacal Light and the Interplanetary Medium.	6,000
NGR 12–001–036	Hawaii, University of, S. H. LAURILA Investigation of a Dynamic Method for Determining the Terrestrial Gravity Field from Satellite Data.	29,761
NGR 12–001–042	Hawaii, University of, S. M. SIEGEL The Performance and Capabilities of Terrestrial Organisms in Extreme and Unusual Gaseous and Liquid Environments.	50,685
NGR 12–001–045	Hawaii, University of, S. LAURILA AND G. WOOLLARD Study of the Degree to Which Satellite-Derived Gravitational Data can be Related to the Surface Gravity Field and other Geophysical Parameters in Areas of Anomalous Gravity Defined by Satellite Orbital Perturbations.	42,027
NSR 12–001–019 A 3	Hawaii, University of, J. T. JEFFERIES Design Development, Fabrication and Installation of 84-Inch Telescope Suitable for Lunar Planetary and Stellar Observation.	820,000

IDAHO:

NsG(T)–135 S 2	University of Idaho, M. L. JACKSON Supporting the Training of Predoctoral Graduate Students in Space-Relating Science and Technology.	36,300

ILLINOIS:

NsG–96 S 6	Chicago, University of, E. N. PARKER Theoretical Investigations of the Effect of the Solar Wind in Interplanetary Space, and Its Association with Terrestrial Phenomena.	63,757
NsG–144 S 7	Chicago, University of, P. MEYER Composition, Energy Spectrum and Intensity of Primary Cosmic Radiation.	252,190
NsG–179 S 7	Chicago, University of, J. A. SIMPSON Research and Development Basic for Experiments in Space Vehicles.	243,188

ILLINOIS—Continued

NsG–179 S 8	Chicago, University of, J. SIMPSON Experimental and Theoretical Studies of Energetic Particles and Electrodynamical Processes in Inter-Planetary Space and in the Vicinity of Planets.	$54,661
NsG–352 S 4	Chicago, University of, M. H. COHEN Theoretical and Experimental Investigations of Super-Conductivity and Magnetism.	85,000
NsG–366 S 6	Chicago, University of, E. ANDERS AND J. V. SMITH Lunar Sample Investigation.	36,400
NsG(T)–2 S 5	Chicago, University of, W. A. WICK Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	175,400
NGR 14–001–102	Chicago, University of, R. N. CLAYTON Support in Up-Grading Apparatus and Procedures for the Analysis of Returned Lunar Materials.	17,173
NASr–65(22)	IIT Research Institute, D. L. ROBERTS Methods for the Evaluation of Lunar Exploration Science.	50,000
NASr–22 A 8	IIT Research Institute, E. J. HAWRYLEWICZ Life in Extraterrestrial Environments.	94,873
NASr–65(01) A 7	IIT Research Institute, W. O. DAVIES Research on Radiative Energy Transfer on Entry into Mars and Venus.	68,090
NASr–65(03) A 10	IIT Research Institute, L. CONROY Technology Utilization-Identification and Dissemination.	147,423
NASr–65(03) A 11	IIT Research Institute, L. CONROY Investigation of Technology Generated through NASA/AEC Sponsored Research.	420,400
NASr–65(06) A 7	IIT Research Institute, C. A. STONE Conduct Studies and Analyses of Space Science Problems Related to the Planning and Directing of NASA Lunar and Planetary Programs.	450,000
NASr–65(09) A 3	IIT Research Institute, Y. HARADA Research for the Study to Determine the Advantages of Graphite-Metal Alloys.	58,497
NASr–65(10) A 6	IIT Research Institute, J. G. BARMBY Scientific and Engineering Studies Related to Manned Space Science Problems.	37,500
NASr–65(10) A 7	IIT Research Institute, J. G. BARMBY Scientific and Engineering Studies Related to Manned Space Science Problems.	59,919
NASr–65(10) A 8	IIT Research Institute, R. DUBINSKY Scientific and Engineering Studies Related to Manned Space Science Problems.	58,531
NASr–65(10) A 9	IIT Research Institute, J. G. BARMBY Scientific and Engineering Studies Related to Manned Space Science Problems.	112,500
NASr–65(18) A 1	IIT Research Institute, R. C. GREENWOOD Conduct an Investigation to Establish the Practical Feasibility of the Neutron Capture Gamma-Ray Techniques for Determination of Lunar and Planetary Surface Compositions.	83,204
NASr–65(19)	IIT Research Institute, T. OWEN Spectroscopic Observations of Mars.	32,786
NASr–65(20)	IIT Research Institute, J. A. GREENSPAN Conduct a Study of the Effectiveness of Several Satellite Systems for Geophysical Research in the Near-Earth Environment During the Period Extending into the Next Decade.	49,711
NASr–65(20) A 1	IIT Research Institute, J. A. GREENSPAN Conduct a Study of the Effectiveness of Several Satellite Systems for Geophysical Research in the Near-Earth Environment during the Period Extending into the Next Decade.	29,765

ILLINOIS—Continued

NASr–65(21)	IIT Research Institute, P. J. DICKERMAN Conduct Measurement of Transition Probabilities for Selected Rare Earth Neutral and Ionized Elements.	$50,000
NSR 14–003–171	IIT Research Institute, F. DICKERMAN Review of Accomplishments in Solar Physics.	2,495
NsG–694 S 3	Illinois Institute of Technology, H. WEINSTEIN Turbulence Coefficients and Stability Studies for the Coaxial Flow of Dissimilar Fluids.	129,500
NsG(T)–25 S 4	Illinois Institute of Technology, A. GRAD Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	108,400
NsG–195 S 4	Illinois, University of, W. J. FRY Experimental Analysis of the Micro-Neuroanatomy of the Central Nervous System.	166,000
NsG–228 S 3	Illinois, University of, W. D. COMPTON Study of Radiation Effects in Semiconductors.	43,184
NsG(T)–24 S 4	Illinois, University of, D. ALPERT Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	168,400
NGR 14–012–004 S 1	Illinois, University of, J. H. BOYER Nitrogen Chemistry Significant to Primordial Systems.	66,000
NGR 14–005–037 S 2	Illinois, University of, L. GOLDSTEIN Investigation of the Basic Processes Occurring in Gaseous Plasma in Various Charge Density and Energy States.	40,000
NGR 14–005–074 S 2	Illinois, University of, H. W. ADES Physiological Responses of Central Vestibular Pathways and Diffuse Ascending Systems to Vestibular Stimulation.	52,757
NGR 14–005–103	Illinois, University of, J. C. CHATO Physiological and Engineering Study of Advanced Thermoregulatory Systems for Extravehicular Space Suits.	32,985
NGR 14–005–107	Illinois, University of (Urbana), J. W. LEONARD Nonlinear Dynamic Analysis of Structures.	30,000
NsG–597 S 3	Northwestern University, J. A. HYNEK Optical Study and Analysis of Transient Lunar Phenomena.	77,892
NsG(T)–17 S 4	Northwestern University, R. H. BAKER Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	119,800
NGR 14–007–041 S 1	Northwestern University, S. S. HAUNG A Study of Celestial Objects of High Angular Momenta.	25,235
NGR 14–007–062	Northwestern University, A. H. RUBENSTEIN Studies and Analysis of the Management of Scientific Research and Development.	110,000
NGR 14–007–067	Northwestern University, G. HERRMANN Dynamics of Mechanical Systems Coupled to Energy Sources.	37,220
NSR 14–007–063	Northwestern University, K. G. HENIZE International Astronomical Union Colloquium on Space Spectroscopy.	5,933
NsG(T)–153 S 1	Southern Illinois University, W. E. SIMEONE Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	37,200
NGR 14–008–003 S 2	Southern Illinois University, G. H. GASS Effect of Chronic Restraint on Absorption from the Gastrointestinal Tract.	3,500
R–104(05) A 3	U.S. Atomic Energy Commission, S. A. GORDON Study of Effect of Gravitational, Magnetic and Electrical Fields on Plants.	100,000

INDIANA:

NGR 15-009-001 S 1	Ball State University, E. MONTAQUE — Study and Analysis of Space Related Developments in Physical and Biochemistry.	$500
NsG-503 S 3	Indiana University, H. JOHNSON — A Theoretical Investigation of the Steady-State Interaction Between Radiation and Matter in Stellar Atmospheres.	40,500
NsG(T)-15 S 4	Indiana University, L. L. MERRITT — Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	100,400
NGR 15-003-007 S 2	Indiana University, W. D. NEFF — An Experimental Investigation of the Neurological Correlates of Information Reception.	16,320
NGR 15-003-050	Indiana University, E. J. STAHR — Multidisciplinary Study of Interrelationships between the Space Program and Society.	25,000
NASr-162 A 4	Indiana University, A. M. WEISMER — Pilot Program on Industrial Applications of Aerospace Research Carried on by the Aerospace Research Applications Center of Indiana University during CY 1967.	150,000
NSR 15-003-052	Indiana University — Filming of Certain Technology Transfers.	725
NSR 15-003-054	Indiana University, A. W. WEIMER — An Experiment in the Decentralized Reproduction and Provision of *Hard-Copy Documents of Aerospace* Generated Technology Contained in the NASA Information Resource.	42,000
NSR 15-003-055	Indiana University, A. W. WEIMER — Experiments in Technology Utilization.	142,500
NsG-339 S 4	Notre Dame, University of, G. F. D'ALELIO — Synthesis of Heat Resistant Polymers and Directed Polymerizations.	40,000
NsG(T)-65 S 4	Notre Dame, University of, P. E. BEICHNER — Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	103,100
NGR 15-004-017 S 1	Notre Dame, University of, T. J. STARR — Application of the "Germfree Animal" to Space Ecology.	56,811
NGR 15-004-021	Notre Dame, University of, E. W. HENRY — Computer Aided Design and Analysis of Circuits and Systems.	10,000
NsG-301 S 4	Purdue University, K. L. ANDREW — High Precision Spectroscopy with Application to the Study of the Atomic Spectra of the Carbon Group, to Secondary Standards in the Vacuum Ultraviolet, and to the Development of Computer Methods of Data Analysis.	50,000
NsG-553 S 3	Purdue University, J. C. LINDENLAUB — Theoretical and Experimental Studies in Synthesis of Self-Adaptive Communication Systems.	15,000
NsG-592 S 2	Purdue University, B. A. REESE — Investigation of the Effects of Thermal and Chemical Non-Equilibrium on Combustion in Supersonic Streams.	47,485
NsG(T)-27 S 4	Purdue University, F. N. ANDREWS — Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	139,500
NsG(T)-161	Purdue University — Supporting the Training of Five Predoctoral Graduate Students in Engineering Design as Related to Aeronautical and Space Technology.	111,000

ILLINOIS—Continued

NGR 15-005-021 S 2	Purdue University, F. N. ANDREWS Multidisciplinary Research in Space-Related Science and Engineering.	$300,000
NGR 15-005-022 S 1	Purdue University, R. OLDENBURGER Flow of Single and Two Phase Fluids in Lines.	20,000
NSR 15-005-037 A 2	Purdue University, D. P. DEWITT Compilation and Analysis of Thermal Radiative Properties Data.	86,648
NGR 15-005-039	Purdue University, W. GAUTACHI Numerical Analysis of Linear Difference Equations.	23,252
NGR 15-005-056	Purdue University, K. R. PURDY Sound Wave and Shear Wave Interaction with Oblique Shock Fronts.	12,338
NGR 15-005-058	Purdue University, B. A. REESE Influence of High Combustion Pressure (4000 PSIA) Upon Performance, Heat Flux, and Combustion Stability.	69,129
NGR 15-005-063	Purdue University, R. GOULARD Precursor Radiation Effects of High Enthalpy Gas Streams.	10,000
NGR 15-008-004	Rose Polytechnic Institute, H. A. SABBAGH A Theoretical Analysis of Static and Dynamic Behavior of Some Maser Systems.	16,000

IOWA:

NsG-62 S 5	Iowa State University, G. K. SERVOY A Study and Investigation of the Application of Blade-Element Techniques and Performance Prediction Problems for Axial-Flow Turbo-Machinery.	61,322
NsG(T)-35 S 4	Iowa State University, J. B. PAGE Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	151,200
NsG-233 S 5	Iowa, University of, J. A. VAN ALLEN Theoretical and Experimental Studies Related to the Particles and Fields Associated with the Major Bodies of the Solar System and with Interplanetary Space.	349,600
NsG(T)-6 S 5	Iowa, University of, D. SPRIESTERSBACH Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	119,700
NGR 16-001-043	Iowa, University of, D. C. MONTGOMERY Waves In Plasmas.	44,989
NSR 16-001-025 A 1	Iowa, University of, D. A. GURNETT A Very-Low-Frequency Radio Noise Experiment to be Flown on a Javelin Sounding Rocket.	55,029

KANSAS:

NsG-692 S 2	Kansas State University, J. L. BROWN Multidisciplinary Research on Space-Related Sciences and Engineering.	75,000
NsG(T)-54 S 4	Kansas State University, R. D. DRAGSDORF Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	104,500
NGR 17-001-026	Kansas State University, D. WILLIAMS Infrared Laboratory Studies of Synthetic Planetary Atmospheres.	44,054
NsG-298 S 5	Kansas, University of, W. P. SMITH Interdisciplinary Studies in Space Science and Technology.	100,000
NSG(F)-36	Kansas, University of, B. G. BARR Construction of a Space Research and Technology Laboratory at the University of Kansas.	1,800,000

KANSAS—Continued

NsG(T)-55 S 4	Kansas, University of, W. P. ALBRECHT. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	$96,800
NsG(T)-160	Kansas, University of. Supporting the Training of Predoctoral Graduate Students in the Field of Engineering Design.	88,800
NGR 17-004-013	Kansas, University of, L. L. BAILIN. A Study of High Performance Antenna Systems for Deep Space Communication.	50,000
NGR 17-002-043	Kansas, University of, D. L. KOHLMAN. Effects of Vortex Core Breakdown on the Aerodynamics Forces Developed by Slender Sharp-Edged Wings.	20,430
NGR 17-002-047	Kansas, University of, K. H. LENZEN. Investigation of Aeroelastic Effects in Aerospace Vehicles.	9,170
NSR 17-004-003 A 7	Kansas, University of, R. K. MOORE. Conduct Radar and Microwave Radiometry Investigations Related to Orbiting Research Laboratories.	12,050

KENTUCKY:

NsG-456 S 4	Kentucky, University of, K. O. LANGE. An Investigation of Gravity Level Preference and the Effects of Gravitational Forces on Small Animals and Primates, and of Techniques for Related Space Flight Experiments.	150,000
NsG(T)-122 S 3	Kentucky, University of, L. W. COCHRAN. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	76,800
NGR 18-001-012 S 1	Kentucky, University of, P. A. THORNTON. An Investigation of Skeleton Response to Immobilization.	13,413
NsG(T)-136 S 2	Louisville, University of, J. A. DILLON. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	55,400
NGR 18-002-005 S 2	Louisville, University of, J. A. DILLON. Multidisciplinary Space-Related Research in the Physical, Engineering, and Life Sciences.	65,000
NGR 18-002-015	Louisville, University of, W. BRODSKY. Effects of Environmental Changes on Cellular Bio-Energetics and Transport Processes.	30,115

LOUISIANA:

NsG(T)-19 S 4	Louisiana State University, M. GOODRICH. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	98,600
NGR 19-001-012 S 1	Louisiana State University, R. W. HUGGETT. Cosmic Ray Investigations Utilizing an Emulsion Chamber-Calorimeter Combination.	160,000
NGR 19-001-016 S 1	Louisiana State University, W. R. PIKE. Evaluation of the Energy Transfer in the Char-Zone During Ablation.	49,994
NGR 19-001-035	Louisiana State University, C. A. WHITEHURST. A Study of the Gap Between Bolted Plates Caused By Fastener Loads as Applied to Joint Thermal Conductance.	27,183
NGR 19-006-001 S 1	Northeast Louisiana State College, D. E. DUPREE. Study of Multivariate Functional Models by Least Squares Techniques.	19,290
NsG(T)-84 S 4	Tulane University, D. R. DEENER. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	112,000

MAINE:

NsG(T)-116 S 3	Maine, University of, E. P. EGGERT Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	$57,300

MARYLAND:

NsG-361 S 4	Johns Hopkins University, H. W. MOOS Investigation of Properties of Rare Earth Ions.	35,000
NsG-520 S 3	Johns Hopkins University, J. PEREZ-CRUET Phychocardiovascular Reactions During Conditions of Weightlessness in an Orbiting Satellite.	29,950
NsG(T)-53 S 4	Johns Hopkins University, G. W. SHAFFER Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	103,200
NGR 21-001-044 S 1	Johns Hopkins University, J. STRONG Partial Support for Observation of the Solar Corona with Balloon-Borne and Ground-Based Infrared Coronagraphs.	10,000
NsG-58 S 3	Maryland, University of, H. LASTER Theoretical Studies in Atmospheric & Space Physics.	50,000
NsG-70 S 5	Maryland, University of, R. W. KRAUSS A Study of Psychophysiology in Controlled Environments.	60,000
NsG-70 S 6	Maryland, University of, R. W. KRAUSS A Study of Psychophysiology in Controlled Environments.	12,000
NsG-283 S 4	Maryland, University of, T. D. WILKERSON Studies of Particle Phenomena in the Interplanetary Plasma and of the Excitation and Ionization Cross-Sections of the Hydrogen, Helium, Oxygen, and Molecular Combinations.	10,000
NsG-359 S 4	Maryland, University of, T. D. WILKERSON Atomic and Molecular Processes Bearing on Plasma Phenomena.	30,000
NsG-398 S 4	Maryland, University of, W. RHEINBOLDT Multidisciplinary Research on the Application of High Speed Computers to Space-Related Research Problems.	350,000
NsG-615 S 3	Maryland, University of, W. C. ERICKSON Studies in the 11 Meter Range of Radio Astronomy Using High Resolution and High Sensitivity Antenna Arrays at Clark Lake.	61,000
NsG-615 S 4	Maryland, University of, W. C. ERICKSON Cooperative Research in Long Wavelength Radio Astronomy.	15,000
NsG-695 S 3	Maryland, University of, H. LASTER Theoretical and Experimental Studies in Space Science Including Consideration of Rocket, Probe, and Satellite Techniques.	196,700
NsG(T)-3 S 5	Maryland, University of, M. J. PELCZAR Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	160,000
NGR 21-002-040 S 4	Maryland, University of, R. G. GRENELL Protein Hydration in Isolated Cell Surface Structure.	25,303
NGR 21-002-053 S 1	Maryland, University of, R. B. BECKMANN Critical Evaluation and Compilation of Viscosity and Diffusivity Data.	103,000
NSR 21-002-056 A 3	Maryland, University of, H. E. TOMPKINS ASEE-NASA Summer Faculty Fellowship Program.	120,000
NGR 21-002-057 S 2	Maryland, University of, R. T. BETTINGER Ionospheric Investigations With In Situ Probes.	80,000

MARYLAND—Continued

NGR 21-002-060 S 2	Maryland, University of, R. T. BETTINGER Analysis of Satellite Data for Studies Related to Ionospheric Plasma Research.	$26,000
NGR 21-002-066 S 1	Maryland, University of, J. A. EARL Primary Cosmic Ray Electrons.	115,000
NGR 21-002-073 S 1	Maryland, University of, H. R. GRIEM Experimental and Theoretical Investigation of Plasma Radiation.	75,000
NGR 21-002-091	University of Maryland, A. G. DEROCCO Intermolecular Forces and the Theory of Fluids.	19,800
NGR 21-002-096 S 1	Maryland, University of, R. T. BETTINGER Research in Atmospheric Physics.	24,000
NGR 21-002-096 S 2	Maryland, University of, R. T. BETTINGER Research in Atmospheric Physics.	21,000
NGR 21-002-109 S 1	Maryland, University of, C. O. ALLEY Feasibility Studies and Techniques for Laser Ranging to Optical Retro-Reflection on the Moon.	45,000
NGR 21-002-113	Maryland, University of, R. M. GINNINGS Adaptive Telemetry Systems.	16,232
NGR 21-002-129	Maryland, University of, P. WOLFE The Theory of Diffraction.	4,389
R 21-018-001 A 1	U. S. Dept. of Health, Education, & Welfare, R. REPASKE Conduct an Investigation of the Physiology and Metabolism of Hydrogenomonas Eutropha.	21,271
R 21-018-002	U. S. Department of Health, Education and Welfare, J. Cox Partial Support of a Programmed Console (Small Computer) for Biomedical Research at Washington University, St. Louis.	114,114
R 21-019-001	U. S. Environmental Science Services Administration, H. H. SCHMID. Perform Studies Related to the Requirements and Performance Specifications of Metric Cameras.	35,000
R 21-009-004 A 2	U. S. Navy-Bureau of Naval Weapons, G. WEIFFENBACH Process and Analyze Space Radiation Data Obtained with APL Radiation Detectors Aboard Various Satellites Including INJUN III, 1963 38C and 1964 38C.	163,000
R-76 A 2	U. S. Navy-Bureau of Naval Weapons, G. L. DUGGER Research on Supersonic Combustion of Hydrogen for Mach 10 Vehicle.	190,000
R 21-009-009 A 2	U. S. Navy-Bureau of Naval Weapons, R. B. KERSHNER Conduct an Investigation of Advanced Concepts for Extravehicular Protection and Operation.	53,000

MASSACHUSETTS:

NsG(T)-107 S 3	Boston University, P. E. KUBZANSKY Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	70,800
NsG(T)-120 S 3	Boston College, W. J. FEENEY Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	40,800
NGR 22-004-016	Boston University, S. C. HANNA Impact of Systems Concepts on Management.	49,990
NsG-375 S 4	Brandeis University, N. O. KAPLAN Effects of Environment and Evolution on Macromolecules.	50,000
NsG(T)-112 S 3	Brandeis University, H. WEISBERG Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	71,500

MASSACHUSETTS—Continued

NsG(T)-93 S 3	Clark University, D. E. LEE. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	$37,800
NsG 22-025-001	Educational Services, Inc. Conducting Area Meetings for High School Physics Teachers on the Subject of "Space Physics."	19,900
NsG-64 S 4	Harvard University, D. H. MENZEL. Study of Ground-Based and Space Vehicle Infrared Instrumentation for Thermal Photography of The Moon and Planets, Including Experimental Programs at Selected Observatories.	44,805
NsG-282 S 3	Harvard University, C. FRONDEL. Mineralogical and Petrographic Studies of Meteorites.	58,817
NsG-438 S 4	Harvard University, L. GOLDBERG. Theoretical and Experimental Studies in Ultraviolet Solar Physics.	375,000
NsG-579 S 3	Harvard University, W. P. KING. Investigation of the Radiation and Circuit Properties of Satellite-Borne V-Antenna.	26,334
NsG-595 S 2	Harvard University, W. H. ABELMAN. A Study of the Physiological Mechanisms and Inter-Relations Between Systemic and Regional Blood Volume, Blood Flow, and Electrolyte Balance.	72,604
NsG-685 S 5	Harvard University, G. R. HUGUENIN. Theoretical and Experimental Investigations in Radio Astronomy and in Long Wavelength Solar Radio Noise, Including an Astrobee-borne Experiment for Observation of Solar Phenomena.	49,533
NsG-685 S 6	Harvard University, G. R. HUGUENIN. Theoretical and Experimental Investigations in Radio Astronomy and in Long Wavelength Solar Radio Noise, Including an Astrobee-Borne Experiment for Observation of Solar Phenomena.	145,367
NsG(T)-89 S 2	Harvard University, R. A. MCFARLAND. The Training of Three (3) Post-M.D. Students in the Field of Aerospace Medicine and Bioastronautics.	61,800
NGR 22-007-053 S 1	Harvard University, W. A. BURGESS. Study of Space Cabin Atmospheres.	36,194
NGR 22-007-056 S 1	Harvard University, R. W. P. KING. Theoretical and Experimental Investigations of Antennas and Waves in Plasma.	50,400
NGR 22-007-068 S 1	Harvard University, A. E. BRYSON. Investigation of On-Board Computer Techniques for Space Navigation.	35,000
NGR 22-007-069 S 1	Harvard University, E. S. BARGHOORN. Infrared Absorption Spectrophotometry of Organic Extractives from Precambrian Sediments.	18,013
NGR 22-007-070 S 1	Harvard University, R. A. MCFARLAND. Human Standards for Apollo, Emphasizing Environmental Influences on Performance.	73,799
NGR 22-007-096	Harvard University, F. R. ERVIN. The Estimation and Prediction of Mental Alertness.	44,991
NGR 22-007-101	Harvard University, D. M. HEGSTED. Factors in Bone Formation and Bone Loss.	21,924
NSR 22-007-067	Harvard University, L. GOLDBERG. Investigation of Center-to-Limb Variations in the Far Ultraviolet Solar Spectrum by Means of a Spectral Scanning Spectrometer Flown Abroad an Aerobee-Hi Rocket.	283,904

MASSACHUSETTS—Continued

NGR 22-091-002 S 1	Holy Cross College, R. C. GUNTER. Investigation of the Effect of Space Environment on Replica Gratings.	$45,000
NsG(T)-148 S 1	Lowell Technological Institute, J. L. STEELE. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	20,400
NGR 22-016-003 S 1	Massachusetts General Hospital, M. SIDMAN. Experimental Investigation of Automated Techniques for Studying Sequential Learning and Memory.	36,600
NGR 22-016-005	Massachusetts General Hospital, H. T. HERMANN. Topological Characteristics in Pattern Perception Physiology in the Vertebrate Cortex.	45,000
NsG-107 S 3	Massachusetts Institute of Technology, T. B. SHERIDAN. Study of the Measurement and Display of Control Information.	46,560
NsG-117 S 7	Massachusetts Institute of Technology, N. J. GRANT. Research on Mechanisms of Alloy Strengthening by Fine Particle Dispersions, with Particular Emphasis on Selective Reductions of Non-Refractory Oxides, Stability of Metal-Metal Oxide Systems, and Solid Solution in Metal-Metal Oxide Alloys.	85,360
NsG-211 S 3	Massachusetts Institute of Technology, K. BIEMANN. Detection and Identification of Life-Related Matters by Mass Spectroscopy.	81,235
NsG-234 S 5	Massachusetts Institute of Technology, J. REINTJES. Investigation of Radar Techniques and Devices Suitable for the Exploration of Planet Venus.	79,600
NsG-254 S 6	Massachusetts Institute of Technology, W. R. MARKEY. Methods and Systems for the Navigation of Interplanetary Vehicles.	164,560
NsG-334 S 4	Massachusetts Institute of Technology, R. G. GALLAGER. Techniques of Communication in the Space Environment.	90,000
NsG-368 S 4	Massachusetts Institute of Technology, J. R. MELCHER. Theoretical and Experimental Investigation in Electro-Hydrodynamics (EHD) and Wave-Type Magnetohydrodynamics (MHD).	58,500
NsG-386 S 4	Massachusetts Institute of Technology, G. W. CLARK. Theoretical and Experimental Investigation of the Interplanetary Medium and in Gamma-Ray Astronomy.	43,000
NsG-419 S 4	Massachusetts Institute of Technology, A. H. BARRETT. Electromagnetic Investigations of Planetary and Solar Atmosphere and the Lunar Surface, Including Balloon-Borne Experiments and Construction of Laboratory Prototype Instrumentation.	184,300
NsG-462 S 4	Massachusetts Institute of Technology, F. O. SCHMITT. Neurosciences Research Program.	100,000
NsG-496 S 6	Massachusetts Institute of Technology, J. V. HARRINGTON. Multidisciplinary Research in the Space-Related Physical, Engineering, Social and Life Sciences.	270,000
NsG-496 S 5	Massachusetts Institute of Technology, J. V. HARRINGTON. Multidisciplinary Research in the Space-Related Physical, Engineering, Social and Life Sciences.	925,000
NsG-577 S 4	Massachusetts Institute of Technology, L. R. YOUNG. Studies of Human Dynamic Space Orientation, Using Techniques of Control Theory.	110,000

MASSACHUSETTS—Continued

NsG(T)–20 S 4	Massachusetts Institute of Technology, H. L. HAZEN. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	$163,300
NGR 22–009–091 S 2	Massachusetts Institute of Technology, R. E. STICKNEY. Surface Properties of Thermionic Electrodes.	40,000
NGR 22–009–052 S 2	Massachusetts Institute of Technology, J. A. FAY. Problems in jxB Plasma Acceleration.	26,821
NGR 22–009–059 S 1	Massachusetts Institute of Technology, Z. M. ELIAS. The Use of Stress Functions in Thin Shell Theory.	23,806
NGR 22–009–114 S 1	Massachusetts Institute of Technology, G. FIOCCO. Investigations of Dust in the Upper Atmosphere by Optical Radar.	40,000
NGR 22–009–121 S 1	Massachusetts Institute of Technology, L. TRILLING. Theoretical Investigation of the Processes of Energy and Momentum Exchange at a Gas-Solid Boundary.	8,084
NGR 22–009–123 S 1	Massachusetts Institute of Technology, F. PRESS. Experimental Techniques in Lunar Passive Seismography.	13,075
NGR 22–009–124 S 1	Massachusetts Institute of Technology, G. C. NEWTON. Studies in Control Optimization, Stabilization and Computer Algorithms.	48,500
NGR 22–009–125 S 1	Massachusetts Institute of Technology, H. C. GATOS. Studies on the Relationship Between Crystalline Structure and Superconductivity.	47,064
NGR 22–009–131 S 2	Massachusetts Institute of Technology, G. FIOCCO. Sensing of Meteorological Variables by Laser Probe Techniques.	48,985
NGR 22–009–156 S 1	Massachusetts Institute of Technology, J. L. MEIRY. Bio-Physical Evaluation of the Human Vestibular System.	29,100
NGR 22–009–163 S 1	Massachusetts Institute of Technology, R. P. RAFUSE. Investigation of Solid State Millimeter Wave Generation and Amplification.	97,000
NGR 22–009–167	Massachusetts Institute of Technology, G. R. HARRISON. Techniques for Ruling Improved Large Diffraction Gratings.	85,000
NGR 22–009–176 S 1	Massachusetts Institute of Technology, G. SIMMONS. Measurement of Physical Properties for the Apollo Program.	150,000
NGR 22–009–207	Massachusetts Institute of Technology, W. R. MARKEY. Research in Trajectory, Guidance and Control.	80,000
NGR 22–009–229	Massachusetts Institute of Technology, W. R. MARKEY. A Study of Problems in Aircraft Navigation and Control.	37,887
NGR 22–009–240	Massachusetts Institute of Technology, A. JAVAN. Spectroscope Applications of Optical and Infrared Masers.	75,000
NGR 22–009–257	Massachusetts Institute of Technology, D. W. STRANGWAY. The Electrical Resistivity of the Moon—the Electrode Problem.	30,000
NASr–249 A 4	Massachusetts Institute of Technology, J. V. HARRINGTON. The Study of a Radio Probe for the Extended Solar Corona.	456,427
NSR 22–009–138 A 1	Massachusetts Institute of Technology, L. L. SUTRO. Automatic Object Recognition for Extraterrestrial Life.	150,000
NsG(T)–138 S 2	Massachusetts, University of, E. C. MOORE. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	70,000

MASSACHUSETTS—Continued

NGR 22-010-012	Massachusetts, University of, R. V. MONOPOLI. Control and Estimation in Systems with Unknown Parameter Variations.	$27,558
NGR 22-010-019	Massachusetts, University of, J. A. FILLO. Development of a Moment Method to Solve the Three-Dimensional Boundary Layer Equations.	8,505
NGR 22-010-023	Massachusetts, University of, W. M. IRVINE. Theoretical Studies of Diffuse Reflection and Transmission Radiation in Planetary Atmospheres.	21,661
NGR 22-021-002 S 1	New England Medical Center Hospitals, P. W. NEURATH. Study of Biomagnetism and Ferritin.	29,705
NsG-355 S 3	Northeastern University, S. S. SANDLER. Theoretical Study of Antenna Problems for Radio Astronomy.	23,000
NsG(T)-64 S 4	Northeastern University, A. A. VERNON. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	45,900
NGR 22-011-007 S 2	Northeastern University, R. E. BACH. Reliable Solid-State Circuits.	78,250
NGR 22-011-024	Northeastern University, B. L. COCHRUN. A Study of Microminiaturized Devices for Bioastronautical Monitoring or Analysis.	40,000
NGR 22-011-025	Northeastern University, K. WEISS. Investigation of New Systems for Potential Laser Action.	25,000
NGR 22-024-001	Smithsonian Institution, S. E. STROM. Study of Abundance Analysis of Stars in the Spectral Types B5-G2.	25,000
NSR 09-015-033 A 2	Smithsonian Institution, F. L. WHIPPLE. A Meteor Research Program.	204,107
NsG(T)-103 S 3	Tufts University, P. H. FLINT. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	35,300
NGR 22-012-006 S 1	Tufts University, D. H. SPODICK. Investigation of Atraumatic Techniques for Monitoring Cardio-Vascular Conditioning.	30,612
R 22-140-001	U.S. Army Materials Research Agency. Manufacture of one X-Ray Concentrator Component.	5,000
R 22-015-004 A 1	U.S. Army Natick Laboratories, H. A. HOLLENDER. Develop Freeze Dried Foods for Space Use Having Maximum Acceptability, Variety, and Nutrition with Minimum Storage Volume.	30,000
R 22-015-006	U.S. Army Natick Laboratories. A Conference on Polymer Structure and Mechanical Properties.	3,500
NsG(T)-142 S 2	Worcester Polytechnic Institute, R. F. MORTON. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	41,000

MICHIGAN:

NGR 23-008-001	Lafayette Clinic, A. F. AX. Psychophysiology of Stress, Motivation, and Learning.	40,000
NsG(T)-58 S 4	Michigan State University, J. VINOCUR. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	95,400
NGR 23-004-041	Michigan State University, C. MARTIN. Problems in Interacting Continua.	22,454
NsG(T)-150 S 1	Michigan Technological University, D. G. YERG. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	37,800

MICHIGAN—Continued

NsG–86 S 7	Michigan, University of, J. A. NICHOLLS. Theoretical and Experimental Studies of the Dynamics of Reacting and Charged Particles in Solid Propellant Rocket Motor Nozzles.	$24,990
NsG–115 S 6	Michigan, University of, C. KIKUCHI. Investigation of the Electromagnetic Properties of Materials for Application to Masers, Lasers, and Other Solid State Devices.	35,000
NsG–572 S 2	Michigan, University of, F. T. HADDOCK. Investigation of Galactic Radio Astronomy.	150,000
NsG(T)–5 S 5	Michigan, University of, H. S. BRETSCH. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	138,000
NGR 23–005–116 S 2	Michigan, University of, F. C. MANN. A Study of Processes for the Utilization of Scientific Findings from Organizational Behavior Research.	23,726
NGR 23–005–131 S 2	Michigan, University of, F. T. HADDOCK. Investigate Feasibility of a Kilometer Wave Orbiting Telescope.	100,000
NGR 23–005–159 S 1	Michigan, University of, W. P. TANNER. An Experimental Investigation of Psychophysical Learning in Auditory Detection Situations.	19,400
NGR 23–005–171	Michigan, University of, W. EDWARDS. Preparatory Research on Probabilistic Information Processing.	80,000
NGR 23–005–185 S 1	Michigan, University of, J. R. P. FRENCH. The Development of Methods for the Early Identification of Heart Disease and Related Job Stresses.	23,466
NGR 23–005–235	Michigan, University of, E. LEITH. Application of Optical Processing Techniques to Aerospace Flight Problems.	85,500
NASr–54(07) A 3	Michigan, University of, J. A. NICHOLLS. Studies of Detonations Phenomena and its Relation to Liquid Rocket Motor Combustion Instability.	91,350
NASr–54(10) A 1	Michigan, University of, L. D. FILKINS. Conduct Navigation Satellite Studies.	75,060
NASr–54(13)	Michigan, University of, L. M. JONES. A Laboratory and Design Study of the Experiments for a Small Aeronomy Satellite.	175,000
NsG(T)–102 S 3	Wayne State University, J. E. HILL. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	47,700
NGR 23–006–047	Wayne State University, C. N. DESILVA. Theoretical Research on the Nonlinear Responses of Elastic Shells to Time-Dependent Loads and Temperature Fields.	16,507
NASr–175 A 3	Wayne State University, H. STILLWELL. A Program to Accelerate the Industrial Utilization of New Knowledge Emanating from Aerospace Research and Technology.	200,935
NSR 23–006–037	Wayne State University, B. W. PRINCE. A Study to Enhance the Transfer of NASA Generated Technology to Other Federal Agencies.	7,000
NSR 23–006–041	Wayne State University, H. STILLWELL. Dissemination of Aerospace Science and Technology to Highway Transportation Programs.	8,950
NSR 23–006–044	Wayne State University, H. STILLWELL. The Study of the Application of Aerospace Generated Technology to Urban Management.	30,665
NSR 23–006–049	Wayne State University, H. STILLWELL. An experiment in the Decentralized Reproduction and Provision of Hard-Copy Documentation of Aerospace Generated Technology Contained in NASA Information Resource.	14,949

MINNESOTA:

NGR 24-001-002	Concordia College, H. R. HOMANN Pentose and Pentitol Metabolism in Hydrogenomanas Species.	$11,419
NsG-327 S 6	Mayo Foundation, E. H. WOOD Studies of the Effects of Acceleration on Cardiovascular and Respiratory Dynamics.	90,000
NASr-27 A 2	Minneapolis-Honeywell Corporation, C. R. STONE Study of Self-Evaluating State Vector Controllers with Applications to Flexible Liquid Fuel Aerial and Vehicles.	866
NsG-281 S 4	Minnesota, University of, J. R. WINKLER, E. P. MAY Support of a Research Program in the Areas of Cosmic Rays, Astrophysics and Energetic Particles in Space.	409,200
NsG(T)-7 S 5	Minnesota, University of, B. CRAWFORD Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	157,400
NGR 24-005-050 S 2	Minnesota, University of, C. J. WADDINGTON Construction and Use of a Gamma-Ray Telescope Employing Spark Chamber Techniques.	67,395
NGR 24-005-070 S 2	Minnesota, University of, C. C. HSIAO Theoretical and Experimental Investigation of the Mechanical Strength of Solids.	30,000
NGR 24-005-095 S 1	Minnesota, University of, R. PLUNKETT Investigation of Optimum Structural Design under Dynamic Loading.	18,000
NASr-248 A 2	Minnesota, University of, A. C. NIER Investigation of the Neutral Constituents of the Atmosphere in the 100-200 km Altitude Range.	100,000
NSR 24-005-062 S 1	Minnesota, University of, W. J. LUYTEN Automatic Proper Motion Survey of the Stellar System.	72,000

MISSISSIPPI:

NsG-650 S 3	Mississippi State University, R. G. TISCHER Influence of Metabolic Accumulation of Products of Hydrogenomonas Cells and their Continued Growth.	28,275
NsG(T)-106 S 3	Mississippi State University, J. C. MCKEE Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	33,600
NsG(T)-118 S 3	Mississippi, University of, L. NOBLES Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	38,400
NsG(T)-139 S 2	Southern Mississippi University, R. S. OWINGS Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	31,500

MISSOURI:

NASr-63(09) A 1	Midwest Research Institute, J. ALCOTT To Study the Feasibility of a NASA Contractors and Subcontractors Capabilities Center.	20,000
NASr-63(11) A 1	Midwest Research Institute, H. L. STOUT Medical Applications of NASA-Developed Science and Technology.	5,976
NASr-63(11) A 2	Midwest Research Institute, H. L. STOUT Medical Applications of NASA-Developed Science and Technology.	5,200
NASr-63(12)	Midwest Research Institute Regional Dissemination Center Operation.	250,000
NASr-63(13)	Midwest Research Institute, H. L. STOUT Support for Biomedical Application Team.	120,000
NSR 26-002-064	Midwest Research Institute, C. E. MOELLER Technology Survey: Special Purpose Thermocouples and Their Utilization.	21,720

MISSOURI—Continued

NsG(T)–60 S 4	Missouri, University of, C. E. MARSHALL — Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	$85,700
NGR 26–004–003 S 2	Missouri, University of, W. J. HASS — Multidisciplinary Research in Space-Related Physical, Engineering and Life Sciences.	150,000
NGR 26–004–011 S 2	Missouri, University of, C. W. GEHRKE — Gas Chromatographic Techniques for the Identification and Study of Nucleosides.	13,000
NGR 26–003–026	Missouri, University of, R. D. RECHTIEN — A Study of the Fluctuating Pressure Field in Regions of Induced Flow Separation at Supersonic Speeds.	32,502
NGR 26–004–035	Missouri, University of, G. W. ZOBRIST — Sensitivity Analysis.	9,800
NsG(T)–59 S 4	University of Missouri (Rolla), W. BOSCH — Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	69,800
NsG(T)–74 S 4	St. Louis University, H. HOWE — Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	90,900
NGR 26–006–016	St. Louis University, F. C. BATES — The Structure and Circulation of the Lower Martian Troposphere.	41,720
NsG–185 S 6	Washington University, M. W. FRIEDLANDER — An Investigation of the Primary Cosmic Radiation Using Spark Chambers and Nuclear Photographic Emulsions.	84,992
NsG–581 S 3	Washington University, R. M. KLINE — University-wide Research Program in Space Related Sciences and Technology.	300,000
NsG(T)–86 S 4	Washington University, G. E. PAKE — Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	111,800
NGR 26–008–042	Washington University, J. KLARMANN — Gamma Ray Experiment Based on Spark Chambers and Nuclear Emulsions. (F)	50,000

MONTANA:

NsG(T)–113 S 3	Montana State University, L. SMITH — Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	78,100
NsG(T)–114 S 3	University of Montana, F. S. HONKALA — Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	39,600
NGR 27–001–015 S 1	Montana State University, K. L. NORDTVEDT — Study of Manual Navigation of Spacecraft.	7,354

NEBRASKA:

NsG(T)–94 S 3	University of Nebraska, J. C. OLSON — Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	69,600

NEVADA:

NsG(T)–61 S 4	Nevada, University of, T. D. O'BRIEN — Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	40,700
NGR 29–001–008 S 2	Nevada, University of, P. L. ALTICK & E. MOORE — Investigation of Methods for the Calculations of Atomic Photoionization Cross Sections.	16,733

NEW HAMPSHIRE:

NsG-624 S 2	New Hampshire, University of, L. J. CAHILL. Studies and Analyses of the Magnetospheric Boundary, the Geomagnetic Trail, and Correlation with Trapped Particle Measurements in the Outer Magnetosphere.	$111,626
NsG(T)-91 S 3	New Hampshire, University of, E. S. MILLS. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	65,500
NsG(T)-128 S 3	Dartmouth College, J. F. HORNIG. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	82,100
NGR 30-002-018 S 2	New Hampshire, University of, E. L. CHUPP. Investigation of Energy Levels in Foil Excited Atomic Beams.	19,594
NGR 30-002-021 S 1	New Hampshire, University of, E. L. CHUPP. Investigation and Development of Techniques for Solar Neutron and Gamma Ray Detection.	120,000
NGR 30-002-028	New Hampshire, University of, L. J. CAHILL. Sounding Rocket Investigation of Auroral Displays.	91,621
NASr-164 A 6	New Hampshire, University of, J. A. LOCKWOOD. Research and Development on Instrumentation Suitable for Measuring Neutron Intensity in Space.	65,425

NEW JERSEY:

NGR 31-011-002	New Jersey College of Medicine & Dentistry, LEAVY & CHERRICK. Morphologic and Functional Effects of Hepatic Proton Irradiation.	60,216
NGR 31-009-004	Newark College of Engineering, P. HRYCAK. Heat Transfer from Impinging Jets.	21,043
NsG-69 S 4	Princeton University, M. SCHWARZSCHILD. Stratoscope II High Altitude Balloon Telescope Program.	400,000
NsG-414 S 5	Princeton University, L. SPITZER. Astrophysical Ultraviolet Studies.	102,000
NsG-641 S 3	Princeton University, I. GLASSMAN. An Investigation of Pre-Ignition and Ignition Processes in the Combustion of Metals.	30,000
NsG(T)-38 S 4	Princeton University. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	170,500
NGR 31-001-044 S 3	Princeton University, R. E. DANIELSON. Design Study of a Diffraction-Limited Orbital Telescope with a Manned Space Station and Design and Test of an Ultraviolet Echelle Spectrograph for Use in a Diffraction-Limited Orbital Telescope.	125,000
NGR 31-001-093	Princeton University, R. B. HARGRAVES. Palemagnetic and Petrographic Investigation of Possible Meteorite—Impact Structures in South Africa.	12,498
NGR 31-001-103	Princeton University, S. H. LAM. Studies of Ionospheric Aerodynamics.	25,000
NASr-217 A 6	Princeton University, L. CROCCO. Theoretical and Experimental Studies of Combustion Instability in Liquid Propellant Rocket Motors.	275,000
NASr-223 A 5	Princeton University, C. S. PITTENDRIGH. Experimental Analysis of Circadian Rhythms under Terrestrial Conditions.	70,725
NASr-231 A 2	Princeton University, J. P. LAYTON. Research on Propulsion Systems and Mission Analysis Pertaining to Advanced Launch Vehicle Technology.	200,000

NEW JERSEY—Continued

NSR 31-001-901	Princeton University, D. C. MORTON. Ultraviolet Spectrographic Investigations by High Altitude Rocket Flights.	$433,530
NsG(T)-97 S 3	Rutgers State University, H. C. TORREY. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	90,600
NGR 31-004-026	Rutgers State University, D. A. LUPFER. Sputtering of Thin Ferroelectric Films.	7,000
NSR 31-004-022	Rutgers State University, C. BRIGHT. Study of Piloting Problems and Flight Mechanics of Stored Energy Landing.	39,578
NsG(T)-77 S 4	Stevens Institute of Technology, R. A. MORGEN. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	62,500
NGR 31-003-014 S 2	Stevens Institute of Technology, R. F. MCALEVY. Investigation of Flame Spreading Over the Surface of Ignited Solid Propellants.	44,468
NGR 31-003-050	Stevens Institute of Technology, G. J. HERSKOWITZ. Microcircuit Models and Diagnostic Techniques for Environmental Failure Mode Prediction.	25,000

NEW MEXICO:

NASr-115 A 3	Lovelace Foundation, E. M. ROTH. Space Medicine Information Analysis.	175,000
NsG-142 S 6	New Mexico State University, C. W. TOMBAUGH. Photographic, Photoelectric and Spectrographic Observations and Studies of the Planets.	129,948
NsG-372 S 4	New Mexico State University, R. J. LIEFELD. Theoretical and Experimental Studies in Long Wave Length X-Ray Spectroscopy.	20,000
NsG(T)-129 S 3	New Mexico State University, M. E. THOMPSON. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	80,900
NGR 32-003-027 S 1	New Mexico State University, J. E. WEISS. Multidisciplinary Research Program in Space Science and Engineering.	150,000
NGR 32-003-027 S 2	New Mexico State University, C. W. TOMBAUGH. Multidisciplinary Research Program in Space Science and Engineering.	5,000
NGR 32-003-037	New Mexico State University, F. F. CARDEN. Study of Video Processing in Low Signal to Noise Environments.	45,066
NSR 32-003-042	New Mexico State Univ. Preparation of a Report on Doppler Geodetic Systems.	15,828
NsG(T)-62 S 4	New Mexico, University of, A. STEGER. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	68,900
NsG-129 S 5	New Mexico, University of, A. ERTEZA. Study of Electromagnetic Scattering from Terrain with Particular Application to the Moon and Planets.	41 391
NGR 32-004-011 S 2	New Mexico, University of, W. E. ELSTON. Volcanological Approach to the Interpretation of Lunar Features.	25,000
NSR 32-004-037	New Mexico, University of, H. L. ENARSON. Technology Application Center Operations.	162,198
R 32-008-001 A 1	U.S. Atomic Energy Commission. Design and Develop a Dual Mode Neutron Generator System.	45,000

NEW YORK:

NsG-394 S 4	Adelphi University, R. GENBERG. Multidisciplinary Research in Space Related Sciences and Technology.	80,000

NEW YORK—Continued

NsG(T)-90 S 3	Adelphi University, M. V. B. JENNINGS. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	$41,600
NsG(T)-111 S 3	Alfred University, E. E. MUELLER. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	18,000
NsG(T)-101 S 3	Clarkson College of Technology, H. L. SHULMAN. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	41,400
NGR 33-007-034	Clarkson College of Technology, L. C. BARRETT. Effects of the Motion of a Body Attached by a Rotating Source.	18,315
NsG-360 S 4	Columbia University, R. NOVICK. Theoretical and Experimental Investigations of Helium and Lithium Atoms and Ions with Emphasis on Excited Energy Levels and the Mechanism of Energy Transfer from Metastable States.	70,000
NsG-445 S 5	Columbia University, L. WOLTJER. Theoretical Research in Space Science.	48,000
NsG-445 S 6	Columbia University, H. FOLEY. Theoretical Research in Space Science.	143,000
NsG(T)-26 S 4	Columbia University, R. S. HALFORD. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	137,700
NGR 33-008-061 S 2	Columbia University, P. W. GAST. Study in Alkali Metal, Alkaline Earth and Lanthanide Elements in Lunar Materials.	39,980
NGR 33-008-090	Columbia University, C. C. HALKIAS. A Systems Approach to Device-Circuit Interaction in Electrical Power Processing.	62,171
NSR 33-008-069 A 1	Columbia University, J. IMBRIE. A Summer Institute in Space Physics and Space Sciences and Engineering.	53,680
NSR 33-009-045 A 1	Cornell Aeronautical Laboratory, Inc., C. E. TREANOR. Energy Transfer Processes in Ionized Gas Flows.	46,500
NASr-109 A 7	Cornell Aeronautical Laboratory, Inc., A. HERTZBERGER. Experimental and Theoretical Research on the Flow of High Temperature Hydrogen through Jet Nozzles.	105,900
NASr-119 A 5	Cornell Aeronautical Laboratory, Inc., A. HORTZBERG. Conduct a Research Program to Determine the Non-Equilibrium Flow Field and the Optical Radiation Around Vehicles Traveling at High Altitudes and Super-Orbital Speeds.	74,969
NsG-382 S 5	Cornell University, T. GOLD. Lunar Surface and Solar System Studies.	173,000
NsG(T)-48 S 4	Cornell University, F. S. ERDMAN. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	175,000
NsG(T)-159	Cornell University, A. SCHULTZ. Supporting the Training of Predoctoral Graduate Students in the Field of Engineering Design.	88,800
NGR 33-010-029 S 1	Cornell University, L. H. GERMER. Research on the Adsorption and Chemical Reactions of Atoms and Molecules on the Surface of Crystals.	32,000
NGR 33-010-047	Cornell University, P. R. MCISAAC. Advanced Concepts of Microwave Power Amplification and Generation Utilizing Linear Beam Devices.	26,601

NEW YORK—Continued

NGR 33-010-051	Cornell University, C. L. TANG Theoretical and Experimental Studies of the Ionized Rare Gas Lasers.	$23,750
NSR 33-010-026 A 2	Cornell University, M. O. HARWIT Astronomical Observations in the Far Infrared.	250,000
NSR 33-010-055	Cornell University, R. WEHE & W. MESERVE An Investigation Directed Toward Designing, Developing and Testing the Components of a Total Control Lunar Roving Vehicle.	70,311
NSR 33-026-003 A 1	Flight Safety Foundation, Inc., J. L. HALEY Analysis and Testing of Aircraft Seats.	59,949
NsG(T)-121 S 3	Fordham University, J. F. MULLIGAN Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	35,400
NSR 33-012-006	Fordham University, J. KUBIS Time and Motion Study on Astronauts' Ground-Based and In-Flight Task Performance.	25,838
NsG-197 S 5	New York, City University of, H. LUSTIG Theoretical Research in Astrophysics.	35,000
NsG(T)-109 S 3	New York, City University of, M. REES Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	76,600
NGR 33-013-011 S 2	New York, City University of, D. H. CHENG Dynamic Response of Structural Elements to Sonic Booms.	25,780
NGR 33-013-017 S 1	New York, City University of, M. KOLODNEY Study of Oxidation Protection of Columbium and Tantalum.	10,872
NGR 33-013-025	New York, City University of, S. M. CHEN Analytical Calibration of D.C. Electromagnetic Flowmeter.	10,944
NGR 33-013-026	New York, City University of, L. M. JIJI Blade Temperature/Response of the Rotor Entry Vehicle.	7,989
NGR 33-145-001	New York Medical College, S. WEINSTEIN The Effects of Isolation, Sensory Deprivation, and Sensory Rearrangement on Visual, Auditory, and Somesthetic Sensation, *Perception and Spatial* Orientation.	7,090
NsG(T)-119 S 3	New York, State University of (Stony Brook), R. M. JORDAN. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	43,100
NsG(T)-151 S 1	New York, State University of, A. W. HOLT Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	70,800
NGR 33-015-016 S 1	New York, State University of, J. DANIELLI Multidisciplinary Research in Theoretical Biology.	100,000
NGR 33-015-035 S 1	New York, State University of, L. L. SEIGLE Investigation of Thermodynamic Properties of Interstitial Elements in the Refractory Metals.	25,000
NGR 33-015-036	New York, State University of, Y. H. KOA Research in Infrared Astronomy.	30,000
NGR 33-015-061	New York, State University of, P. BLISS Study of Extra-Contractual Influences in Government Contracting.	71,320
NsG-499 S 5	New York University, J. E. MILLER Theoretical Research on the Properties of the Atmospheres of the Earth and Other Planets and on the Atmospheric Effects of Solar Activity.	71,875
NsG-617 S 3	New York University, B. JOSEPHSON, JR. An Experimental Investigation of Spin-Lattice Interactions.	30,000

NEW YORK—Continued

NsG(T)-40 S 4	New York University, J. R. RAGAZZINI. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	$140,100
NGR 33-016-067 S 1	New York University, J. R. RAGAZZINI. Multidisciplinary Research in Space Science and Engineering.	300,000
NGR 33-016-102	New York University (School of Medicine), J. POST. Biological Effects of Radiation: Metabolic and Replication Kinetics Alterations.	25,265
NGR 33-016-117	New York University, W. J. PIERSON. Radar Satellite Oceanography.	59,629
NGR 33-016-119	New York University, A. FERRI. Engine Effect on Sonic Boom—Unsteady Engine Inlet Interaction.	64,800
NASr-183 A 4	New York University, L. DAUERMAN. Investigation of the Chemical Kinetics of Reactions that Occur in Advanced High Energy Propellant Combustion.	63,000
NsG-589 S 3	Polytechnic Institute of Brooklyn, H. J. JURETSCHKE. Theoretical and Experimental Studies of the Electronic Properties of Thin Films.	50,000
NsG(T)-71 S 4	Polytechnic Institute of Brooklyn, A. B. GIORDANO. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	145,200
NGR 33-006-020	Polytechnic Institute of Brooklyn, K. K. CLARKE. A Space Communication Study.	75,000
NsG-100 S 8	Rensselaer Polytechnic Institute, S. E. WIBERLY. Interdisciplinary Materials Research Program.	300,000
NsG-113 S 4	Rensselaer Polytechnic Institute, J. M. GREENBERG. Theoretical Research on Interstellar Dust and its Interaction with Ultraviolet Radiation.	38,000
NsG-663 S 1	Rensselaer Polytechnic Institute, J. B. HUDSON. Spatial Nucleation and Crystal Growth.	13,000
NsG(T)-10 S 5	Rensselaer Polytechnic Institute, S. E. WIBERLEY. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	154,600
NGR 33-018-053 S 1	Rensselaer Polytechnic Institute, F. A. WHITE. Techniques for Increasing the Sensitivity of Mass Spectrometric Gas Analysis, Utilizing Ion Factors.	12,000
NGR 33-018-086	Rensselaer Polytechnic Institute, P. HARTECK. A Study of the Effect of Surfaces on Oxygen Atom Recombination at Low Pressures.	35,000
NGR 33-018-090	Rensselaer Polytechnic Institute, J. J. CORELLI. Investigation of the Structure of Radiation Damage in Lithium Diffused Silicon Solar Cells.	30,000
NGR 33-018-091	Rensselaer Polytechnic Institute, S. YERAZUNIS. Analysis and Design of a Capsule Landing System and Surface Vehicle Control System for Mars Exploration.	80,000
NsG-308 S 4	Rochester, University of, P. W. BAUMEISTER. The Properties of Multilayer Optical Filters.	35,000
NsG(T)-73 S 4	Rochester, University of, R. G. LOEWY. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	149,800
NASr-14 A 9	Rochester, University of, R. E. HOPKINS. Studies and Investigations of Optical Systems.	33,000
NsG-385 S 2	Syracuse University, C. LIBOVE. An Exact Stress Analysis of a Rectangular Sheet Bound by Four Edge Stiffeners and Subjected to Loads and Temperature Gradients.	21,309
NsG-433 S 3	Syracuse University, D. V. KELLER. Theoretical and Experimental Studies of Adhesion of Metals in High Vacuum.	41,150

NEW YORK—*Continued*

NsG–619 S 3	Syracuse University, K. SCHRODER Experimental Studies of Creep in Metals Under Elevated Temperatures and High Vacuum Conditions.	$9,965
NsG(T)–78 S 4	Syracuse University, W. C. WHEADON Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	95,700
NGR 33–022–035 S 1	Syracuse University, M. E. BARZELAY Gas Radiation and Transport Properties at High Temperatures.	26,000
R–104(07) A 5	U.S. Atomic Energy Commission, A. H. SPARROW Conduct Research Feasibility Studies for Experiments Suitable for use in a Biosatellite to Determine the Influence of Space Environment on Mutation Process Using Controlled Gamma Ray Exposure as a Standard.	23,500
R–104(07) A 6	U.S. Atomic Energy Commission, A. SPARROW Conduct Feasibility Studies for Experiments Suitable for use in a Biosatellite to Determine the Influence of Space Environment on Mutation Process Using Controlled Gamma Ray Exposures.	106,000
NsG(T)–144 S 2	Yeshiva University, A. GELBART Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	70,800
NGR 33–023–018 S 1	Yeshiva University, A. G. W. CAMERON Research in Space Physics.	81,000
NSR 33–023–026	Yeshiva University, A. G. W. CAMERON Summer Faculty Program in Space Physics.	44,300

NORTH CAROLINA:

NsG–152 S 6	Duke University, T. G. WILSON Satellite Electrical Power Conversion Systems and Circuit Protection.	68,227
NsG(T)–16 S 4	Duke University, R. L. PREDMORE Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	85,400
NGR 34–001–005 S 2	Duke University, F. W. BARTON Multidisciplinary Space-Related Research in the Physical, Engineering, and Life Sciences.	100,000
NSR 34–001–025	Duke University, T. D. REYNOLDS Design and Production of Supplementary Materials for Teachers of High School Mathematics.	45,631
NASr–235 A 5	North Carolina Science & Technology Research Ctr., P. J. CHENERY. Regional Technology Transfer Program for NASA-Generated Technology.	58,086
NSR 34–007–004	North Carolina Science & Technology Research Ctr. To Provide the Personnel Services, Materials and Facilities to Produce a Motion Picture Film Clip of Technology Transfers.	480
NSR 34–007–005	North Carolina Science & Technology Research Ctr. Three Special Experimental Projects in Technology Utilization.	35,500
NsG–678 S 2	North Carolina State University, D. S. GROSCH The Utilization of Habrobracon and Artemia as Expreimental Materials in Bioastronautic Studies.	5,049
NsG(T)–31 S 4	North Carolina State University, W. J. PETERSON Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	92,200
NGR 34–002–017 S 2	North Carolina State University, W. H. BENNETT Transverse Instabilities of Magnetically Self-Focusing Streams in Plasmas.	17,474

NORTH CAROLINA—Continued

NGR 34-002-035 S 1	North Carolina State University, F. D. HART. Research Studies of Statistical Energy Methods in Sound and Structural Vibration Analysis.	$24,799
NGR 34-002-038 S 1	North Carolina State University, F. J. TISCHER. A Study of Electro-Optical Data Processing and Reduction.	34,631
NGR 34-002-047 S 1	North Carolina State University, F. J. TISCHER. Study of Rectangualr-Guide-Like Structures for Millimeter Wave Transmission.	39,457
NGR 34-002-048	North Carolina State University, H. A. HASSAN. Theoretical Investigation of Surface Interaction Effects on Plasma Accelerators and MHD Power Generators.	50,000
NGR 34-002-055	North Carolina State University, R. G. PEARSON. Human Factors Aspects of Noise.	32,000
NGR 34-002-056	North Carolina State University, L. A. JONES. Synthesis and Structural Studies of Aromatic and Heterocyclic Compounds.	16,017
NsG(T)-63 S 4	North Carolina, University of, E. WALLACE. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	90,700
NGR 34-003-021 S 2	North Carolina, University of, H. A. TYROLER. Study and Assessment of Community Health Factors Near Major Aerospace Installations.	41,313
NGR 34-003-026 S 1	North Carolina, University of, J. W. HANSON. The Application of Linear Programming to Functional Approximation.	22,500
NSR 34-004-045	Research Triangle Institute, J. N. BROWN. Biomedical Applications Team.	113,900

NORTH DAKOTA:

NsG(T)-132 S 3	North Dakota State University, G. S. SMITH. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	35,500
NsG(T)-152 S 1	North Dakota, University of, C. J. HAMRE. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	42,700

OHIO:

NGR 36-002-070	Battelle Memorial Institute, A. P. KOFSTAD. High-Temperature Oxidation of Alloys: Cobalt-Chromium Base Alloys.	50,000
NASr-100(02) A 6	Battelle Memorial Institute, H. BATCHELDER. Assist NASA in Evaluating and Preparing for Dissemination NASA Technological Developments which have Non-Space Applications.	84,800
NASr-100(02) A 7	Battelle Memorial Institute, H. BATCHELDER. Assist NASA in Evaluating and Preparing for Dissemination NASA Technological Developments which have Non-Space Applications.	59,800
NASr-100(08)	Battelle Memorial Institute, J. M. ALLEN. An Experimental and Analytical Study to Determine the Feasibility of Using a Resonant System to Provide High-Amplitude Pressurse for Calibrating and Evaluating High-Frequency Response Pressure Tranducers.	21,200
NASr-100(09)	Battelle Memorial Institute, R. I. JAFFEE. Conduct Research Investigations on Stress-Corrosion Titanium Alloys.	131,600
NASr-100(10)	Battelle Memorial Institute, A. F. HOENIE. The Preparation of Interpretive Reports on Selected Subjects.	27,880
NsG-110 S 7	Case Institute of Technology, L. A. SCHMIT. Application of Structural Synthesis to Aerospace Vehicle Structure.	75,000

OHIO—Continued

NsG–639 S 3	Case Institute of Technology, J. F. WALLACE An Experimental Investigation on Modified Eutectic Alloys for High Temperature Service.	$15,000
NsG(T)–42 S 4	Case Institute of Technology, L. GORDON Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	155,800
NGR 36–003–054 S 2	Case Institute of Technology, J. L. KOENIG Mechanical Properties of Polyethylene Terephthalate under Selected Conditions and Methods of Preparation.	60,000
NGR 36–003–064 S 2	Case Institute of Technology, S. OSTRACH Basic Scientific Research in Fluid Physics.	115,000
NGR 36–003–067 S 1	Case Institute of Technology, A. KUPER Impurities and Interface States in the SiO2/Si Systems.	19,950
NGR 36–003–079 S 1	Case Institute of Technology, W. KO Investigation of Implantable Multichannel Biotelemetry.	50,000
NGR 36–003–088	Case Institute of Technology, S. OSTRACH Investigation of Biological Fluid Mechanics.	91,500
NGR 36–003–100	Case Institute of Technology, A. R. COOPER Diffusive Mixing as a Tool for Confirming the Origin of Tektites.	17,965
NSR 36–003–051 A 3	Case Institute of Technology, E. J. MORGAN A Summer Institute in Space-Related Engineering.	104,100
NSR 36–003–092	Case Institute of Technology, G. M. FRYE Spark Chamber Detection of (A) Solar and Cosmic Gamma Rays and (B) Geomagnetically Trapped Radiation at Low Altitudes.	99,800
NSR 36–003–111	Case Institute of Technology, R. H. THOMAS Conference on Properties of Polymers at Cryogenic Temperatures.	4,000
NsG(T)–43 S 4	Cincinnati, University of, C. CROCKETT Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	72,200
NGR 36–004–014 S 1	Cincinnati, University of, R. P. HARRINGTON Multidisciplinary Space-Related Research in the Physical, Engineering, Life and Social Sciences.	150,000
NsG–437 S 3	Fels Research Institute, E. S. VALENSTEIN Experimental Studies of Reinforcing Brain Stimulation, Including Consideration of Behavioral Consequences.	50,000
NGR 36–006–002	John Carroll University, E. F. CAROME Experimental Studies of Fluids in the Vicinity of the Critical Point.	21,460
NGR 36–006–003	John Carroll University, J. TRIVISONNO	29,240
NsG–568 S 3	Kent State University, T. N. BHARGAVA Stochastic Models for Multi-Dimensional, Multi-Valued Relations.	20,742
NsG(T)–56 S 4	Kent State University, J. WHITE Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	41,000
NGR 39–007–017 S 1	Lehigh University, A. KALNINE Analysis of Large Deformation of Shells.	25,600
NGR 36–022–001	Miami University, D. E. CUNNINGHAM A Study of NASA-University Scientific Relationships.	42,210
NsG–74 S 6	Ohio State University, C. A. LEVIS Research on Receiver Techniques and Detectors for use at Millimeter and Submillimeter Wave Lengths.	40,000
NsG–295 S 3	Ohio State University, E. P. HIATT Biological Effects of Prolonged Exposure of Animals to Unusual Gaseous Environments.	35,575

OHIO—Continued

NsG(T)–66 S 4	Ohio State University, R. ARMITAGE. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	$98,300
NGR 36–008–076	Ohio State University, R. L. COSGRIFF. Techniques for Generation of Control and Guidance Signals Derived from Optical Fields.	34,994
NGR 36–008–080	Ohio State University, C. LEWIS. Millimeter-Wavelength Propagation Studies.	54,000
NSR 36–008–096	Ohio State University. Development and Presentation for NASA of a Program of Instruction in Applications of Nomographics for Structuring and Administration of Incentive Contracts.	25,666
NsG(T)–124 S 3	Ohio University, T. CULBERT. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	36,000
NsG(T)–104 S 3	Toledo, University of, A. N. SOLBERG. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	42,400
R 36–015–001 A 2	U.S. Dept. of Health, Education, & Welfare, K. H. LEWIS. Conduct Investigation of the Ecology and Thermal Inactivation of Microbes in and on Space Vehicle Components.	88,000
NsG–653 S 3	Western Reserve University, B. S. CHANDRASEKHAR. Theoretical and Experimental Investigations of Electronic Transport Phenomena in Semimetals.	30,000
NsG(T)–88 S 4	Western Reserve University, W. HESTON. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	107,500

OKLAHOMA:

NsG–300 S 4	Oklahoma City University, J. P. JORDAN. Interdisciplinary Studies of the Effects of the Space Environment on Biological Systems.	40,000
NsG(T)–67 S 4	Oklahoma State University, M. T. EDMISON. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	88,600
NGR 37–002–051	Oklahoma State University, R. L. LOWERY. Structural Responses to Sonic Booms.	31,016
NASr–7 A 9	Oklahoma State University, F. C. TODD. Shock, Flow and Radiation Studies from the Hypervelocity Impact of Microparticles.	50,000
NsG(T)–36 S 4	Oklahoma, University of, C. RIGGS. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	82,800
NGR 37–003–026 S 1	Oklahoma, University of, C. RIGGS. Multidisciplinary Research Program in Space Science and Engineering.	100,000
NGR 37–003–035	Oklahoma, University of, D. M. EGLE. Free Vibrations of Ring and Stringer Stiffened Cylindrical Shells with Stiffeners Treated as Discrete Elements.	14,704
NSR 37–004–006	Southeastern State College, L. B. ZINK. A Program to Enhance the Transfer of new Technology to Potential Industrial, Governmental, and Academic Users in the Oklahoma Area.	98,000

OREGON:

NsG(T)–68 S 4	Oregon State University, H. P. HANSEN. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	105,200

OREGON—Continued

NGR 38-002-017	Oregon State University, R. Y. MORITA Hydrostatic Pressure-Temperature, as Environmental Parameters, on Growth, Biochemistry and Physiology of Microorganisms.	$27,710
NGR 38-002-018	Oregon State University, S. E. WILLIAMS Development of a Lexicon of Space Science Terms for use of Elementary School Grades 4-6.	16,050
NGR 38-002-020 S 1	Oregon State University, R. A. SCHMITT Instrumental Activation Analysis of Rare Earths and Other Elements.	62,140
NGR 38-003-009	Oregon, University of, D. F. WEILL Plagioclase Thermometry of Igneous Rocks.	120,000
NGR 38-003-010	Oregon, University of, G. C. GOLES Geochemistry of Trace Elements in Meteorites and Related Materials.	70,000
NGR 38-003-012	Oregon, University of, A. MCBIRNEY Criteria for Interpretation of Volcanic Depression in Terrestrial and Lunar Environments.	99,951

PENNSYLVANIA:

NsG(T)-41 S 4	Carnegie Institute of Technology, A. F. STREHLER Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	144,800
NGR 39-002-011 S 1	Carnegie Institute of Technology, J. J. WOLKEN Microspectrophotometric Techniques of Studying the Constituents of Living Cells and Organelles.	26,368
NsG(T)-147 S 1	Drexel Institute of Technology, O. W. WITZELL Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	38,400
NGR 39-004-013	Drexel Institute of Technology, P. C. CHOU Transient Response of Shell Structures.	28,000
NGR 39-004-015	Drexel Institute of Technology, M. M. LABES Mechanisms for the Effects of Electric and Magnetic Fields on Biological Systems.	22,000
NsG(T)-134 S 2	Duquesne University, H. H. PETIT Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	38,900
NSR 39-005-018 A 5	Franklin Institute, R. GOODMAN Research in Life Sciences Instrumentation Pertinent to Studies in Space Biology.	78,908
NSR 39-005-018 A 6	Franklin Institute, R. GOODMAN Research in Life Sciences Instrumentation Pertinent to Studies in Space Biology.	6,697
NsG-287 S 4	Haverford College, L. C. GREEN Wave Functions, Transition Probabilities, and Spectra.	36,104
NsG(T)-57 S 4	Lehigh University, R. D. STOUT Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	101,200
NGR 39-007-007 S 2	Lehigh University, R. W. KRAFT Investigation of the Solidification Structure and Properties of Euctectic Alloys, Including Consideration of Properties Control.	35,000
NGR 39-007-025	Lehigh University, G. C. M. SIH Elastic and/or Plastic Analyses of Fracture Theories and Crack Problems.	29,254
NGR 39-008-013 S 1	Mellon Institute, S. POLLACK X-Ray Detection of Disordered Orthopyroxenes in Meteorites.	18,084
NsG-134 S 6	Pennsylvania State University, J. NISBET Theoretical and Analytical Research on Electron Densities in the Ionosphere, Including Studies of a Rocket and Separating-Capsule Experimental Technique.	105,000

PENNSYLVANIA—Continued		
NsG–537 S 2	Pennsylvania State University, G. F. WISLICENUS. Investigations and Analysis of Flow Phenomena of Secondary Motions in Axial Flow Inducers.	$70,500
NsG(T)–22 S 4	Pennsylvania State University, M. N. MCGEARY. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	162,500
NGR 39–009–023 S 2	Pennsylvania State University, J. L. SHEARER. Research and Development of On-Board Control Systems and Elements for Aerospace Vehicles.	56,391
NGR 39–009–032 S 2	Pennsylvania State University, B. R. F. KENDALL. Study and Evaluation of the Constant-Momentum Mass Spectrometer for Ion Analysis in the D and E Regions of the Ionosphere.	37,040
NGR 39–009–042 S 2	Pennsylvania State University, K. VEDAM. The Mechanism and Kinetics of Oxidation of Silicon in Air.	34,815
NsG–316 S 5	Pennsylvania, University of, M. ALTMAN. Research in the Conversion of Various Forms of Energy by Unconventional Techniques.	150,000
NsG(T)–69 S 4	Pennsylvania, University of, A. N. HIXSON. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	148,900
NASr–191 A 6	Pennsylvania, University of, P. S. BALAS. Operation of a Power Information Center.	42,600
NASr–169 A 6	Pittsburgh, University of, N. WALD. Automatic Analysis of Cytogenic Material.	97,225
NsG(T)–70 S 4	Pittsburgh, University of, P. F. JONES. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	136,100
NsG(T)–156	Pittsburgh, University of, D. C. STONE. Supporting the training of 5 Predoctoral Graduate Students in Public Administration with Emphasis on Policy Development, Management, and Administration of Large Scientific and Technological Programs.	90,000
NGR 39–011–013 S 1	Pittsburgh, University of, W. L. FITE. Laboratory Research on Airglow Excitation Mechanisms Using Atomic Beam Techniques.	76,800
NGR 39–011–030 S 2	Pittsburgh, University of, E. C. ZIPF. Laboratory Studies on the Excitation and Collisional Deactivation of Metastable Atoms, and Molecules in the Aurora and Airglow.	140,219
NGR 39–011–035 S 2	Pittsburgh, University of, E. GERJUOY. New Formulas for Collision Amplitudes and Related Quantities.	10,000
NASr–179 A 4	Pittsburgh, University of, T. M. DONAHUE. Continue Sounding Rocket and Related Theoretical Investigations in the Study of the Helium Geocorona and Airglow in the Upper Atmosphere.	170,000
NSR 39–011–064	Pittsburgh, University of, A. KENT. Space Technology Information Dissemination.	19,473
NSR 39–011–078	Pittsburgh, University of. Experiment in Direct Provision of Hard-Copy Documentation of Aerospace Generated Technology to Potential Users.	28,838
NsG(T)–140 S 2	Temple University, G. H. HUGANIR. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	37,000
NsG(T)–154 S 1	Villanova University, A. H. BUFORD. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	13,200
RHODE ISLAND:		
NGR 40–002–009 S 2	Brown University, P. T. MAEDER. Multidisciplinary Space-Related Research Programs.	150,000

RHODE ISLAND—Continued

NsG(T)-127 S 3	Brown University, M. J. BRENNAN Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	$115,200
NGR 40-002-015 S 2	Brown University, J. P. LASALLE Theory of Differential Equations and their Relationship to Dynamical Systems Theory.	56,630
NGR 40-002-053	Brown University, B. CASWELL The Mechanics of Viscoelastic Fluids.	46,000
NGR 40-002-059	Brown University, E. A. MASON Study of Short-Range Intermolecular Forces and High-Temperature Gas Properties.	33,000
NsG(T)-72 S 4	Rhode Island, University of, P. H. NASH Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	48,500

SOUTH CAROLINA:

NsG(T)-44 S 4	Clemson University, F. BROWNLEY Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	58,000
NsG(T)-115 S 3	South Carolina, University of, J. A. MORRIS Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	62,100
NGR 41-002-003 S 1	South Carolina, University of, J. R. DURIG Infrared Spectra of Molecules and Materials of Astro-Physical Interest.	29,922

SOUTH DAKOTA:

NGR 42-003-003	South Dakota State University, F. C. FITCHEN *Adaptability of FET Models to Computer-Aided* Circuit Design.	6,330
NsG(T)-138 S 2	South Dakota, University of, W. W. GUTZMAN Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	42,600

TENNESSEE:

NGR 43-003-003	Tennessee Technology University, G. R. BUCHANAN Analysis of Vibrational Response of Plates with Large Deflection.	13,069
NGR 43-003-007	Tennessee Technology University, R. KINSLOW Investigation of Stress Waves in Laminated Materials.	12,616
NSG-539 S 3	Tennessee, University of, N. M. GAILER Theoretical and Experimental Very High Resolution Spectroscopic Studies of Line Shapes of Atmospheric Cases and of Absorption Bands of Inorganic Solids.	101,461
NsG-587 S 3	Tennessee, University of, W. K. STAIR Theoretical and Experimental Studies of Visco-Type and Buffered Shaft Seals.	38,000
NsG-671 S 3	Tennessee, University of, D. G. BOGUE Study of Constitutive Equations in Two-Dimensional Non-Neutonian Flow.	14,988
NsG(T)-81 S 4	Tennessee, University of, H. A. SMITH Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	97,000
NGR 43-001-018 S 2	Tennessee, University of, J. E. SPRUIELL Experimental and Theoretical Investigation of the Relation Between Atomic Structure and the Physical Properties of Metallic Solid Solutions.	15,006
NGR 43-001-021 S 1	Tennessee, University of, C. O. THOMAS Multidisciplinary Research Program in the Space Sciences and Engineering.	250,000

TENNESSEE—Continued

NGR 43-001-023 S 1	Tennessee, University of, M. W. MILLIGAN. Fundamental Study in Low-Density Gas Dynamics.	$32,000
R-104(01) A 3	U.S. Atomic Energy Commission, R. G. ALSMILLER. Partial Support for the Radiation Shielding Information Center (Space Shielding).	420,000
R-104(03) A 3	U.S. Atomic Energy Commission, J. MONTOUR. Research on Biological Effects of Protons and other Radiation, Especially Directed Toward Development of Biosatellite Experiments.	47,000
R-104(04) A 4	U.S. Atomic Energy Commission, M. A. BENDER. Conduct and Expand Human Blood Irradiation Experiments.	22,500
R-104(08) A 3	U.S. Atomic Energy Commission, F. J. DE SERRES. Conduct Research and Development in Connection with Two Biological Experiments for Possible Inclusion on Biosatellite Flights.	184,697
R-104(08) A 4	U.S. Atomic Energy Commission, F. J. DE SERRES. Conduct Research and Development in Connection with two Biological Experiments for Possible Inclusion on Biosatellite Flights.	241,000
R-104(10) A 2	U.S. Atomic Energy Commission, S. K. PENNY. Radiation Shielding Information Center (Space Shielding).	75,000
NsG(T)-85 S 4	Vanderbilt University, R. T. LAGEMANN. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	102,500

TEXAS:

NsG(T)-155 S 1	Baylor University, J. D. BRAGG. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	17,700
NGR 44-003-018 S 1	Baylor University, J. J. CHIDONI. Studies of Liver and Gastrointestinal Tract Irradiated with Protons.	36,861
NGR 44-003-025 S 2	Baylor University, H. S. LIPSCOMB. Space Related Biomedical Research.	49,681
NGR 44-003-031	Baylor University, R. ROESSLER. Physiological Correlates of Optimal Performance.	39,694
NSR 44-004-029 A 1	Southwest Center for Advanced Studies, W. B. HANSON. Rocket Probes for the Upper F-Region.	174,922
NSR 44-004-041 A 3	Southwest Center for Advanced Studies, W. J. HEIKKILA. Telemetry Equipment to be Developed and Furnished.	16,042
NsG(T)-52 S 4	Houston, University of, J. C. ALLRED. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	93,900
NGR 44-005-021 S 1	Houston, University of, J. C. ALLRED. Multidisciplinary Space Related Research.	125,000
NGR 44-005-022 S 1	Houston, University of, C. GOODMAN. Interactions of Hydromagnetic Wave Energy with Energetic Plasmas, and Other Space-Related Scientific and Technical Investigations.	79,250
NGR 44-005-037 S 1	Houston, University of, D. R. TRAYLOR. Estimation of Transition Matrices, Abelian Groups, Structure of Near-Rings, and Metrization of Topological Spaces.	40,000
NGR 44-005-039 S 1	Houston, University of, R. D. SHELTON. Advancement of the General Theory of Multiplexing with Application to Space Communication.	52,458

TEXAS—Continued

NGR 44-005-041 S 1	Houston, University of, C. GOODMAN Study of Solar Flare Particle Events and Related Solar Physics.	$69,536
NGR 44-005-060	Houston, University of, S. B. CHILDS Numerical Integration Via Power Series Expansions.	14,932
NSR 44-005-016 A 2	Houston, University of, C. J. HUANG Summer Institute in Space-Related Engineering.	102,700
NSR 44-005-059	Houston, University of, C. J. HUANG A Program of Faculty Space Systems Engineering Institute.	88,860
NSR 44-005-068	Houston, University of, J. ORO Isotopic Carbon Analysis of Meteoritic Organic Matter.	53,062
NsG-6 S 8	Rice University, F. R. BROTZEN Studies of the Physics of Solid Materials Including Investigation of the Basic Laws Governing the Behavior of Solids at High Temperatures.	200,000
NsG(T)-9 S 5	Rice University, W. E. GORDON Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	159,300
NGR 44-006-033 S 1	Rice University, K. S. PITZER Multidisciplinary Space Related Research.	200,000
NGR 44-006-044	Rice University, R. C. HAYMES Lunar Neutron Albedo Experiment for the A. E. S. Lunar Orbiter.	20,000
NGR 44-006-059 S 1	Rice University, E. ALTENBURG Effects of Ultraviolet and Heavy Particle Radiation on Drosophila Germ Cells.	27,250
NGR 44-006-061	Rice University, D. HEYMANN Lunar Sample Investigation.	14,355
NGR 44-006-063	Rice University, A. MIELE Theoretical Studies of Hypersonic Lifting Bodies.	36,410
NGR 44-006-070	Rice University, J. A. S. ADAMS The Application of the K-Ar Method to the Dating of Shocked Rocks.	14,908
NSR 44-006-065	Rice University, E. J. LOW To Construct and Operate a Flying Infrared Telescope.	94,641
NsG-708 S 3	Southern Methodist University, G. W. CRAWFORD Study of Semiconductor-Dosimeter Characteristics, as Applied to Problems of Whole Body Dosimetry.	2,750
NsG(T)-99 S 3	Southern Methodist University, C. C. ALBRITTON Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	54,000
NGR 44-007-006 S 2	Southern Methodist University, J. C. DENTON Multidisciplinary Research in Space-Related Science and Technology.	100,000
NsG-269 S 6	Southwest Center for Advanced Studies, F. JOHNSON Multidisciplinary Research in Space-Related Science and Technology.	708,589
NGR 44-004-026 S 2	Southwest Center for Advanced Studies, F. JOHNSON Investigations into the Mechanism and Rates of Atmospheric Mixing in the Lower Thermosphere.	126,951
NGR 44-004-030 S 2	Southwest Center for Advanced Studies, W. J. HEIKKILA. Study of Electron Collision Frequency Under Ionospheric Conditions.	29,105
NGR 44-004-042 S 1	Southwest Center for Advanced Studies, M. CAHEN Research on Gravitational Waves and Other Problems in General Relativity.	55,000
NASr-94(07) A 2	Southwest Research Institute, H. N. ABRAMSON Preparation of Monograph on Liquid Dynamic Behavior in Rocket Propellant Tanks.	4,947

TEXAS—Continued

NsG–239 S 5	Texas A & M University, H. E. WHITMORE Interdisciplinary Space-Oriented Research Program in the Physical, Life and Engineering Sciences.	$100,000
NsG–669 S 4	Texas A & M University, C. F. KETTLEBOROUGH Improvement of Propeller Static Thrust Estimation.	57,019
NsG(T)–8 S 5	Texas A & M University, W. C. HALL Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	143,400
NGR 44–001–031 S 1	Texas A & M University, T. J. KOZIK Analysis of Structurally Orthotropic Shells by Means of the Compliance Method.	43,258
NGR 44–001–044	Texas A & M University, J. A. STRICKLIN Nonlinear Static and Dynamic Analysis of Shells of Revolution with Asymmetrical Stiffness Properties.	33,528
NGR 44–001–050	Texas A & M University, M. E. EISNER Transport Properties and Distribution Function, Dynamics in One Dimensional Plasma Models.	11,182
NSR 44–001–053	Texas A & M University, F. W. R. HUBERT The Design and Production of Supplementary Materials for Teachers of High School Physics.	39,866
NsG(T)–105 S 3	Texas Christian University, E. L. SECREST Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	57,600
NGR 44–009–003 S 2	Texas Christian University, C. B. ELAM Integration of Stimulus Cues in Control Decisions.	12,306
NGR 44–009–008 S 1	Texas Christian University, S. B. SELLS Study of Social Structure and Group Behavior in Extended Duration Space Missions.	29,941
NsG(T)–82 S 4	Texas Technology College, F. D. RIGBY Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	58,400
NGR 44–011–020	Texas Technological College, D. D. WALLING A Study to Determine the Usefulness of Interval Analysis in Solving Problems in Celestial Mechanics.	11,380
NsG–210 S 4	Texas, University of (Medical School), P. MONTGOMERY. Study of the Influence of Gravity on Unicellular Organisms.	38,788
NsG–353 S 4	Texas, University of, A. A. DOUGAL Research on Propagation and Dispersion of Hydromagnetic and Ion Cyclotron Waves in Plasmas Immersed in Magnetic Fields.	39,935
NsG–432 S 4	Texas, University of, C. W. Tolbert Investigation of Millimeter Wavelength Radiation from Solar System Bodies.	106,800
NsG–551 S 3	Texas, University of, B. D. TAPLEY Study of Low Thrust Guidance Techniques.	40,120
NsG(T)–83 S 4	Texas, University of, W. G. WHALEY Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	158,300
NGR 44–012–045 S 1	Texas, University of, J. A. MACHIN A Study of Ignimbrites in the Cordilleran Region as a Basis for Interpretation of Lunar Plains.	24,984
NGR 44–012–046 S 1	Texas, University of, B. D. TAPLEY Investigation of Methods for Defining Optimal Open-Loop Control Procedure for Continuous Powered Space Flight.	16,500
NGR 44–012–055 S 1	Texas, University of, J. N. DOUGLAS Polarization and time structure of Jovian Decametric Radiation and the Structure of Interplanetary Plasma.	108,173

TEXAS—Continued		
NGR 44–012–066	Texas, University of, D. G. LAINIOTIS Optimal Adaptive Estimation of Stochastic Processes with Random Parameters.	$20,000
NGR 44–012–088	Texas, University of, B. FRUCHTER Investigation of Multivariate Techniques for Biomedical Analysis.	47,990
NGR 44–012–093	Texas, University of, J. J. BERTIN Interactions Between the Thermal Protection Material for the Mariner Class Spacecraft (Entry Probe) and its Environment.	24,116
NASr–242 A 5	Texas, University of, H. J. SMITH Design, Development, Fabrication, and Installation at McDonald Observatory of 105-Inch Telescope Suitable for Lunar and Planetary Observations.	400,000
NASr–242 A 6	Texas, University of, H. J. SMITH Design, Development, Fabrication, and Installation at McDonald Observatory of 105-Inch Telescope Suitable for Lunar and Planetary Observations.	327,000
NsG–440 S 4	Texas Woman's University, P. B. MACK An Experimental Investigation of Skeletal Mineral Losses in Humans and Pigtail Monkeys During Immobilization.	35,247
NGR 44–013–005	Texas Woman's University, G. P. VOSE Physical and Biochemical Changes Occurring in Human Bone as a Result of Bed Rest.	37,949
UTAH:		
NsG(T)–96 S 3	Brigham Young University, W. P. LLOYD Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	37,300
NSR 45–004–001	Latter Day Saints Hospital, D. H. NELSON Hormone Measurements on Urine of Astronauts.	24,879
NsG(T)–80 S 4	Utah State University, J. S. WILLIAMS Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	74,000
NsG(T)–79 S 4	Utah, University of, S. M. MCMURRIN Supporting the Training of Predoctoral Students in Space-Related Science and Technology.	89,800
NGR 45–003–019 S 1	Utah, University of, N. W. RYAN Investigation of the Combustion Chemistry of Composite Rocket Propellants.	42,700
NGR 45–003–027 S 1	Utah, University of, R. W. GROW Theoretical and Experimental Investigation of Solid State Mechanisms for Generating Coherent Radiation in the Ultraviolet and X-ray Regions.	25,150
NGR 45–003–029 S 1	Utah, University of, M. L. WILLIAMS The Mechanics of Fracture in Viscoelastic Media.	27,964
NGR 45–003–037	Utah, University of, M. L. WILLIAMS Paramagnetic Resonance Effect in Viscoelastic Materials.	49,987
NGR 45–003–038	Utah, University of, W. J. COLES Asymptotic Behavior of Solutions of Second Order Ordinary Differential Equations.	24,015
NGR 45–003–041	Utah, University of, F. R. GOLDSCHMIED The Optimization of Hydraulic Compound Vortex Amplifiers.	15,980
VERMONT:		
NsG(T)–28 S 4	Vermont, University of, W. H. MACMILLAN Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	54,800
NGR 46–001–008 S 2	Vermont, University of, C. D. COOK Multidisciplinary Research Program in Space Sciences and Engineering, with Particular Emphasis on Bio-Engineering.	150,000

VIRGINIA:

NGR 47-002-012	Medical College of Virginia, S. W. LIPPINCOTT. The Tracer Measurement of Mammalian Body Composition Following Proton Bombardment.	$15,000
NSR 47-007-003 A 3	Virginia Associated Research Center, W. H. MCFARLANE. A Summer Institute in Space-Related Engineering.	107,100
NsG(T)-11 S 4	Virginia Polytechnic Institute, F. W. BULL. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	117,000
NGR 47-004-006 S 4	Virginia Polytechnic Institute, F. W. BULL. Multidisciplinary Space-Related Research in Engineering and the Physical and Life Sciences.	50,000
NGR 47-004-016	Virginia Polytechnic Institute, J. P. WIGHTMAN. The Adsorption of Gases on Stainless Steel in the Pressure Range 10^{-10} to 10^{-8} Torr.	26,365
NGR 47-004-018 S 1	Virginia Polytechnic Institute, W. E. C. MOORE. A Study of Techniques for Determining the Presence of Anaerobic Bacteria.	24,150
NGR 47-004-023	Virginia Polytechnic Institute, G. H. BEYER. Conference on Bioastronautics.	21,390
NGR 47-004-024	Virginia Polytechnic Institute, H. L. WOOD. A Study of the Application of Microwave Techniques to the Measurement of Solid Propellant Burning Rates.	44,972
NsG-340 S 3	Virginia, University of, R. L. RAMEY. A Study of Thin-Film Vacuum-Deposited Junctions.	39,940
NsG-682 S 3	Virginia, University of, K. ZIACK. Multidisciplinary Research in the Space-Related Sciences and Technology.	25,000
NsG(T)-14 S 4	Virginia, University of, E. YOUNGER. Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	115,600
NGR 47-005-022 S 2	Virginia, University of, J. W. BEAMS. Investigation to Increase the Accuracy of Newtonian Gravitational Constant, G.	37,441
NGR 47-005-026 S 4	Virginia, University of, J. W. MOORE. A Force Balance System for the Measurement of Skin Friction Drag Force in the Presence of Large Vibrations and Extreme Temperatures.	49,100
NGR 47-005-029 S 1	Virginia, University of, R. SMOAK. Theoretical and Experimental Investigation of a Three-Dimensional Magnetic-Suspension Balance for Dynamic-Stability Research in Wind Tunnels.	4,600
NGR 47-005-029 S 2	Virginia, University of, H. M. PARKER. Development of a Three-Dimensional Magnetic-Suspension Balance for Dynamic-Stability Research in Wind Tunnels.	199,363
NGR 47-005-046 S 1	Virginia, University of, O. F. HAGENA. Research in the Field of Molecular Collision Phenomena Using Molecular Beam Techniques.	45,000
NGR 47-005-049 S 1	Virginia, University of, F. R. WOODS. An Investigation in Irreversible Macroscopic Phenomena.	18,153
NGR 47-005-050 S 1	Virginia, University of, E. J. GUNTER, JR. Investigation of the Dynamic Stability of the Rigid Body Rotor—Phase II.	22,951
NGR 47-005-067	Virginia, University of, N. CABRERA. Studies in High Energy Physics.	85,000
NGR 47-005-077	Virginia, University of, J. W. BORING. The Interaction of Oxygen Atoms With Solid Surfaces at eV Energies.	37,918

VIRGINIA—Continued		
NSR 47-005-070	Virginia, University of, R. L. JENNINGS To Conduct the Third Bio-Space Technology Training Program at NASA Wallops Station.	$54,900
R 47-017-001	U.S.A.F.—Office of Scientific Research Development of the Fluid Transpiration Arc Leading to Improved Spectrum Simulation of the Solar Spectrum.	75,000
NsG-567 S 5	William and Mary, College of, W. M. JONES Multidisciplinary Research in Space Science and Technology.	200,000
NsG-636 S 2	William and Mary, College of, H. O. FUNSTEN A Performance Study for the Meson Channel for the SREL 600 MeV Synchrocyclotron and Multimode Operation Feasibility Study.	12,175
NsG-710 S 3	William and Mary, College of, J. D. LAWRENCE Atmospheric Investigation by Laser Techniques.	29,970
NsG(T)-141 S 2	William and Mary, College of, R. T. SIEGEL Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	40,800
WASHINGTON:		
R 48-005-001 A 2	U.S. Atomic Energy Commission, O. J. WICK A Study of Tungsten-Technetium Alloys.	30,000
NsG(T)-100 S 3	Washington State University, J. F. SHORT Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	67,400
NsG-484 S 3	Washington, University of, J. I. MUELLER Multidisciplinary Research Activity on the Materials Sciences with Emphasis on Investigations of Inorganic Non-Metallic (Ceramic) Materials.	300,000
NsG(T)-87 S 4	Washington, University of, J. L. MCCARTHY Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	91,800
NGR 48-002-044	Washington, University of, A. HERTZBERG Generation of Coherent Radiation and the Use of Intense Coherent Radiation for the Generation of Plasmas.	140,000
WEST VIRGINIA:		
NsG(T)-21 S 4	West Virginia University, J. LUDLUM Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	87,800
NGR 49-001-013 S 1	West Virginia University, A. D. KENNY Calcium Homeostasis in Stress and Immobilization.	20,000
NGR 49-001-014 S 1	West Virginia University, J. E. PALMER Research on the Thermal Radiation Characteristics of Spacecraft Thermal Control Panels.	9,000
NGR 49-001-019 S 1	West Virginia University, W. H. MORAN The Effect of Changing Gravity and Weightlessness on Vasopressin Control Systems.	28,000
WISCONSIN:		
NsG(T)-149 S 1	Marquette University, L. W. FRIEDRICH Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	17,700
NsG-275 S 5	Wisconsin, University of, R. M. BOCK Multidisciplinary Research in Space Science and Engineering with Special Emphasis on Theoretical Chemistry.	650,000
NsG-618 S 3	Wisconsin, University of, A. D. COLE Investigations and Studies of Ultraviolet Stellar Spectra and Associated Instrumentation.	150,000
NsG(T)-23 S 4	Wisconsin, University of, R. A. ALBERTY Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	166,200

WISCONSIN—Continued		
NGR 50-002-041 S 1	Wisconsin, University of, L. A. BASKIN Neutron Activation Analysis for Rare Earths, Lanthanides, and Yttrium, on Simulated Lunar Samples.	$35,000
NGR 50-002-078	Wisconsin, University of, E. C. DICK A Study of Methods to Effect a More Complete and Rapid Detection of Human Infectious Agents.	26,460
NGR 50-002-044 S 2	Wisconsin, University of, W. L. KRAUSCHAAR Cosmic and Solar Physics.	145,447
WYOMING:		
NsG(T)-143 S 2	Wyoming, University of, R. H. BRUCE Supporting the Training of Predoctoral Graduate Students in Space-Related Science and Technology.	36,300
NGR 51-001-010	Wyoming, University of, E. A. RINEHART Relative and Absolute Intensity Measurements of Microwave Spectral Lines in Pure and Dilute Cases.	94,907
FOREIGN:		
NsG-54 S 7	Auckland, University of, J. E. TITHERIDGE Investigations of The Ionosphere Using Radio Signals from Artificial Satellites.	14,000
NGR 52-026-019	Toronto, University of (Hospital for Sick Children), D. A. TURNER. Effect of Space Flight Environment on the Red Cell Membrane and Related Phenomena.	60,247

Appendix P

Institutions Currently Participating in NASA's Predoctoral Training Program

(June 30, 1967)

Adelphi University
Alabama, University of
Alaska, University of
Alfred University
Arizona State University
Arizona, University of
Arkansas, University of
Auburn University
Baylor University
Boston College
Brandeis University
Brigham Young University
Brooklyn, Polytechnic Institute of
Brown University
California Institute of Technology
California, University of, at Berkeley
California, University of, at Los Angeles
California, University of, at Riverside
California, University of, at San Diego
California, University of, at Santa Barbara
Carnegie Institute of Technology
Case Institute of Technology
Catholic University of America
Chicago, University of
Cincinnati, University of
Clark University
Clarkson College of Technology
Clemson University
Colorado School of Mines
Colorado State University
Colorado, University of
Columbia University
Connecticut, University of
*Cornell University
Dartmouth College
Delaware, University of
Denver, University of
Drexel Institute of Technology
Duke University
Duquesne University
Emory University
Florida State University
Florida, University of
Fordham University
George Washington University
Georgetown University
*Georgia Institute of Technology
Georgia, University of
Hawaii, University of
Houston, University of
Howard University
Idaho, University of
Illinois Institute of Technology
Illinois, University of
Indiana University
Iowa State University
Iowa, University of
Johns Hopkins University
Kansas State University
*Kansas, University of
Kent State University
Kentucky, University of
Lehigh University
Louisiana State University
Louisville, University of
Lowell Technological Institute
Maine, University of
Marquette University
Maryland, University of
Massachusetts Institute of Technology

* Institutions receiving training grants specifically for engineering design.

Massachusetts, University of
Miami, University of
Michigan State University
Michigan Technological University
Michigan, University of
Minnesota, University of
Mississippi State University
Mississippi, University of
Missouri, University of
Missouri, University of, at Rolla
Montana State University
Montana, University of
Nebraska, University of
Nevada, University of
New Hampshire, University of
New Mexico State University
New Mexico, University of
New York, The City University of
New York, State University of, at Buffalo
New York, State University of, at Stony Brook
New York University
North Carolina State of the University of North Carolina
North Carolina, University of
North Dakota State University
North Dakota, University of
Northeastern University
Northwestern University
Notre Dame, University of
Ohio State University
Ohio University
Oklahoma State University
Oklahoma, University of
Oregon State University
Pennsylvania State University
Pennsylvania, University of
**Pittsburgh, University of
Princeton University
*Purdue University
Rensselaer Polytechnic Institute
Rhode Island, University of
Rice University
Rochester, University of
St. Louis University
South Carolina, University of
South Dakota, University of
**Southern California, University of
Southern Illinois University
Southern Methodist University
Southern Mississippi, University of
*Stanford University
Stevens Institute of Technology
Syracuse University
Temple University
Tennessee, University of
Texas A&M University
Texas Christian University
Texas Technological College
Texas, University of
Toledo, University of
Tufts University
Tulane University
Utah State University
Utah, University of
Vanderbilt University
Vermont, University of
Villanova University
Virginia Polytechnic Institute
Virginia, University of
Washington State University
Washington University (St. Louis)
Washington, University of
Wayne State University
West Virginia University
Western Reserve University
William and Mary, College of
Wisconsin, University of
Worcester Polytechnic Institute
Wyoming, University of
Yale University
Yeshiva University

* Institutions receiving training grants specifically for engineering design.
** Institutions receiving training grants specifically for public administration.

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