NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1974 ESTIMATES

AGENCY SUMMARY AND RESEARCH AND DEVELOPMENT

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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GENERAL STATEMENT

The National Aeronautics and Space Administration, established October 1, 1958, conducts space and aeronautical activities for peaceful purposes for the benefit of all mankind. In maintaining United States leadership in research, technology, and utilization in these fields, NASA's programs:

--extend man's knowledge of the earth, its environment, the solar system, and the universe;

--expand practical applications of space technology;

--develop, operate, and improve manned and unmanned space vehicles;

--improve the civil and military usefulness of aeronautical vehicles while minimizing their environmental effects;

--disseminate pertinent findings to potential users; and

--promote international cooperation in peaceful activities in space.

The industrial community, under contracts with NASA, will continue to carry forward the prime design, development, and fabrication effort of the major hardware elements involved in the NASA programs. Other elements of the programs will be pursued within NASA installations, other government agencies, universities, and research contractors.

Appropriations totaling $3,016,000,000 are requested for FY 1974 to support the program described in these justifications. The budget plan by appropriation is summarized below and reflects $91,000,000 of FY 1973 funds applied to the FY 1974 plan.

BUDGET PLAN SUMMARY

	(Thousands of Dollars)		
	1972	1973	1974
Obligational Authority			
Research and development.....	$2,508,386	$2,509,900	$2,288,000
Construction of facilities.....	54,300	77,300	112,000
Research and program management.....	740,312	715,000	707,000
TOTAL BUDGET PLAN.....	$3,302,998	$3,302,200	$3,107,000
FY 1973 funds applied to FY 1974 program.....			-91,000
Budget Authority Requested.....			$3,016,000
TOTAL OUTLAYS.....	$3,442,862	$3,062,100	$3,136,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

BUDGET SUMMARY

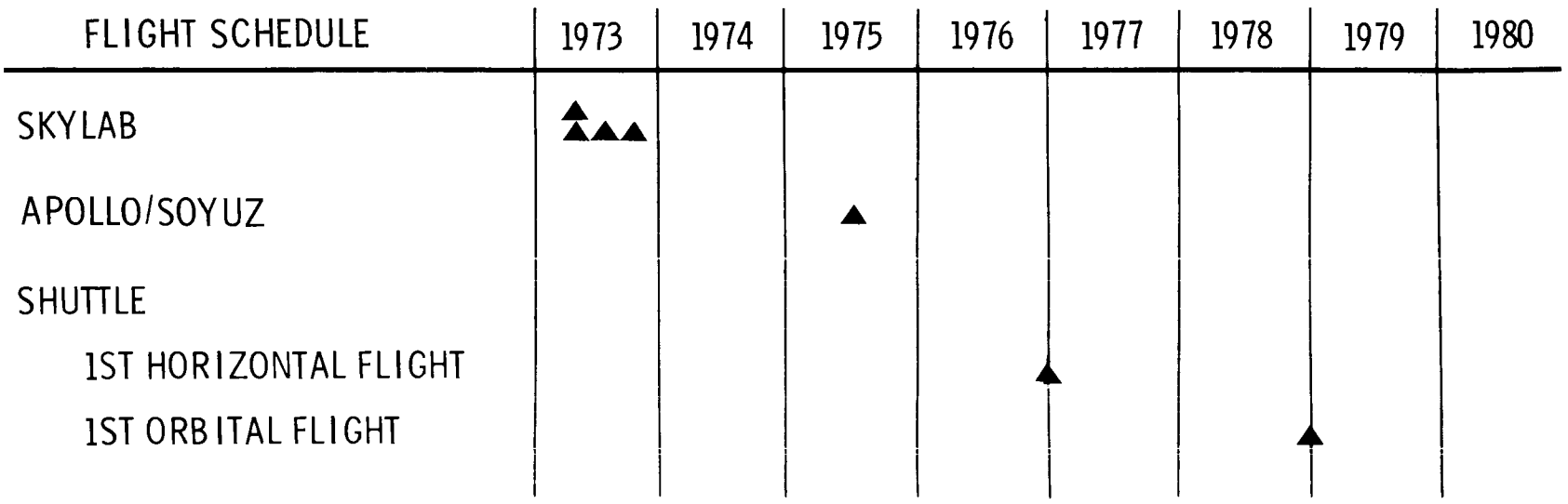
(Thousands of Dollars)

Research and Development	Budget Plan FY 1972	Budget Plan FY 1973	Budget Plan FY 1974	FY 1973 Funds Applied to FY 1974 Program	FY 1974 Budget Authority Requested
MANNED SPACE FLIGHT.....	1,285,475	1,157,200	1,057,000	25,000	1,032,000
Space flight operations	582,775	879,000	580,500	25,000	555,500
Space shuttle.....	100,000	200,000	475,000	---	475,000
Advanced missions.....	1,500	1,500	1,500	---	1,500
Apollo.....	601,200	76,700	---	---	---
SPACE SCIENCE.....	552,900	679,169	584,000	31,000	553,000
Physics and astronomy..	110,100	126,200	95,000	30,400	64,600
Lunar and planetary exploration.....	291,500	331,969	312,000	---	312,000
Launch vehicle procurement.....	151,300	221,000	177,000	600	176,400
APPLICATIONS.....	187,500	188,700	153,000	6,000	147,000
Space applications.....	187,500	188,700	153,000	6,000	147,000
AERONAUTICS AND SPACE TECHNOLOGY.....	213,511	232,500	240,000	29,000	211,000
Aeronautical research and technology.....	109,340	150,640	171,000	25,000	146,000
Space research and technology.....	74,365	64,760	65,000	---	65,000
Nuclear power and propulsion.....	29,806	17,100	4,000	4,000	---
TRACKING AND DATA ACQUISITION.....	264,000	248,331	250,000	---	250,000
TECHNOLOGY UTILIZATION..	5,000	4,000	4,000	---	4,000
TOTAL RESEARCH AND DEVELOPMENT.....	2,508,386	2,509,900	2,288,000	91,000	2,197,000
Construction of Facilities	54,300	77,300	112,000	---	112,000
Research and Program Mgmt.	740,312	715,000	707,000	---	707,000
TOTAL.....	3,302,998	3,302,200	3,107,000	91,000	3,016,000
TOTAL OUTLAYS.....	3,422,862	3,062,100	3,136,000		

MANNED SPACE FLIGHT

- TO EXTEND MAN'S CAPABILITY TO LIVE AND WORK IN SPACE – SKYLAB
- TO SUBSTANTIALLY ENHANCE OPERATIONAL CAPABILITIES AND REDUCE THE COST OF SPACE OPERATIONS – SHUTTLE
- TO DEVELOP AND TEST SYSTEMS FOR INTERNATIONAL COOPERATIVE MANNED MISSIONS – ASTP

MAJOR FLIGHT ACTIVITY



SPACE SCIENCE

- TO GAIN FUNDAMENTAL SCIENTIFIC KNOWLEDGE ABOUT:
  - THE EARTH - VARIETY OF SCIENTIFIC SATELLITES
  - THE SUN - SOLAR OBSERVATORIES
  - THE PLANETS - PIONEER, MARINER & VIKING SPACECRAFT
  - THE UNIVERSE - ASTRONOMICAL OBSERVATORIES

MAJOR FLIGHT ACTIVITY

FLIGHT SCHEDULE	1973	1974	1975	1976	1977	1978	1979	1980
EXPLORERS	▲▲	▲▲▲	▲▲▲▲	▲	▲	▲		
ORBITING SOLAR OBSERVATORY - OSO		▲						
MARINER VENUS/MERCURY	▲							
PIONEER-JUPITER	▲							
HELIOS		▲		▲				
VIKING - MARS LANDER			▲▲					
MARINER-JUPITER/SATURN					▲▲			

SPACE APPLICATIONS

- TO EXPAND THE PRACTICAL APPLICATIONS OF SPACE TECHNOLOGY WITH:
  - WEATHER SATELLITES
  - COMMUNICATIONS AND NAVIGATION SATELLITES
  - EARTH RESOURCES SURVEYS
  - RELATED GROUND-BASED ACTIVITIES

MAJOR FLIGHT ACTIVITY

FLIGHTS SCHEDULED	1973	1974	1975	1976	1977	1978	1979	1980
NIMBUS		F			G			
TIROS					N			
SMS	A	B						
GEOS		C						
ERTS				B				
ATS		F						
CAS			C					
LAGEOS				A				

AERONAUTICS

- TO MAINTAIN U. S. LEADERSHIP
- TO MEET URGENT DOMESTIC TRANSPORTATION NEEDS
- TO SUPPORT MILITARY AIRCRAFT DEVELOPMENT

MAJOR PROGRAMS

- QUIET ENGINE FOR STOL AIRCRAFT
- ENGINE QUIETING TECHNOLOGY FOR CURRENT NARROW BODY CIVIL AIRCRAFT
- NOISE REDUCTION BY FLIGHT PROCEDURES
- ADVANCED AIR-TRANSPORT TECHNOLOGY
- VERTICAL TAKEOFF AND LANDING (VTOL) RESEARCH AND TEST VEHICLES

SPACE RESEARCH & TECHNOLOGY

- TO BUILD THE TECHNOLOGY BASE FOR FUTURE SPACE ACTIVITIES

PROGRAM ACTIVITIES

- SPACE ELECTRIC POWER TECHNOLOGY
- HIGH IMPULSE PROPULSION SYSTEMS
- SYNCHRONOUS LASER EXPERIMENT
- SPACE STORABLE PROPULSION MODULE EXPERIMENT
- LIFTING BODY FLIGHT TESTS
- MATERIALS, STRUCTURES, GUIDANCE, CONTROL AND INFORMATION SYSTEMS
- ISOTOPE BRAYTON POWER CONVERSION SYSTEM
- ELECTROPHYSICS RESEARCH AND TECHNOLOGY

TRACKING & DATA ACQUISITION

- TO SUPPORT ALL NASA MISSIONS WITH TRACKING, ACQUISITION OF SCIENTIFIC AND ENGINEERING DATA, TRANSMISSION OF COMMANDS, COMMUNICATIONS AND DATA PROCESSING

MAJOR ACTIVITIES

SUPPORT:
- SKYLAB MISSIONS
- 40 ACTIVE UNMANNED SATELLITES
- PLANETARY EXPLORATION MISSIONS

TECHNOLOGY UTILIZATION

- TO SPEED AND WIDEN THE DISSEMINATION OF SCIENTIFIC, TECHNOLOGICAL AND ENGINEERING INFORMATION

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1974 ESTIMATES

SUMMARY OF APPROPRIATIONS

Appropriations	1972 (Thousands of Dollars) PL 92-78 PL 92-306*	1973 PL 92-383	1974 Request
Research and Development	$2,522,700	$2,600,900	$2,197,000
Construction of Facilities	52,700	77,300	112,000
Research and Program Management	734,722	729,450	707,000
Basic appropriation	($722,635)	($729,450)	($707,000)
*Supplemental appropriation (pay increases)	($12,087)	---	---
Total	$3,310,122	$3,407,650	$3,016,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1974 ESTIMATES

SUMMARY RECONCILIATION OF APPROPRIATIONS TO BUDGET PLAN
(Thousands of Dollars)

Fiscal Year 1972	Total	Research and Development	Construction of Facilities	Research and Program Management
Basic Appropriation, PL 92-78.....	$3,298,035	$2,522,700	$52,700	$722,635
Supplemental Appropriation, PL 92-306...	+12,087	---	---	+12,087
Total Appropriated.....	3,310,122	2,522,700	52,700	734,722
Transfers to other accounts:				
"Operating Expenses, Public Buildings Service," General Services Administration (85 Stat. 124).....	-131	---	---	-131
"Salaries and Expenses," Economic Stabilization Activities (85 Stat. 641).....	-2,000	---	---	-2,000
Total Adjusted Appropriation (Budget Authority).....	3,307,991	2,522,700	52,700	732,591
Unobligated R&PM balance available until September 30, 1971.....	+8,046	---	---	+8,046
Prior year funds applied to 1972 program.....	+9,200	+9,000	+200	---
Transfers between appropriations.....	---	-1,400	+1,400	---
Unobligated balance lapsing.....	-22,239	-21,914	---	-325
Total Budget Plan.....	$3,302,998	$2,508,386	$54,300	$740,312

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1974 ESTIMATES

SUMMARY RECONCILIATION OF APPROPRIATIONS TO BUDGET PLAN (CONTINUED)
(Thousands of Dollars)

Fiscal Year 1973	Total	Research and Development	Construction of Facilities	Research and Program Management
Appropriation, PL 92-383	$3,407,650	$2,600,900	$77,300	$729,450
Transfers to other accounts: "Operating Expenses, Public Buildings Service," General Services Administration (86 Stat. 489).	-15	---	---	-15
Total Adjusted Appropriation (Budget Authority)	3,407,635	2,600,900	77,300	729,435
1973 funds applied to 1974 program plans	-91,000	-91,000	---	---
Unobligated balance lapsing	-14,435	---	---	-14,435
Total Budget Plan	$3,302,200	$2,509,900	$77,300	$715,000
Fiscal Year 1974				
Appropriation request	$3,016,000	$2,197,000	$112,000	$707,000
1973 funds applied to 1974 program authority	+91,000	+91,000	---	---
Total Budget Plan	$3,107,000	$2,288,000	$112,000	$707,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1974 ESTIMATES

SUMMARY OF APPROPRIATION BUDGET PLANS BY INSTALLATION

(In millions of dollars)

Installation	Research and Development			Construction of Facilities			Research and Program Management			Total		
	1972	1973	1974	1972	1973	1974	1972	1973	1974	1972	1973	1974
John F. Kennedy Space Center, NASA..	168.2	185.6	124.8	15.2	10.1	---	92.6	91.4	90.4	276.0	287.1	215.2
Manned Spacecraft Center.....	445.8	510.2	657.9	---	.6	---	113.0	109.9	109.2	558.8	620.7	767.1
Marshall Space Flight Center.....	669.2	477.2	307.7	---	---	---	146.9	135.3	132.9	816.1	612.5	440.6
Goddard Space Flight Center.....	455.9	482.1	385.4	.7	.6	1.4	96.5	94.5	93.7	553.1	577.2	480.5
Wallops Station.....	12.2	15.5	14.1	---	.4	1.1	10.9	10.6	10.9	23.1	26.5	26.1
Jet Propulsion Laboratory.....	157.4	128.6	122.9	---	.6	1.3	---	---	---	157.4	129.2	124.2
Ames Research Center.....	72.7	74.5	83.0	6.5	1.8	---	42.2	42.0	42.8	121.4	118.3	125.8
Flight Research Center.....	14.2	14.9	16.6	---	---	---	11.7	11.3	11.1	25.9	26.2	27.7
Langley Research Center.....	245.9	316.3	291.2	---	4.3	4.0	80.2	78.0	79.2	326.1	398.6	374.4
Lewis Research Center.....	154.5	209.3	192.6	.9	9.7	---	84.7	81.9	76.5	240.1	300.9	269.1
NASA Headquarters:	112.4	95.7	91.8	---	---	---	61.6	60.1	60.3	174.0	155.8	152.1
Various Locations.....	---	---	---	19.6	27.9	71.2	---	---	---	19.6	27.9	71.2
Rehabilitation and Modification.....	---	---	---	7.9	11.6	14.8	---	---	---	7.9	11.6	14.8
Minor Construction.....	---	---	---	---	1.7	4.6	---	---	---	---	1.7	4.6
Facility Planning and Design.....	---	---	---	3.5	8.0	13.6	---	---	---	3.5	8.0	13.6
Total Budget Plan.....	2,508.4	2,509.9	2,288.0	54.3	77.3	112.0	740.3	715.0	707.0	3,303.0	3,302.2	3,107.0

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1974 ESTIMATES

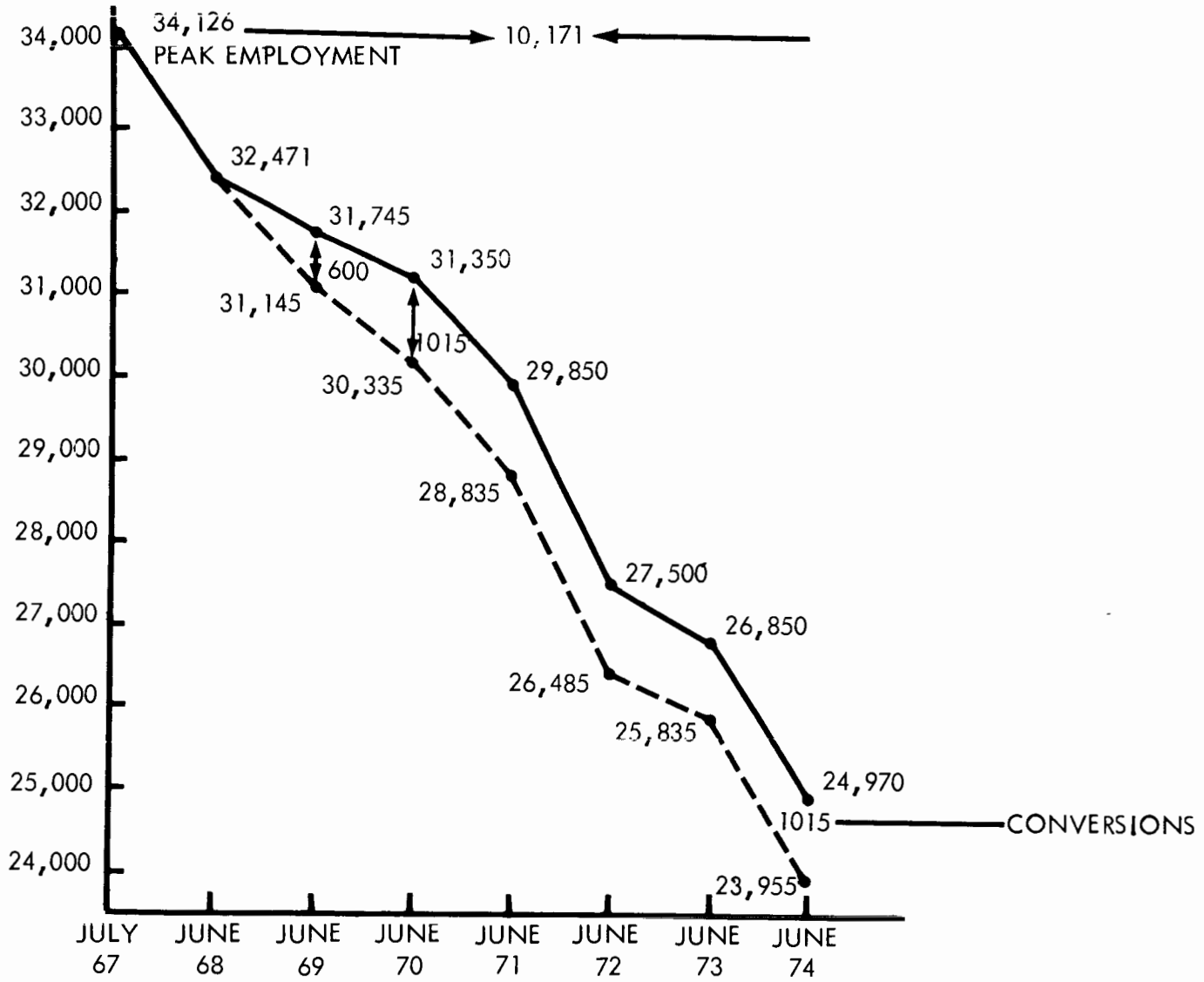
RESEARCH AND PROGRAM MANAGEMENT

SUMMARY OF PERMANENT POSITIONS BY INSTALLATION

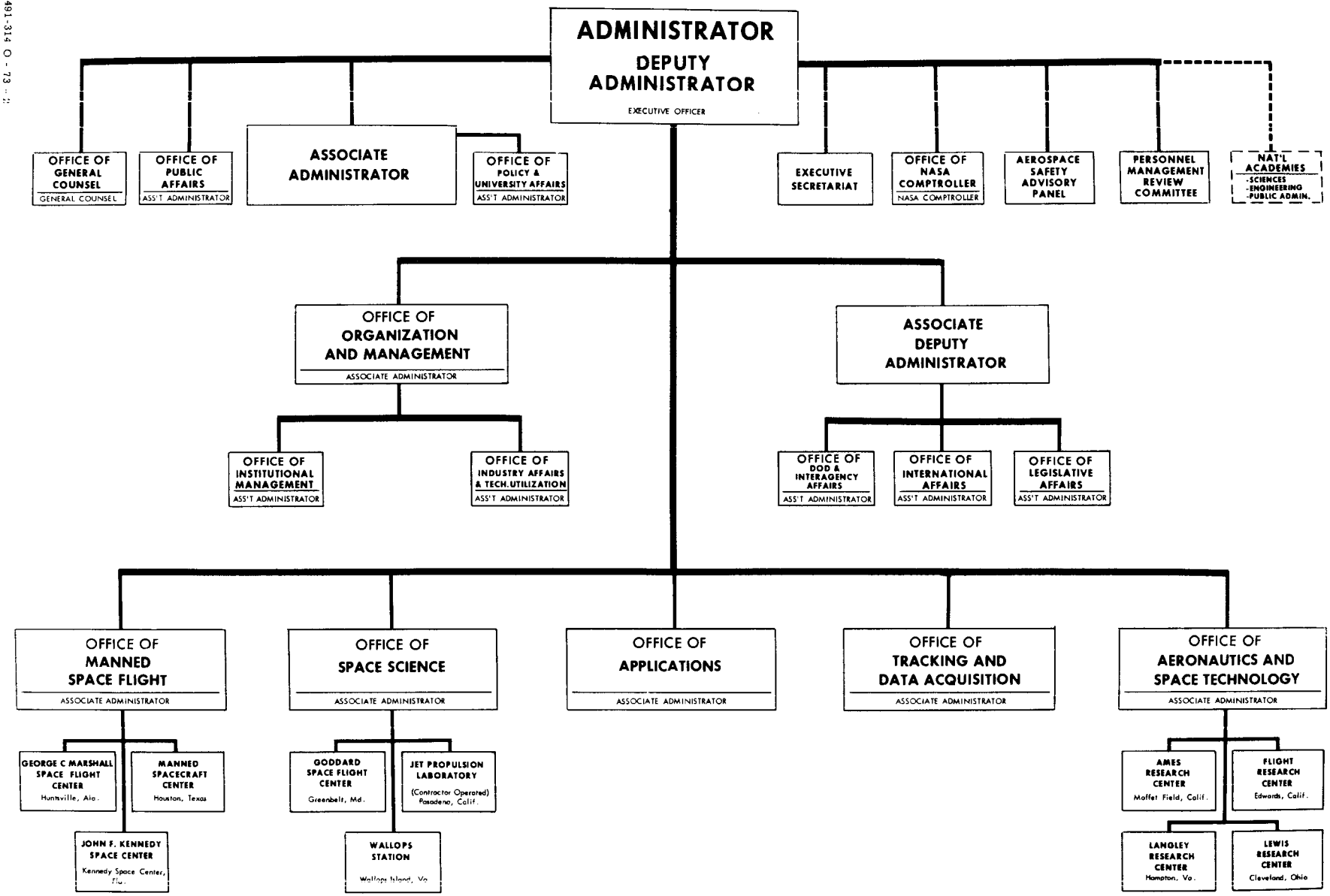
INSTITUTIONAL DIRECTOR AND INSTALLATION	Fiscal Year 1972	Fiscal Year 1973	Fiscal Year 1974
MANNED SPACE FLIGHT.....	11,625	11,350	10,525
John F. Kennedy Space Center, NASA.....	2,467	2,409	2,309
Manned Spacecraft Center.....	3,817	3,727	3,652
Marshall Space Flight Center.....	5,341	5,214	4,564
SPACE SCIENCE.....	4,509	4,403	4,228
Goddard Space Flight Center.....	4,061	3,966	3,808
Wallops Station.....	448	437	420
AERONAUTICS AND SPACE TECHNOLOGY....	9,594	8,984	8,636
Ames Research Center.....	1,771	1,729	1,699
Flight Research Center.....	493	482	482
Langley Research Center.....	3,495	3,411	3,371
Lewis Research Center.....	3,835	3,362	3,084
NASA HEADQUARTERS.....	1,772	1,731	1,581
UNFILLED POSITIONS.....	---	382	---
TOTAL.....	27,500	26,850	24,970

PERMANENT CIVIL SERVICE EMPLOYMENT & CHANGES

JULY 1967 – JUNE 1974



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION



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RESEARCH AND DEVELOPMENT

FISCAL YEAR 1974 ESTIMATES

GENERAL STATEMENT

The National Aeronautics and Space Administration program of research and development maintains and advances the United States' position of world leadership in aeronautics and space. The major program elements for achieving this objective are:

MANNED SPACE FLIGHT: A program utilizing the capabilities developed in the Apollo program to conduct manned missions involving the first long duration earth orbital laboratory and a cooperative test project with the USSR, and to develop a new transportation system which will provide significantly greater capabilities and reduced costs for future missions.

SPACE SCIENCE: An unmanned space flight program directed toward scientific investigations of the earth, the atmosphere, the moon, the sun, the planets, the stars, and interplanetary space.

APPLICATIONS: Research and development to demonstrate the application of space techniques for the benefit of mankind in the areas of weather and climate, pollution monitoring, earth resources survey, earth and ocean physics, communications, and space processing.

AERONAUTICS AND SPACE TECHNOLOGY: A sustained effort to acquire fundamental knowledge and to expand the technological base needed to continue United States leadership in aeronautics and space programs.

TRACKING AND DATA ACQUISITION: The worldwide activity supporting the NASA manned and unmanned flight programs.

TECHNOLOGY UTILIZATION: A program that provides for the expeditious public availability of scientific, technological, and engineering information and concepts which flow from NASA's work.

MANNED SPACE FLIGHT

The Apollo lunar exploration program has been successfully completed in FY 1973 and the flight missions of Skylab, the first long duration manned orbiting laboratory, are scheduled to begin late in the fiscal year. The FY 1974 plan provides for completion of the Skylab missions, preparations for

the Apollo/Soyuz Test Project, the first cooperative manned flight effort between the United States and the USSR, and increased activity in the design and development of the Space Shuttle, the key element in future space transportation.

The Apollo lunar flights have been successfuly completed with the Apollo 16 mission to the Descartes site in April 1972 and the Apollo 17 mission to Taurus-Littrow in December 1972. These highland sites were selected and the missions were configured to provide the maximum scientific return.

The Skylab program provides for the launch of the first long duration orbiting laboratory in the spring of 1973 and for three manned missions over the ensuing eight months. On these missions crews of three astronauts each will inhabit the Skylab for periods up to 56 days to evaluate crew performance in space and the biomedical effects of long duration space flight and to conduct experiments emphasizing earth resources surveys, comprehensive studies of the sun, and special materials processing in space.

The Apollo/Soyuz Test Project is a joint United States-USSR effort to develop and test systems for rendezvous and docking of manned spacecraft. In the test mission, planned for 1975, American astronauts using a modified Apollo Command and Service Module and a newly developed docking module will rendezvous and dock in earth orbit with a Soyuz spacecraft manned by Soviet cosmonauts. Joint activities, including crew transfers between spacecraft, will be conducted in orbit.

The Space Shuttle is the key element in future space operations in earth orbit. The Shuttle system will consist of a reusuable delta wing orbiter vehicle, a large expendable fuel tank, and reusable twin, solid rocket boosters. The Shuttle will provide a wide range of operational capabilities including placement and retrieval of satellites, in-orbit servicing of satellites, short duration manned orbital missions, and delivery of payloads and propulsive stages for high energy missions to earth orbit. The Space Shuttle is designed to introduce new concepts into space operations by making transportation to and from earth orbit routinely available for both unmanned payloads and for manned missions involving scientists and other personnel who do not have special astronaut training. In addition to reducing transportation costs, the Shuttle is expected to permit major savings in payload costs resulting from repair and reuse of payloads and from relaxation of the stringent weight, size, and reliability requirements currently imposed on payload designers.

SPACE SCIENCE

The FY 1974 budget request provides for continued scientific investigation of phenomena of our universe using automated spacecraft, sounding rockets, balloons and aircraft, and ground-based research.

A broad program of investigations is underway to determine the physical characteristics of the earth and its atmosphere, the moon, the sun, the

planets, and the interplanetary medium. The study of the sun, its processes, and its effects on earth's environment are continuing with the Orbiting Solar Observatory, OSO-7, and with the planned solar observations on the Skylab missions. OSO-I, to be launched in 1974, will continue solar observations into the mid-1970's. The Orbiting Astronomical Observatory Copernicus, launched in 1972, will continue to transmit data on the stars and interstellar matter. Effort on the High Energy Astronomical Observatory, authorized by Congress in FY 1972, has been suspended and will be replanned during FY 1974 to achieve many of its objectives at a substantial reduction in cost.

The planetary exploration program will receive a major impetus when Pioneer 10, which is now in the Asteroid Belt, encounters Jupiter, and the Mariner Venus/Mercury spacecraft achieves the first multiple flyby of two planets, Venus and Mercury. Both of these events are scheduled to be accomplished in FY 1974. Effort continues on the international Helios project to study the interplanetary medium in the near sun environment, with first launch scheduled for 1974. The Viking spacecraft designed to orbit and land on Mars to investigate a variety of phenomena, especially life-related phenomena, will be undergoing final integration and testing. Development effort will continue on the outer planet missions to Jupiter and Saturn using Mariner-class spacecraft to be launched in 1977.

In the unmanned launch vehicle program, emphasis will continue on reliability and quality assurance improvements aimed toward continuing the 100% success rate achieved in 1972.

SPACE APPLICATIONS

To promote the application of space technology toward solving some of man's urgent needs on earth, a strong ground-based research and technology effort and a carefully planned flight program will be conducted in FY 1974. The applications program covers the areas of earth resources surveys, weather and climate, pollution monitoring, earth and ocean physics, communications, and space processing. Earth resources activity during 1974 will include continued mission operations for the first Earth Resources Technology Satellite, ERTS-1; continued development of ERTS-B; and a supporting program of airborne surveys using sensors similar to those on the satellites. In weather-oriented activities, the Nimbus-F will be launched as a follow-on to the Nimbus-5 meteorological sensor development mission. Developmental work leading to an operational geostationary weather satellite system providing day and night coverage of short-term weather phenomena will culminate in the launch of the Synchronous Meteorological Satellites, SMS-A and SMS-B. Development will continue on the third generation of operational weather satellites, the TIROS-N, planned for launch in 1977.

In air pollution monitoring, work will be initiated on the Nimbus-G mission to provide for flight experiments with advanced sensors for air pollution measurements. The Nimbus-G advanced sensors will also contribute to ocean dynamics monitoring for the earth and ocean physics program. Work

will continue toward launch in 1974 of GEOS-C, designed to demonstrate the feasibility of using satellite altimeters for measuring the topography of ocean surfaces. Effort directed toward geodesy and a potential future earthquake prediction capability will include ground-based experiments and measurements, and the start of work on LAGEOS, a high density, laser reflector satellite which will provide a stable, long-term reference point for earth motion studies. In communications activities, the Applications Technology Satellite, ATS-F, mission will be launched in 1974 to conduct user communications experiments for State and Federal agencies and foreign countries using a large space-erectable antenna. Work will continue on the Cooperative Applications Satellite, CAS-C, a joint project with Canada leading to a developmental communications satellite using a recently allocated, higher frequency band, as well as several other advanced spacecraft design features. Investigations into the use of space as an environment for the generation and processing of materials that are impossible or too costly to produce on earth will be conducted using the results of Skylab experiments.

AERONAUTICS AND SPACE TECHNOLOGY

The FY 1974 Aeronautics research and technology effort will continue to be directed toward the goal of maintaining the nation's international leadership in civil and military aviation technology. The FY 1974 budget request provides for the continuation of experimental programs begun in FY 1973. Work on the experimental rotor test and tilt rotor aircraft will be in the design and fabrication phase. Work will also be in progress on clean, quiet propulsion applicable to Short Take-Off and Landing and Conventional Take-Off and Landing aircraft. This work includes propulsion system technology which could be applied to current narrow-body civil jet transports, resulting in substantially quieter operation without an adverse effect on operational characteristics. The 1974 program also provides for continuation of activities to provide a technology base for advanced supersonic aircraft involving work in the disciplines of propulsion, structures and materials, aerodynamics, and stability and control. Experimental programs will be supplemented by a strong technology program encompassing materials, structures, avionics, propulsion, aerodynamics, vehicle configurations, operating procedures, and aeronautical life sciences.

The Space research and technology effort is designed to build a technology base which will adequately support current and future space activities. Research is conducted on materials and structures, on improving the electronic systems used in space exploration and applications, on chemical and electric propulsion, on power generation and processing, and on entry aerothermodynamic and heat protection problems. The FY 1974 budget includes a program to reduce the cost of space systems through subsystem standardization and an effort to apply high energy lasers to power transmission in space. Nuclear efforts will focus on electrophysics research and on a low power level isotope Brayton cycle power conversion system.

TRACKING AND DATA ACQUISITION

This program furnishes support to NASA space flight programs through the management of the worldwide NASA communications system, the tracking of manned and unmanned spacecraft, and the acquisition of data from these spacecraft. During FY 1973 and 1974, work will continue on the process of merging the capabilities of the Satellite Network and the Manned Spaceflight Network into a single, consolidated Spaceflight Tracking and Data Network which will be capable of supporting increasingly complex missions. The major support requirements during this period are associated with Skylab, Orbiting Astronomical Observatory Copernicus, the Earth Resources Technology Satellite, Atmospheric Explorer-C, Pioneers 10 and G, and Mariner Venus/Mercury. Augmentation of the data processing facilities needed to provide support for the higher data-rate satellites will also continue.

TECHNOLOGY UTILIZATION

The objective of this program is to provide wide and rapid dissemination to the user community of scientific and technical information resulting from NASA efforts. Emphasis in FY 1974 is on applying these research and technology developments to major public problems in the areas of pollution, medicine, transportation, and law enforcement through special government-university-industry teams.

FUNDING

The FY 1974 Research and Development budget plan totals $2,288,000,000, a decrease of $221,900,000 from FY 1973. The program plan is proposed to be financed by $2,197,000,000 of New Obligational Authority and application of $91,000,000 of FY 1973 funds to the FY 1974 program.

Research and Development outlays in FY 1974 are estimated at $2,359,000,000, up $63,000,000 from the $2,296,000,000 estimate in FY 1973.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

Research and Development

For necessary expenses, not otherwise provided for, including research, development, operations, services, minor construction, maintenance, repair, rehabilitation and modification of real and personal property; and purchase, hire, maintenance, and operation of other than administrative aircraft, necessary for the conduct and support of aeronautical and space research and development activities of the National Aeronautics and Space Administration, [$2,600,900,000, of which $24,000,000 shall be available only for aeronautical research in the fields of noise abatement and aviation safety] *$2,197,000,000,* to remain available until expended. (*42 U.S.C. 2451, et seq.; Department of Housing and Urban Development; Space, Science, Veterans, and Certain Other Independent Agencies Appropriation Act, 1973; additional authorizing legislation to be proposed.*)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT

Program and Financing (in thousands of dollars)

Identification code 27-00-0108-0-1-250	Budget plan (amounts for research and development actions programed)			Costs and obligations		
	1972 actual	1973 estimate	1974 estimate	1972 actual	1973 estimate	1974 estimate
Program by activities:						
Direct program:						
1. Manned space flight:						
(a) Space flight operations	582,775	879,000	580,500	557,777	779,800	653,400
(b) Space shuttle	100,000	200,000	475,000	59,509	154,000	450,000
(c) Advanced manned mission studies	1,500	1,500	1,500	1,432	2,400	1,400
(d) Apollo	601,200	76,700	----------	698,411	263,800	16,600
2. Scientific investigations in space:						
(a) Physics and astronomy	117,500	142,500	102,200	127,692	140,300	103,200
(b) Lunar and planetary exploration	321,600	389,969	381,500	297,158	400,200	390,700
(c) Launch vehicle development and support	94,800	126,900	91,600	98,247	123,700	97,600
3. Space applications	205,400	208,100	161,700	225,183	202,400	160,700
4. Space and nuclear research and technology:						
(a) Space research and technology	75,465	65,160	65,000	100,909	62,400	64,000
(b) Nuclear power and propulsion	29,806	17,100	4,000	39,796	15,000	6,000
5. Aeronautical research and technology	109,340	150,640	171,000	103,656	120,000	158,000
6. Supporting activities:						
(a) Tracking and data acquisition	264,000	248,331	250,000	249,779	238,000	253,000
(b) Sustaining university program	----------	----------	----------	6,117	3,000	2,000
(c) Technology utilization	5,000	4,000	4,000	5,069	5,000	5,000
Total direct program costs, funded	2,508,386	2,509,900	2,288,000	2,570,735	2,510,000	2,361,600
Reimbursable program:						
1. Manned space flight:						
(a) Space flight operations	----------	7,700	8,700	----------	7,700	8,700
(b) Space shuttle	494	300	300	559	410	300
(c) Advanced manned mission studies	34	----------	----------	----------	34	----------
(d) Apollo	6,160	----------	----------	3,991	3,064	----------
2. Scientific investigations in space:						
(a) Physics and astronomy	----------	1,271	1,212	1,269	1,813	1,212
3. Space applications	62,632	71,641	67,043	73,233	99,352	67,043
4. Space and nuclear research and technology:						
(a) Space research and technology	440	2,110	7,700	830	2,490	7,700
(b) Nuclear power and propulsion	4,541	----------	----------	9,584	336	----------
5. Aeronautical research and technology	12,980	20,528	16,195	6,731	34,155	16,195
6. Supporting activities:						
(a) Tracking and data acquisition	373	490	450	595	716	450
(c) Technology utilization	81	160	----------	87	215	----------
Total reimbursable program costs	87,735	104,200	101,600	96,879	150,285	101,600
Total program costs, funded	2,596,121	2,614,100	2,389,600	2,667,614	2,660,285	2,463,200
Change in selected resources [1]	----------	----------	----------	−133,134	138,754	−73,600
10 Total	2,596,121	2,614,100	2,389,600	2,534,480	2,799,039	2,389,600

[1] Selected resources as of June 30 are as follows:

Program and Financing (in thousands of dollars)—Continued

Identification code 27-00-0108-0-1-250	Budget plan (amounts for research and development actions programed)			Costs and obligations		
	1972 actual	1973 estimate	1974 estimate	1972 actual	1973 estimate	1974 estimate
Financing:						
Receipts and reimbursements from:						
11 Federal funds	−52,252	−78,880	−92,770	−52,252	−78,880	−92,770
14 Non-Federal sources	−35,483	−25,320	−8,830	−35,483	−25,320	−8,830
21 Unobligated balance available, start of year:						
For completion of prior year budget plans:						
Direct				−104,121	−159,247	
Reimbursable				−30,782	−27,092	
Reprograming from prior year budget plans	−9,000					
Available to finance new budget plans: Direct			−91,000			−91,000
23 Unobligated balance transferred to other accounts	1,400			2,605	1,400	
24 Unobligated balance available, end of year:						
For completion of prior year budget plans:						
Direct				159,247		
Reimbursable				27,092		
Available to finance new budget plans: Direct		91,000			91,000	
25 Unobligated balance lapsing	21,914			21,914		
40 **Budget authority (appropriation)**	**2,522,700**	**2,600,900**	**2,197,000**	**2,522,700**	**2,600,900**	**2,197,000**
Relation of obligations to outlays:						
71 Obligations incurred, net				2,446,745	2,694,839	2,288,000
72 Obligated balance, start of year				1,333,091	1,156,675	1,555,514
74 Obligated balance, end of year				−1,156,675	−1,555,514	−1,484,514
90 Outlays				2,623,160	2,296,000	2,359,000

	1971	*1972 adjustments*	*1972*	*1973*	*1974*
Stores	63,470	22,055	89,695	89,695	89,695
Undelivered orders	845,114		707,810	846,564	772,964
Total selected resources	908,584	22,055	797,505	936,259	862,659

Note.—Reconciliation of budget plan to obligations:

	1972 actual	*1973 estimate*	*1974 estimate*
Total budget plan	2,596,121	2,614,100	2,389,600
Deduct portion of budget plan to be obligated in subsequent years	143,463		
Add obligations of prior year budget plans	81,822	184,939	
Total obligations	2,534,480	2,799,039	2,389,600

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT PROGRAMS

(Thousands of Dollars)

Research and Development	Budget Plan FY 1972	Budget Plan FY 1973	Budget Plan FY 1974	FY 1973 Funds Applied to FY 1974 Program	FY 1974 Budget Authority Requested
MANNED SPACE FLIGHT.....	1,285,475	1,157,200	1,057,000	25,000	1,032,000
Space flight operations	582,775	879,000	580,500	25,000	555,500
Space shuttle.....	100,000	200,000	475,000	---	475,000
Advanced missions.....	1,500	1,500	1,500	---	1,500
Apollo.....	601,200	76,700	---	---	---
SPACE SCIENCE.....	552,900	679,169	584,000	31,000	553,000
Physics and astronomy..	110,100	126,200	95,000	30,400	64,600
Lunar and planetary exploration.....	291,500	331,969	312,000	---	312,000
Launch vehicle procurement.....	151,300	221,000	177,000	600	176,400
APPLICATIONS.....	187,500	188,700	153,000	6,000	147,000
Space applications.....	187,500	188,700	153,000	6,000	147,000
AERONAUTICS AND SPACE TECHNOLOGY.....	213,511	232,500	240,000	29,000	211,000
Aeronautical research and technology.....	109,340	150,640	171,000	25,000	146,000
Space research and technology.....	74,365	64,760	65,000	---	65,000
Nuclear power and propulsion.....	29,806	17,100	4,000	4,000	---
TRACKING AND DATA ACQUISITION.....	264,000	248,331	250,000	---	250,000
TECHNOLOGY UTILIZATION..	5,000	4,000	4,000	---	4,000
TOTAL.....	2,508,386	2,509,900	2,288,000	91,000	2,197,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1974 ESTIMATES

DISTRIBUTION OF RESEARCH AND DEVELOPMENT BUDGET PLAN BY INSTALLATION AND FISCAL YEAR

(Thousands of dollars)

PROGRAM		TOTAL	Kennedy Space Center	Manned Spacecraft Center	Marshall Space Flight Center	Goddard Space Flight Center	Jet Propulsion Laboratory	Wallops Station	Ames Research Center	Flight Research Center	Langley Research Center	Lewis Research Center	NASA Headquarters
CE OF MANNED SPACE IGHT, TOTAL	1972	1,285,475	165,425	430,153	643,175	2,005	668	210	8,873	375	2,872	340	31,379
	1973	1,157,200	182,800	494,725	446,360	140	650	150	9,000	250	1,310	150	21,665
	1974	1,057,000	120,900	626,485	287,290	300	400	150	8,350	100	550	250	12,225
e Flight Operations	1972	582,775	19,375	159,928	378,620	1,875	630	210	8,773	375	2,502	25	10,462
	1973	879,000	179,100	303,125	372,560	140	650	150	9,000	250	1,310	150	12,565
	1974	580,500	116,600	255,685	189,090	300	400	150	8,350	100	550	250	9,025
e Shuttle	1972	100,000	300	36,100	59,200	---	---	---	---	---	---	150	4,250
	1973	200,000	700	147,300	48,000	---	---	---	---	---	---	---	4,000
	1974	475,000	4,100	370,000	97,900	---	---	---	---	---	---	---	3,000
nced Programs	1972	1,500	150	200	1,150	---	---	---	---	---	---	---	---
	1973	1,500	---	---	1,500	---	---	---	---	---	---	---	---
	1974	1,500	200	800	300	---	---	---	---	---	---	---	200
lo	1972	601,200	145,600	233,925	204,205	130	38	---	100	---	370	165	16,667
	1973	76,700	3,000	44,300	24,300	---	---	---	---	---	---	---	5,100
	1974	---	---	---	---	---	---	---	---	---	---	---	---
CE OF SPACE SCIENCE, TOTAL	1972	552,900	2,786	1,051	15,606	112,327	77,294	2,670	22,542	---	189,977	80,523	48,124
	1973	679,169	2,651	480	23,832	147,212	66,208	2,735	22,651	---	246,254	119,012	48,134
	1974	584,000	3,600	11,523	10,610	104,516	61,149	2,705	19,137	---	205,871	111,900	52,989
ics and astronomy	1972	110,100	---	626	14,438	67,266	490	2,620	5,005	---	1,575	---	18,080
	1973	126,200	---	130	23,330	68,106	677	2,670	6,895	---	4,555	---	19,837
	1974	95,000	---	125	8,785	55,535	660	2,640	6,730	---	2,783	---	17,742
r and planetary exploration	1972	291,500	---	425	247	4,804	75,952	50	17,537	---	173,680	---	18,805
	1973	331,969	---	350	---	4,791	64,771	65	15,756	---	226,541	---	19,695
	1974	312,000	---	11,398	25	4,441	59,689	65	12,407	---	191,008	---	32,967
ch vehicle procurement	1972	151,300	2,786	---	921	40,257	852	---	---	---	14,722	80,523	11,239
	1973	221,000	2,651	---	502	74,315	760	---	---	---	15,158	119,012	8,602
	1974	177,000	3,600	---	1,800	44,540	800	---	---	---	12,080	111,900	2,280
CE OF APPLICATIONS, TOTAL	1972	187,500	25	12,385	345	152,086	1,100	2,829	1,542	---	3,595	3,520	10,073
	1973	188,700	150	14,482	310	147,424	681	6,022	3,030	---	6,996	3,994	5,611
	1974	153,000	300	18,959	5,580	94,251	1,847	4,689	6,986	---	8,552	4,450	7,386
e applications	1972	187,500	25	12,385	345	152,086	1,100	2,829	1,542	---	3,595	3,520	10,073
	1973	188,700	150	14,482	310	147,424	681	6,022	3,030	---	6,996	3,994	5,611
	1974	153,000	300	18,959	5,580	94,251	1,847	4,689	6,986	---	8,552	4,450	7,386
CE OF AERONAUTICS AND PACE TECHNOLOGY, TOTAL	1972	213,511	---	2,202	9,768	3,995	21,162	60	39,735	11,192	48,363	70,096	6,938
	1973	232,500	---	505	6,670	3,605	17,236	91	39,759	13,047	61,040	86,184	4,363
	1974	240,000	---	889	4,240	4,035	13,372	50	48,495	14,903	75,649	76,003	2,364

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1974 ESTIMATES

DISTRIBUTION OF RESEARCH AND DEVELOPMENT BUDGET PLAN BY INSTALLATION AND FISCAL YEAR

(Thousands of dollars)

PROGRAM		TOTAL	Kennedy Space Center	Manned Spacecraft Center	Marshall Space Flight Center	Goddard Space Flight Center	Jet Propulsion Laboratory	Wallops Station	Ames Research Center	Flight Research Center	Langley Research Center	Lewis Research Center
OFFICE OF MANNED SPACE FLIGHT, TOTAL	1972	1,285,475	165,425	430,153	643,175	2,005	668	210	8,873	375	2,872	340
	1973	1,157,200	182,800	494,725	446,360	140	650	150	9,000	250	1,310	150
	1974	1,057,000	120,900	626,485	287,290	300	400	150	8,350	100	550	250
Space Flight Operations	1972	582,775	19,375	159,928	378,620	1,875	630	210	8,773	375	2,502	25
	1973	879,000	179,100	303,125	372,560	140	650	150	9,000	250	1,310	150
	1974	580,500	116,600	255,685	189,090	300	400	150	8,350	100	550	250
Space Shuttle	1972	100,000	300	36,100	59,200	---	---	---	---	---	---	150
	1973	200,000	700	147,300	48,000	---	---	---	---	---	---	---
	1974	475,000	4,100	370,000	97,900	---	---	---	---	---	---	---
Advanced Programs	1972	1,500	150	200	1,150	---	---	---	---	---	---	---
	1973	1,500	---	---	1,500	---	---	---	---	---	---	---
	1974	1,500	200	800	300	---	---	---	---	---	---	---
Apollo	1972	601,200	145,600	233,925	204,205	130	38	---	100	---	370	165
	1973	76,700	3,000	44,300	24,300	---	---	---	---	---	---	---
	1974	---	---	---	---	---	---	---	---	---	---	---
OFFICE OF SPACE SCIENCE, TOTAL	1972	552,900	2,786	1,051	15,606	112,327	77,294	2,670	22,542	---	189,977	80,523
	1973	679,169	2,651	480	23,832	147,212	66,208	2,735	22,651	---	246,254	119,012
	1974	584,000	3,600	11,523	10,610	104,516	61,149	2,705	19,137	---	205,871	111,900
Physics and astronomy	1972	110,100	---	626	14,438	67,266	490	2,620	5,005	---	1,575	---
	1973	126,200	---	130	23,330	68,106	677	2,670	6,895	---	4,555	---
	1974	95,000	---	125	8,785	55,535	660	2,640	6,730	---	2,783	---
Lunar and planetary exploration	1972	291,500	---	425	247	4,804	75,952	50	17,537	---	173,680	---
	1973	331,969	---	350	---	4,791	64,771	65	15,756	---	226,541	---
	1974	312,000	---	11,398	25	4,441	59,689	65	12,407	---	191,008	---
Launch vehicle procurement	1972	151,300	2,786	---	921	40,257	852	---	---	---	14,722	80,523
	1973	221,000	2,651	---	502	74,315	760	---	---	---	15,158	119,012
	1974	177,000	3,600	---	1,800	44,540	800	---	---	---	12,080	111,900
OFFICE OF APPLICATIONS, TOTAL	1972	187,500	25	12,385	345	152,086	1,100	2,829	1,542	---	3,595	3,520
	1973	188,700	150	14,482	310	147,424	681	6,022	3,030	---	6,996	3,994
	1974	153,000	300	18,959	5,580	94,251	1,847	4,689	6,986	---	8,552	4,450
Space applications	1972	187,500	25	12,385	345	152,086	1,100	2,829	1,542	---	3,595	3,520
	1973	188,700	150	14,482	310	147,424	681	6,022	3,030	---	6,996	3,994
	1974	153,000	300	18,959	5,580	94,251	1,847	4,689	6,986	---	8,552	4,450
OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY, TOTAL	1972	213,511	---	2,202	9,768	3,995	21,162	60	39,735	11,192	48,363	70,096
	1973	232,500	---	505	6,670	3,605	17,236	91	39,759	13,047	61,040	86,184
	1974	240,000	---	889	4,240	4,035	13,372	50	48,495	14,903	75,649	76,003

OFFICE OF SPACE SCIENCE, TOTAL	1972	552,900	2,786	1,051	15,606	112,327	77,294	2,670	22,542	---	189,977	80,523
	1973	679,169	2,651	480	23,832	147,212	66,208	2,735	22,651	---	246,254	119,012
	1974	584,000	3,600	11,523	10,610	104,516	61,149	2,705	19,137	---	205,871	111,900
Physics and astronomy	1972	110,100	---	626	14,438	67,266	490	2,620	5,005	---	1,575	---
	1973	126,200	---	130	23,330	68,106	677	2,670	6,895	---	4,555	---
	1974	95,000	---	125	8,785	55,535	660	2,640	6,730	---	2,783	---
Lunar and planetary exploration	1972	291,500	---	425	247	4,804	75,952	50	17,537	---	173,680	---
	1973	331,969	---	350	---	4,791	64,771	65	15,756	---	226,541	---
	1974	312,000	---	11,398	25	4,441	59,689	65	12,407	---	191,008	---
Launch vehicle procurement	1972	151,300	2,786	---	921	40,257	852	---	---	---	14,722	80,523
	1973	221,000	2,651	---	502	74,315	760	---	---	---	15,158	119,012
	1974	177,000	3,600	---	1,800	44,540	800	---	---	---	12,080	111,900
OFFICE OF APPLICATIONS, TOTAL	1972	187,500	25	12,385	345	152,086	1,100	2,829	1,542	---	3,595	3,520
	1973	188,700	150	14,482	310	147,424	681	6,022	3,030	---	6,996	3,994
	1974	153,000	300	18,959	5,580	94,251	1,847	4,689	6,986	---	8,552	4,450
Space applications	1972	187,500	25	12,385	345	152,086	1,100	2,829	1,542	---	3,595	3,520
	1973	188,700	150	14,482	310	147,424	681	6,022	3,030	---	6,996	3,994
	1974	153,000	300	18,959	5,580	94,251	1,847	4,689	6,986	---	8,552	4,450
OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY, TOTAL	1972	213,511	---	2,202	9,768	3,995	21,162	60	39,735	11,192	48,363	70,096
	1973	232,500	---	505	6,670	3,605	17,236	91	39,759	13,047	61,040	86,184
	1974	240,000	---	889	4,240	4,035	13,372	50	48,495	14,903	75,649	76,003
Aeronautical research and technology	1972	109,340	---	---	1,115	---	1,449	60	31,914	9,977	31,666	29,166
	1973	150,640	---	205	880	---	1,172	91	32,479	11,665	46,788	54,493
	1974	171,000	---	199	900	---	850	50	40,216	13,853	60,290	53,241
Space research and technology	1972	74,365	---	2,202	8,140	3,935	16,268	---	7,173	1,215	16,255	16,654
	1973	64,760	---	300	5,465	3,555	13,389	---	6,699	1,382	13,835	18,817
	1974	65,000	---	690	3,340	4,035	11,672	---	7,739	1,050	15,018	20,838
Nuclear power and propulsion	1972	29,806	---	---	513	60	3,445	---	648	---	442	24,276
	1973	17,100	---	---	325	50	2,675	---	581	---	417	12,874
	1974	4,000	---	---	---	---	850	---	540	---	341	1,924
OFFICE OF TRACKING AND DATA ACQUISITION	1972	264,000	---	---	300	185,530	57,181	6,458	---	2,614	1,065	---
	1973	248,331	---	---	---	183,750	43,781	6,500	---	1,650	700	---
	1974	250,000	---	---	---	182,300	46,100	6,500	---	1,650	600	---
OFFICE OF TECHNOLOGY UTILIZATION	1972	5,000	---	---	---	---	---	---	---	---	---	---
	1973	4,000	---	---	---	---	---	---	---	---	---	---
	1974	4,000	---	---	---	---	---	---	---	---	---	---
TOTAL BUDGET PLAN	1972	2,508,386	168,236	445,791	669,194	455,943	157,405	12,227	72,692	14,181	245,872	154,479
	1973	2,509,900	185,601	510,192	477,172	482,131	128,556	15,498	74,440	14,947	316,300	209,340
	1974	2,288,000	124,800	657,856	307,720	385,402	122,868	14,094	82,968	16,653	291,222	192,603

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OFFICE OF SPACE SCIENCE, TOTAL	1972	552,900	2,786	1,051	15,606	112,327	77,294	2,670	22,542	---	189,977	80,523	48,124
	1973	679,169	2,651	480	23,832	147,212	66,208	2,735	22,651	---	246,254	119,012	48,134
	1974	584,000	3,600	11,523	10,610	104,516	61,149	2,705	19,137	---	205,871	111,900	52,989
Physics and astronomy	1972	110,100	---	626	14,438	67,266	490	2,620	5,005	---	1,575	---	18,080
	1973	126,200	---	130	23,330	68,106	677	2,670	6,895	---	4,555	---	19,837
	1974	95,000	---	125	8,785	55,535	660	2,640	6,730	---	2,783	---	17,742
Lunar and planetary exploration	1972	291,500	---	425	247	4,804	75,952	50	17,537	---	173,680	---	18,805
	1973	331,969	---	350	---	4,791	64,771	65	15,756	---	226,541	---	19,695
	1974	312,000	---	11,398	25	4,441	59,689	65	12,407	---	191,008	---	32,967
Launch vehicle procurement	1972	151,300	2,786	---	921	40,257	852	---	---	---	14,722	80,523	11,239
	1973	221,000	2,651	---	502	74,315	760	---	---	---	15,158	119,012	8,602
	1974	177,000	3,600	---	1,800	44,540	800	---	---	---	12,080	111,900	2,280
OFFICE OF APPLICATIONS, TOTAL	1972	187,500	25	12,385	345	152,086	1,100	2,829	1,542	---	3,595	3,520	10,073
	1973	188,700	150	14,482	310	147,424	681	6,022	3,030	---	6,996	3,994	5,611
	1974	153,000	300	18,959	5,580	94,251	1,847	4,689	6,986	---	8,552	4,450	7,386
Space applications	1972	187,500	25	12,385	345	152,086	1,100	2,829	1,542	---	3,595	3,520	10,073
	1973	188,700	150	14,482	310	147,424	681	6,022	3,030	---	6,996	3,994	5,611
	1974	153,000	300	18,959	5,580	94,251	1,847	4,689	6,986	---	8,552	4,450	7,386
OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY, TOTAL	1972	213,511	---	2,202	9,768	3,995	21,162	60	39,735	11,192	48,363	70,096	6,938
	1973	232,500	---	505	6,670	3,605	17,236	91	39,759	13,047	61,040	86,184	4,363
	1974	240,000	---	889	4,240	4,035	13,372	50	48,495	14,903	75,649	76,003	2,364
Aeronautical research and technology	1972	109,340	---	---	1,115	---	1,449	60	31,914	9,977	31,666	29,166	3,993
	1973	150,640	---	205	880	---	1,172	91	32,479	11,665	46,788	54,493	2,867
	1974	171,000	---	199	900	---	850	50	40,216	13,853	60,290	53,241	1,401
Space research and technology	1972	74,365	---	2,202	8,140	3,935	16,268	---	7,173	1,215	16,255	16,654	2,523
	1973	64,760	---	300	5,465	3,555	13,389	---	6,699	1,382	13,835	18,817	1,318
	1974	65,000	---	690	3,340	4,035	11,672	---	7,739	1,050	15,018	20,838	618
Nuclear power and propulsion	1972	29,806	---	---	513	60	3,445	---	648	---	442	24,276	422
	1973	17,100	---	---	325	50	2,675	---	581	---	417	12,874	178
	1974	4,000	---	---	---	---	850	---	540	---	341	1,924	345
OFFICE OF TRACKING AND DATA ACQUISITION	1972	264,000	---	---	300	185,530	57,181	6,458	---	2,614	1,065	---	10,852
	1973	248,331	---	---	---	183,750	43,781	6,500	---	1,650	700	---	11,950
	1974	250,000	---	---	---	182,300	46,100	6,500	---	1,650	600	---	12,850
OFFICE OF TECHNOLOGY UTILIZATION	1972	5,000	---	---	---	---	---	---	---	---	---	---	5,000
	1973	4,000	---	---	---	---	---	---	---	---	---	---	4,000
	1974	4,000	---	---	---	---	---	---	---	---	---	---	4,000
TOTAL BUDGET PLAN	1972	2,508,386	168,236	445,791	669,194	455,943	157,405	12,227	72,692	14,181	245,872	154,479	112,366
	1973	2,509,900	185,601	510,192	477,172	482,131	128,556	15,498	74,440	14,947	316,300	209,340	95,723
	1974	2,288,000	124,800	657,856	307,720	385,402	122,868	14,094	82,968	16,653	291,222	192,603	91,814

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1974 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR

MANNED SPACE FLIGHT PROGRAMS

(Thousands of Dollars)

Programs	Budget Plan FY 1972	Budget Plan FY 1973	Budget Plan FY 1974	FY 1973 Funds Applied to FY 1974 Program	FY 1974 Budget Authority Requested
Space flight operations	582,775	879,000	580,500	25,000	555,500
Space shuttle.....	100,000	200,000	475,000	---	475,000
Advanced missions.....	1,500	1,500	1,500	---	1,500
Apollo.....	601,200	76,700	---	---	---
Total.....	1,285,475	1,157,200	1,057,000	25,000	1,032,000

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1974 ESTIMATES

BUDGET SUMMARY

OFFICE OF MANNED SPACE FLIGHT — SPACE FLIGHT OPERATIONS PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1972	1973	1974
Skylab	$538,500,000	$502,000,000	$233,800,000
Apollo Soyuz test project	6,900,000	38,500,000	90,000,000
Development, test and mission operations	(319,881,000)	294,000,000	220,200,000
Space life sciences	19,775,000	23,500,000	21,000,000
Mission systems and integration	17,600,000	21,000,000	15,500,000
Total	$582,775,000	$879,000,000	$580,500,000
FY 1973 funds applied to FY 1974 program			-25,000,000
Budget authority requested			$555,500,000

Distribution of Program Amount by Installation:

John F. Kennedy Space Center	$19,375,000	$179,100,000	$116,600,000
Manned Spacecraft Center	159,928,000	303,125,000	255,685,000
Marshall Space Flight Center	378,620,000	372,560,000	189,090,000
Goddard Space Flight Center	1,875,000	140,000	300,000
Jet Propulsion Laboratory	630,000	650,000	400,000
Wallops Station	210,000	150,000	150,000
Ames Research Center	8,773,000	9,000,000	8,350,000
Flight Research Center	375,000	250,000	100,000
Langley Research Center	2,502,000	1,310,000	550,000
Lewis Research Center	25,000	150,000	250,000
NASA Headquarters	10,462,000	12,565,000	9,025,000
Total	$582,775,000	$879,000,000	$580,500,000

HIGHLIGHTS OF BUDGET PLAN

Skylab

The FY 1974 requirements include the launch, mission operations and associated support of the Skylab launches which begin in the Spring of 1973 and extend through a period of approximately eight months.

	1972	1973	1974
Workshop Cluster - Maintenance of critical orbital workshop, multiple docking adapter, airlock, and telescope mount activities including systems engineering and integration; mission operations support to the workshop (launch in Spring of 1973) flight anomaly analysis and resolution; reduction, analysis and evaluation of flight data; backup workshop capability; and contract closeout.....	$278,401,000	$174,600,000	$45,700,000
Experiment Development - Application and science, technology and engineering, and biomedical activities including pre- and post-launch efforts of principal investigators; postdelivery hardware support; operational experiment data collection and analysis during the missions; and postflight data reduction and analysis.....	49,742,000	35,800,000	18,400,000
Payload Integration - Maintenance of contractor inplant capability in support of two manned flights in FY 1974 plus a potential rescue mission. Included are: configuration and interface management; stowage and government furnished equipment support; mission operations support; systems engineering; dynamics cluster control and thermal analyses; failure mode and effects analyses; and postflight documentation.....	32,591,000	23,500,000	10,000,000
Program Support - Support of a wide range of activities outside major prime contractor structure. Included are: operation of automatic checkout equipment in support of the telescope mount; analytic and diagnostic testing; calibration rocket data analysis; program-wide systems engineering; earth-based astronomy supporting			

	1972	1973	1974
Program Support (Cont'd) orbital astronomy observations; student project; and contract administration services.....	$31,823,000	$39,300,000	$13,400,000
Space Vehicles - Launch vehicle and spacecraft prelaunch checkout and launch support for two launches in FY 1974 (initial launches Spring of 1973); maintenance of Saturn V launch vehicle for potential backup workshop launch; maintenance of inplant flight support to resolve anomalies, accomplish required modifications, perform postflight analyses, and provide logistics support; contractor inplant flight and postflight support of guidance and navigation hardware and software, and government furnished equipment; contractor real time mission support; and contract closeout.....	136,388,000	228,800,000	146,300,000
Operations - As in FY 1973, FY 1974 requirements are included under Development, Test, and Mission Operations.....	9,555,000	---	---
Total, Skylab.....	$538,500,000	$502,000,000	$233,800,000

Apollo Soyuz Test Project

The FY 1974 Apollo Soyuz Test Project effort includes modification of existing hardware and development and testing of new hardware in preparation for the 1975 launch of an Apollo spacecraft to rendezvous with a USSR Soyuz spacecraft.

Command and Service Module - Spacecraft and launch adapter modifications; guidance and navigation requirements; ground testing; integration, checkout and reliability engineering support; and contract administration.....	$2,900,000	$15,000,000	$28,300,000

	1972	1973	1974
Docking Module and Docking System - Fabrication, assembly and checkout of test and flight articles; ground testing; and engineering support...	$3,800,000	$17,400,000	$25,700,000
Experiments - Experiment design, development and testing.....	---	1,000,000	4,600,000
Launch Vehicle - Definition of modifications and associated design, development and testing; launch vehicle support; and update of ground support equipment and the system development facility.....	---	---	9,500,000
Launch Operations - Contractor support to modify, test and checkout of launch facilities and ground support equipment in preparation for launch operations.....	---	---	8,500,000
Flight Support and Operations - Engineering support of command and service module, docking module and docking system; camera system maintenance; food and waste system and bioinstrumentation requirements; command and service module fuels and transportation; and procurement of space suits, crew provisions and television.....	200,000	5,100,000	13,400,000
Total, Apollo Soyuz Test Project.	$6,900,000	$38,500,000	$90,000,000
Development, Test and Mission Operations			
Research and Test Operations			
Engineering and Test - Engineering support and test activities involving propulsion, structures, materials, life support, information systems, guidance and control, and telemetry/communications systems.....	$(62,852,000)	$60,600,000	$33,300,000

	1972	1973	1974
Applications and Science - Real time support of Skylab earth resources experiments; continued Apollo lunar science data analysis assistance; research and development of remote sensing and data processing techniques; and biomedical support of spacecraft design; operational support related to flight crew health; and space flight medical studies.....	$(13,162,000)	$9,600,000	$9,700,000
Reliability, Quality and Safety - Support activities involving reliability assurance, risk analysis, tests, checkout, subsystems, components, and support equipment as related to manufacture, delivery, prelaunch checkout, and launch of space vehicles and payloads.....	(9,008,000)	10,000,000	6,700,000
Total, Research and Test Operations.....	$(85,022,000)	$80,200,000	$49,700,000
Crew and Flight Operations			
Crew - Crew training; hardware update of simulators and trainers; pilot equipment; and operational activities involving mission simulators, part task trainers, and aircraft.....	$(22,061,000)	$16,600,000	$14,100,000
Flight - Mission planning; flight control; computation facility operation including the data reduction complex; Skylab recovery; mission planning update; computer modifications related to experiment data conversion; crew procedure updates.....	(18,665,000)	19,800,000	13,900,000

	1972	1973	1974
Mission Control - Maintenance and operation of the mission control center including the real time computer complex and the display/control, communication command and telemetry, voice communication, and the mission simulation, checkout and training systems.....	$(43,592,000)	$38,500,000	$33,700,000
Total, Crew and Flight Operations.....	$(84,318,000)	$74,900,000	$61,700,000
Operations Support			
Manned Space Flight installation activities including technical facility maintenance and operation; postlaunch refurbishment; renovations; rigging; closed circuit television related to training and test facilities; documentation and technical report preparation; logistic support; chemical purging services; design and drafting involving launch equipment and facilities; telecommunications; and maintenance of technical and production facilities.....	$(59,702,000)	$68,600,000	$58,400,000
Total, Operations Support....	$(59,702,000)	$68,600,000	$58,400,000
Launch Systems Operations			
Mechanical Ground Systems - Operation and maintenance of launch complex facilities and related equipment including the mobile service structure, altitude chambers, propellant loading systems, pneumatics, and VAB adjustable platforms; launch-related services involving propellant handling, life support, technical shops, chemical cleaning and decontamination, and systems safety....	$(48,757,000)	$36,100,000	$27,600,000

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	1972	1973	1974
Electrical Instrumentation Systems - Operation and maintenance of electrical/electronic and launch instrumentation systems including automatic checkout equipment, operational voice and TV communications, measurements, telemetrics, and other electrical/electronic systems.....	$(32,757,000)	$34,200,000	$22,800,000
Total, Launch Systems Operations.....	$(81,514,000)	$70,300,000	$50,400,000
OMSF Engineering Support.....	$(9,325,000)	---	---
Total, Development, Test and and Mission Operations.....	$(319,881,000)	$294,000,000	$220,200,000
Space Life Sciences			
Space Life Research - Medical, behavioral and biological research, and flight experiments involving human body functions as related to weightlessness, space radiation, and biological rhythm alterations.....	$8,499,000	$11,040,000	$9,700,000
Life Support and Protective Equipment - Advancement of technology through development and testing of experimental life support and protective devices including environment control life support systems, spacesuits and portable life support systems.....	7,261,000	7,960,000	7,000,000
Bioinstrumentation and Man-Machine Technology - Advancement of technology through development, test and utilization of bioinstrumentation; bioassay concepts; medical, physiological, and performance measurement equipment; and human augmentation devices such as teleoperators.....	4,015,000	4,500,000	4,300,000
Total, Space Life Sciences.....	$19,775,000	$23,500,000	$21,000,000

	1972	1973	1974
Mission Systems and Integration			
Mission and Payload Integration - Studies and analyses involving low cost payload concepts; development of payload design criteria and requirements; retrieval, repair and payload refurbishment studies; payload traffic and capture analyses; and payload and carrier vehicle characteristic analyses...	$10,500,000	$6,000,000	$5,500,000
Sortie Lab/Concept Verification Testing - Support of definition studies including design and construction of engineering mock-ups; design, analysis and testing of atmospheric cooling concepts; subsystem design studies; and concept verification testing involving the integration and verification of operational concepts.....	---	6,000,000	2,500,000
Advanced Development - Development of long lead items, experimental systems, and operational techniques; establishment of specifications and design requirements for planned and potential manned space flight programs; and technology development involving Space Tug requirements.....	a/	9,000,000	7,500,000
Space Station.....	7,100,000	---	---
Total, Mission Systems and Integration.....	$17,600,000	$21,000,000	$15,500,000

a/ Funded under Apollo in FY 1972 and prior years.

FLIGHT SCHEDULE

PROJECT	MISSION	CALENDAR YEAR
Skylab	Workshop Cluster	Spring 1973
Skylab	First Manned Mission	Spring 1973
Skylab	Second Manned Mission	Summer 1973
Skylab	Third Manned Mission	Fall 1973
Apollo Soyuz Test Project	International Test Docking	Summer 1975

ALSEPs still producing usable scientific data, the Particles and Fields Satellite left in lunar orbit by Apollo 15, and Skylab.

In the unmanned space flight area, the number of satellites requiring support in FY 1974 is expected to average approximately 40 satellites, and it will be necessary to make continuing adjustments in priorities of all satellites supported to assure adequate coverage within the total STDN capability. Of the new satellites to be launched, the Atmospheric Explorer-C, Radio Astronomy Explorer-B, Nimbus F, and ATS-F missions will impose a substantial workload on the network due to their unique support requirements. The overall workload for the STDN is indicated in the accompanying charts.

Deep Space Network Operations

The primary function of the Deep Space Network is to support planetary and interplanetary space flight missions. In the past these missions have involved spacecraft traveling to Venus and Mars, distances up to two hundred million miles from the earth. Future missions will travel to Jupiter and beyond, involving distances of six hundred million miles and greater. As a result of these great distances, the facilities in this network which receive the data must be able to perform critical functions using extremely low signal levels. As flight distances continue to increase and the missions become more complex, equipment designs and computer program techniques are required in this network which truly push the state of the art in interplanetary communications.

The Deep Space Network: (a) provides tracking data which are used to determine and make corrections and changes to spacecraft trajectories, (b) acquires engineering telemetry data for determining performance of the spacecraft, (c) transmits commands to the spacecraft, and (d) receives and records the scientific and engineering data which are acquired from the spacecraft. The network stations are located at Goldstone, California; Canberra, Australia; Madrid, Spain; Johannesburg, South Africa; and Cape Kennedy, Florida.

The control center for the Deep Space Network is the Space Flight Operations Facility (SFOF) at the Jet Propulsion Laboratory in Pasadena, California. The two basic types of functions carried out in the SFOF are network control and mission operations. In the past, both types of functions were under the management responsibility of the Office of Tracking and Data Acquisition. Actual experience over several years of supporting lunar and planetary spaceflight missions has indicated that management responsibilities would be clarified by separating the two types of functions. Accordingly, in FY 1973, the mission operations functions were transferred to the Office of Space

OFFICE OF MANNED SPACE FLIGHT — SPACE FLIGHT OPERATIONS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Space Flight Operations program includes Skylab; the Apollo Soyuz Test Project; and developmental and supporting activities conducted under Development, Test and Mission Operations; Space Life Sciences; and Mission Systems and Integration.

Skylab operations begin in the Spring of 1973 with the launch of the unmanned Orbital Workshop by a two-stage Saturn V vehicle, followed by manned missions using a Saturn 1B launch vehicle and a modified Apollo Command and Service Module. The general objective of the Skylab program is to accomplish scientific, technological, and biomedical investigations in earth orbit. The Skylab orbiting vehicle consists of an S-IVB stage modified into an orbiting laboratory, an Airlock Module, a Multiple Docking Adapter, a Telescope Mount, and a docked Command and Service Module. There will be three manned visits during an eight month period. The crews will conduct experiments involving 270 investigations and representing virtually every scientific field that can benefit from manned operations in near-earth orbit.

The U.S. and the USSR have agreed to jointly implement the Apollo Soyuz Test Project to develop and test a system for rendezvous and docking of future manned spacecraft and stations that would be suitable for use as a standard international system. Basically, this is a manned flight experiment involving the rendezvous and docking of a manned Apollo spacecraft with a manned Soyuz spacecraft. The Soyuz spacecraft will be launched from the USSR. The Apollo spacecraft will then be launched from the U.S. and will rendezvous with the Soyuz spacecraft in orbit where joint docked operations, including crew transfer, will be accomplished.

Development, Test and Mission Operations encompasses the basic engineering and test operations conducted by Manned Space Flight field centers in support of all programs, together with the provisions for crew training, and launch, flight, and operational support required for space flight missions.

Space Life Sciences complements on-going and planned space activities through ground-based and flight research projects involving studies of man as an operator and controller of hardware in space. Space Life Sciences provides for the requisite advanced technology development of systems designed to support and protect the life of man or to extend his capabilities in space.

Mission Systems and Integration encompasses work essential to the planning and preparation for future manned space flights. The principal areas of activity are: mission and payload integration, Sortie Laboratory studies and concept verification testing, and advanced development.

BASIS OF FUND REQUIREMENTS:

Skylab

The launch of the Skylab workshop cluster this Spring will mark the beginning of another significant space chapter--the operation of a manned space laboratory with an extensive program of scientific, medical, and engineering experimentation.

Four launches are planned; one unmanned Saturn V flight and three manned Saturn IB flights. Additionally, a rescue capability will be maintained through completion of the last manned mission. The unmanned workshop cluster will be launched from Kennedy Space Center by a two-stage Saturn V launch vehicle and will be inserted into an orbit of approximately 435 kilometers (235 nautical miles) altitude and 50° inclination. The cluster, consisting of the Orbiter Workshop, the Multiple Docking Adapter, the Airlock, and the telescope mount will then be activated by ground command, and telemetry data will be evaluated to assure suitable operational conditions. Upon successful completion of this phase and approximately one day later, the first crew in a Command and Service Module will be launched by a Saturn IB vehicle. After rendezvous and docking with the workshop, the crew will transfer to the workshop and begin in-orbit flight operational activities. A total of three crews will visit the workshop over a period of about eight months and conduct a variety of tasks and experiments in a broad spectrum of scientific, technological and biomedical disciplines. Mission time on the first visit will be 28 days or almost double the mission time of any previous U.S. manned flight. On the second and third visits, the mission time will be increased to 56 days--again doubling the previous experience for consecutive days in space.

In addition to extensive medical and biological experimentation related to long duration flight, the crews will conduct solar astronomy, earth observations, and scientific investigations.

Skylab

	1972	1973	1974
Workshop cluster.....	$278,401,000	$174,600,000	$45,700,000
Experiment development.....	49,742,000	35,800,000	18,400,000
Payload integration.....	32,591,000	23,500,000	10,000,000
Program support.....	31,823,000	39,300,000	13,400,000
Space vehicles.....	136,388,000	228,800,000	146,300,000
Operations.....	9,555,000	---	---
Total, Skylab.....	$538,500,000	$502,000,000	$233,800,000

Workshop Cluster

	1972	1973	1974
Orbital workshop.....	$158,525,000	$93,700,000	$21,300,000
Multiple docking adapter.....	31,248,000	20,100,000	4,000,000
Airlock.....	77,720,000	56,400,000	19,600,000
Telescope mount.....	10,908,000	4,400,000	800,000
Total.....	$278,401,000	$174,600,000	$45,700,000

The Workshop Cluster is the assembly consisting of the Orbital Workshop, the Multiple Docking Adapter, the Airlock, and the Telescope Mount.

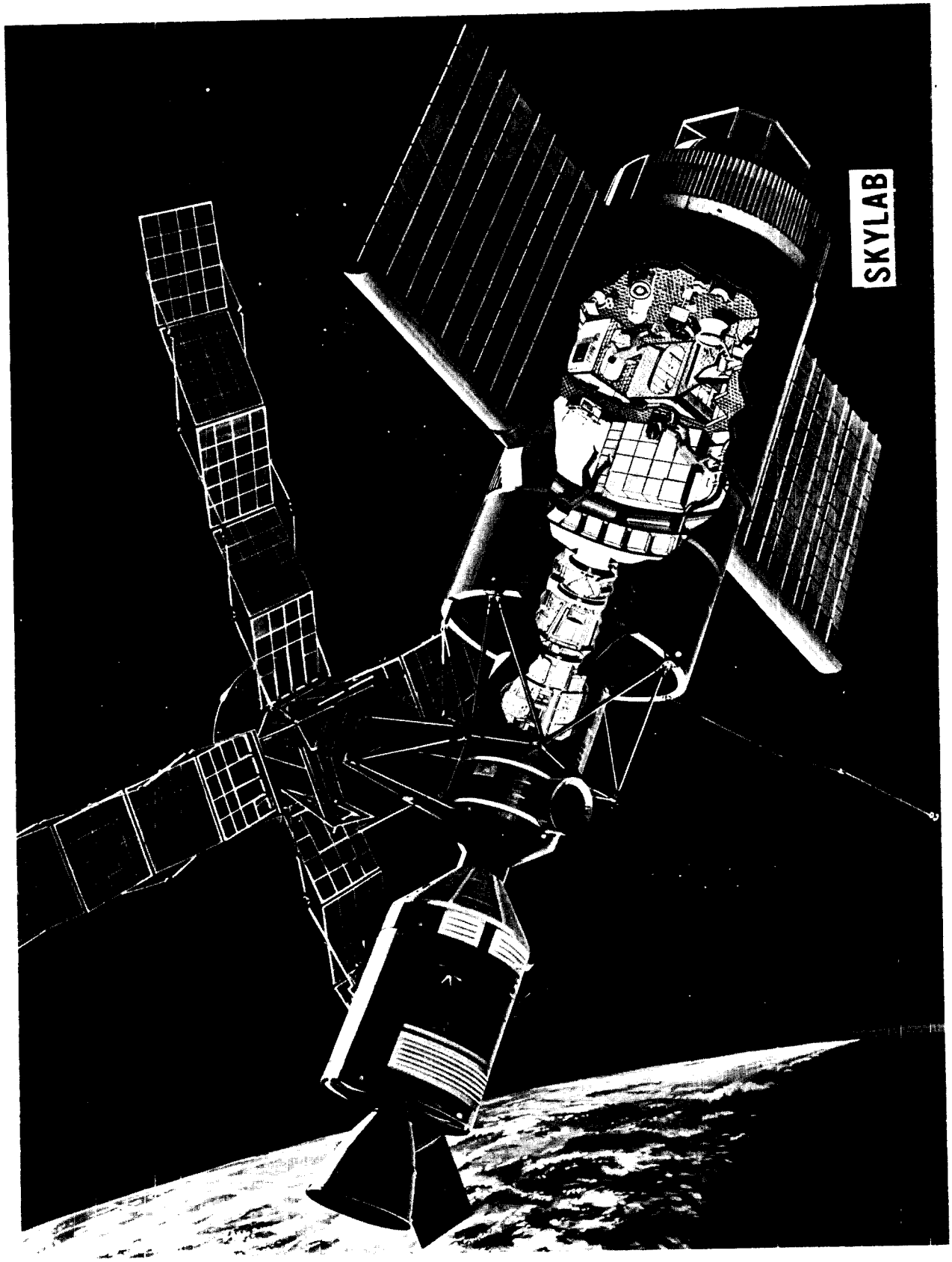
The Orbital Workshop is the primary in-orbit living and working quarters for Skylab crews. It is a modified S-IVB stage originally designed as the third stage of the Saturn V launch vehicle. It was manufactured by the McDonnell Douglas Astronautics Corporation in its Huntington Beach plant in California. The Orbital Workshop is equipped to house the crew of three astronauts for uninterrupted periods of up to 56 days.

The Multiple Docking Adapter provides the docking ports for the arriving and departing Skylab crews. The primary port is the forward end of the adapter module. A contingency port is located on the side.

The Airlock Module constructed at the Eastern Division of the McDonnell Douglas Astronautics Corporation in St. Louis, Missouri, provides the pressurized tunnel through which the Skylab crews can move between the Multiple Docking Adapter and the Workshop. It is also the environmental and electrical control center for Skylab, containing the controls for cluster pressurization and atmosphere purification, electrical power and communications, and the cluster malfunction alarm system (the caution and warning system).

The Telescope Mount houses a sophisticated space observatory for monitoring and recording the sun's behavior to better understand its affect on the earth's environment and on the solar system. It also provides the attitude control or stabilization of the entire cluster and supplies about half the electrical power needed for the cluster through its solar arrays.

FY 1973 funding for the Workshop Cluster has supported the completion of all flight units; fabrication and assembly of the workshop, airlock module and multiple docking adapter backup units and refurbishment of the prototype Telescope Mount as a backup flight article; completion of component qualification testing; the extensive assembly and checkout activities which are now in progress at the Kennedy Space Center; and the contractor in-plant support required during the prelaunch and launch activities and the initial in-orbit activities of the Workshop.



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FY 1974 funds are required for major critical activities required until splashdown of the final revisit mission. The key elements of the industrial team of specialists established early in the Skylab program will remain intact to perform the necessary system engineering and integration; support mission operations; to conduct confidence testing of backup hardware in support of the orbiting workshop; and to perform the reduction, analysis, and evaluation of flight data including flight anomalies. FY 1974 funding will also provide for maintaining, through September 1973, the personnel, equipment, and facilities required to support the completion, checkout and launch of the backup Workshop Cluster. In addition, funds are required to close out the cluster contracts upon conclusion of the flight phase of Skylab activity.

Experiment Development

	1972	1973	1974
Applications and science.....	$23,368,000	$18,600,000	$12,100,000
Technology and engineering.....	22,724,000	15,600,000	5,200,000
Biomedical.....	3,650,000	1,600,000	1,100,000
Total.....	$49,742,000	$35,800,000	$18,400,000

Approximately 70 experiments, utilizing 57 instruments and providing data for 270 separate investigations, have been developed for the Skylab program. These experiments are installed in the Workshop, Command and Service Modules, Multiple Docking Adapter, Telescope Mount, Airlock Module, and Instrument Unit.

Applications and Science embraces three basic areas of earth orbit experiments: Earth Resources, Solar Physics and Astrophysics.

Earth Resources - The Skylab Earth Resources Experiment Package will test and validate remote sensing techniques and their application to the study of crop and forestry cover; health state of vegetation; types of soil; water storage in snow pack; surface or near surface mineral deposits; sea state; sea surface temperature; and the location of likely feeding areas for fish. Comprehensive surveys of such resources will provide data to help cope with problems such as food supplies, mineral shortages, energy needs, environment pollution and expanding patterns of human settlements. Acquired data will be correlated with information obtained simultaneously about the ground truth sites from aircraft and/or from in situ measurements, and will complement the Earth Resources Technology Satellite measurements. The data acquired with the Earth Resources Experiment Package will be analyzed by 146 principal investigators in the study of 170 specific problems. The individual investigators are affiliated with private and governmental organizations located in 31 states, the District of Columbia, the Canal Zone, 20 foreign countries, and the United Nations.

Solar Physics - The solar experiments represent the first step taken by our country's space program toward a large and sophisticated manned space observatory. Since the observatory will be operated above the shielding affects of the earth's atmosphere, data of unmatched quality will be obtained and will appreciably advance our knowledge of the sun. Skylab astrophysical experiments cover the areas of ultraviolet airglow horizon photography; gegenschein/zodiacal light; particle collection; nuclear emulsion; ultraviolet stellar astronomy; galactic x-ray mapping; and ultraviolet panorama.

The Technology and Engineering experiments include zero-g systems studies, and space environment and material processing investigations. Experiments oriented toward the interaction of man with his new zero gravity environment involve habitability and crew quarters, astronaut maneuvering equipment; crew activities and maintenance; manual navigation sightings; and the effect of crew movement on vehicle stabilization.

Experiments designed to study the spacecraft environment, both natural and induced, involve radiation in the spacecraft, thermal coatings, inflight aerosol analysis, and contamination measurement.

The material processing investigations will involve flammability experiments in zero gravity; the demonstration of a materials processing facility for use in space; the study of the behavior of molten metals in space, of structures formed in metals melted and rapidly solidified, and of the joining of metals by electron beam welding; the demonstration of the ability to cast highly spherical structures from molten metal; alloy casting in the absence of gravity and thermal convection to obtain more perfect structures with improved strength characteristics; and the study of crystal growth by growing single crystals to produce material of exceptionally high chemical and crystalline perfection. The special condition of virtual weightlessness in orbital flight makes it possible to perform these materials processing experiments. Melting and mixing without the contaminating effects of containers, the suppression of convection and buoyancy in liquids and molten material, and control of voids open the way to new knowledge of material properties and processes and ultimately to valuable new products for use on earth. These potential products range from new alloys with highly specialized physical properties, to large highly perfect crystals, with valuable electrical and optical properties.

Biomedical - Each manned mission in the United States space program was built upon the cumulative experience of preceding flights. Skylab will fly men in a larger spacecraft, with more varied activities, and for longer times than any previous flight. It will provide the test conditions under which the medical effects observed from previous missions can be studied more extensively than has previously been possible.

The Skylab Biomedical program consists of four parts, each designed for separate purposes:

1. The actual stay of three men in space, with the associated operational medical monitoring and the observations of crew performance in a wide variety of scientific and operational tasks. These observations are designed to verify our expectations that man can perform safely and effectively in space.

2. Medical experiments designed to investigate in depth the physiological effects revealed on previous flights. The results of these experiments will provide greater understanding of the factors which could limit the duration of man's stay in space.

3. Biology experiments designed to study fundamental biological processes in the weightless environment which might ultimately be the factors limiting the survival time of any animal in space.

4. Biotechnology experiments directed toward advancing the effectiveness of man-machine systems in space operations and improving the technology of space-borne bioinstrumentation.

FY 1973 Experiment Development funding provides for completion of experiment fabrication and testing; the integration and checkout of the equipment in the flight stages; the integration of flight type training hardware into the crew trainer; retrofit activity; the preparation for data acquisition; the activities of principal investigators and contractors during the launch checkout period; and data analysis during the initial operational period of the Skylab project.

FY 1974 Experiment Development funding will provide for: the prelaunch and postlaunch activities of principal investigators and contractors; post-delivery hardware support; operational experiment data collection and analyses during the mission; and for postflight data reduction and analysis up to one year after the data has been turned over to the investigators.

Payload Integration

	1972	1973	1974
Payload integration.....	$32,591,000	$23,500,000	$10,000,000
Total.....	$32,591,000	$23,500,000	$10,000,000

Payload Integration activities insure that proper relationships and interfaces exist among all elements of the program: the Workshop Cluster, the experiment hardware, the launch vehicle, and the Saturn IB/Command and Service Module logistics system. The Martin Marietta Corporation, Denver Division, is the prime contractor responsible for the payload integration effort.

FY 1973 funding provides for mission planning and analysis, configuration and interface management, support requirements, flight planning and flight crew and man-machine integration, mechanics and structure analysis, systems engineering, and documentation.

FY 1974 funding will provide for maintenance of contractor in-plant capability necessary to support the two manned flights scheduled in FY 1974, as well as a possible rescue Saturn IB/Command and Service Module flight. This includes configuration and interface management, stowage and government furnished equipment support, mission operations support, systems engineering, dynamics cluster control and thermal analyses, failure mode and effects analyses, and postflight documentation.

Program Support

	1972	1973	1974
Program support	$31,823,000	$39,300,000	$13,400,000
Total	$31,823,000	$39,300,000	$13,400,000

FY 1973 and FY 1974 funding provides for a wide range of activities outside of the major prime hardware contractor structure. Included are: operation of the Automatic Checkout Equipment station in support of the Telescope Mount at the Marshall Space Flight Center; analytic and diagnostic testing; calibration-rocket data analysis; program-wide systems engineering in support of the Skylab Program Office; the earth-based astronomy program designed to complement the in-orbit astronomy observations; the student experiments project; and reimbursement to the Department of Defense for contract administration services.

Space Vehicles

	1972	1973	1974
Saturn V	$4,100,000	$56,600,000	$29,700,000
Spacecraft	92,706,000	106,900,000	52,100,000
Saturn IB	39,582,000	65,300,000	64,500,000
Total	$136,388,000	$228,800,000	$146,300,000

The Skylab Space Vehicles funding covers the effort associated with the Saturn V and Saturn IB launch vehicles and modified Apollo spacecraft used to launch the workshop cluster and to conduct the manned missions. The basic space vehicle hardware was procured as part of the Apollo program.

Saturn V - The first two powered stages of the Skylab launch vehicle, the S-IC and S-II stages, are essentially the same as those used on the Apollo Saturn V missions. The third stage of the Saturn V is replaced by the Orbital Workshop. The instrument unit, which includes the tracking, command, measuring, and telemetry systems, completes the Skylab Saturn V launch vehicle. There are two Skylab Saturn V launch vehicles, one to launch the workshop cluster, the other to launch the backup workshop if required.

Spacecraft - Four modified Apollo Command and Service Modules are assigned to the Skylab missions. Three are for the primary manned missions. The fourth is the backup rescue spacecraft. Required spacecraft modifications have been made to accommodate the different operational and support requirements of Skylab including longer mission duration, new orbital rendezvous requirements, cluster support requirements, mission attitude constraints, and increased return payload. These modifications include removal of one fuel cell and the provision of electrical umbilical connectors to the workshop; insulation heaters and control wiring installed in the Service Module to permit long duration propellant storage at low temperature; removal of three large unneeded Service Module propellant and pressurization tanks to save weight; provision of a battery pack to allow reactivation of the Command Module prior to undocking and reentry; changes to the caution, warning and communications subsystems to facilitate operations within the cluster; guidance and control system software changes unique to Skylab; and special provisions for experiments to be carried in the Command and Service Module.

Saturn IB - The Skylab program includes four Saturn IB launch vehicles. Three vehicles are assigned to the primary manned missions; the fourth will be available for a backup or rescue launch. The major components of the Saturn IB launch vehicle are the S-IB and S-IVB stages, and the instrument unit. The Saturn IB launch vehicles were completed several years ago and placed in storage.

FY 1973 Space Vehicle funding provides for the vehicle stage and spacecraft checkout activities at the Kennedy Space Center; contractor supporting activities related to the launch vehicle engine, ground support equipment, and vehicle systems; in-plant checkout of the third spacecraft; and the systems installation and checkout of the rescue/backup spacecraft. FY 1973 funds will also provide for contractor in-plant flight support. This includes preflight and postflight problem resolution, design support for modification kits, and laboratory and test support for qualification failure analysis.

FY 1974 Space Vehicle funding will provide prelaunch checkout and launch support for the second and third revisit missions and a rescue mission; and for the maintenance of a Saturn V launch vehicle to permit launch of a backup workshop cluster within 15 months from a go-ahead decision. This capability will be maintained through September 1973. FY 1974 funding also provides for the maintenance of an in-plant stage and engine contractor flight support capability to resolve anomalies encountered during launch preparations,

perform any necessary modifications, provide postflight analysis, and to perform logistic support activities. Additionally, FY 1974 funding provides for: contractor in-plant support necessary during the mission including flight and postflight support for guidance and navigation software and hardware, and government furnished equipment (i.e., suits, astronaut life support assembly, etc.); and real time mission support by the support contractors. Funding will also provide for an orderly phasedown and contract closeout.

Operations

	1972	1973	1974
Operations.....	$9,555,000	---	---
Total.....	$9,555,000	---	---

As in FY 1973, no funds are being requested in Skylab Operations in FY 1974. These activities are included in Development, Test and Mission Operations.

Apollo Soyuz Test Project

As part of the agreement on cooperation in space between the United States and the Soviet Union which President Nixon signed in Moscow on May 24, 1972, both countries have agreed to develop compatible rendezvous and docking systems for future generations of manned spacecraft and to conduct a joint experimental flight during 1975 to test these systems. Joint US-USSR working groups have been meeting on a scheduled basis to review and agree on the numberous technical and operational aspects of this joint mission. The test mission, designated the Apollo Soyuz Test Project (ASTP), will be a joint flight experiment to rendezvous and dock a manned Apollo spacecraft with a manned Soyuz-type spacecraft. The Soyuz-type spacecraft will be launched from the USSR prior to launch of the Apollo spacecraft. The Apollo spacecraft will be launched from the U.S. to rendezvous with the Soyuz in a nominal circular orbit where joint docked operations, including crew transfer, will be accomplished.

The ASTP mission will include the testing of a compatible rendezvous system in orbit; testing of universal docking assemblies; verification of techniques from transfer of astronauts and cosmonauts; activities by U.S. and USSR crews in docked flight; development of experience for the possible conduct of future joint flights by U.S. and USSR spacecraft, including, in case of necessity, rendering aid in emergency situations; and the performance of experiments.

The major U.S. program elements for the ASTP mission include an Apollo Command and Service Module, a docking module and docking system, a Saturn IB launch vehicle, experiments, launch operations, and flight support and operations. The docking module and docking system include all hardware necessary to achieve compatibility of rendezvous and docking systems with the USSR Soyuz-type spacecraft. The docking module and system will be stowed in the

spacecraft launch adapter and extracted by the Command and Service Module while in earth orbit in a manner similar to that performed with the Lunar Module on an Apollo lunar mission. The launch is planned for July 1975.

Apollo Soyuz Test Project

	1972	1973	1974
Command and service module.....	$2,900,000	$15,000,000	$28,300,000
Docking module and docking system	3,800,000	17,400,000	25,700,000
Experiments.....	---	1,000,000	4,600,000
Launch vehicle.....	---	---	9,500,000
Launch operations.....	---	---	8,500,000
Flight support and operations....	200,000	5,100,000	13,400,000
Total.....	$6,900,000	$38,500,000	$90,000,000

Command and Service Module

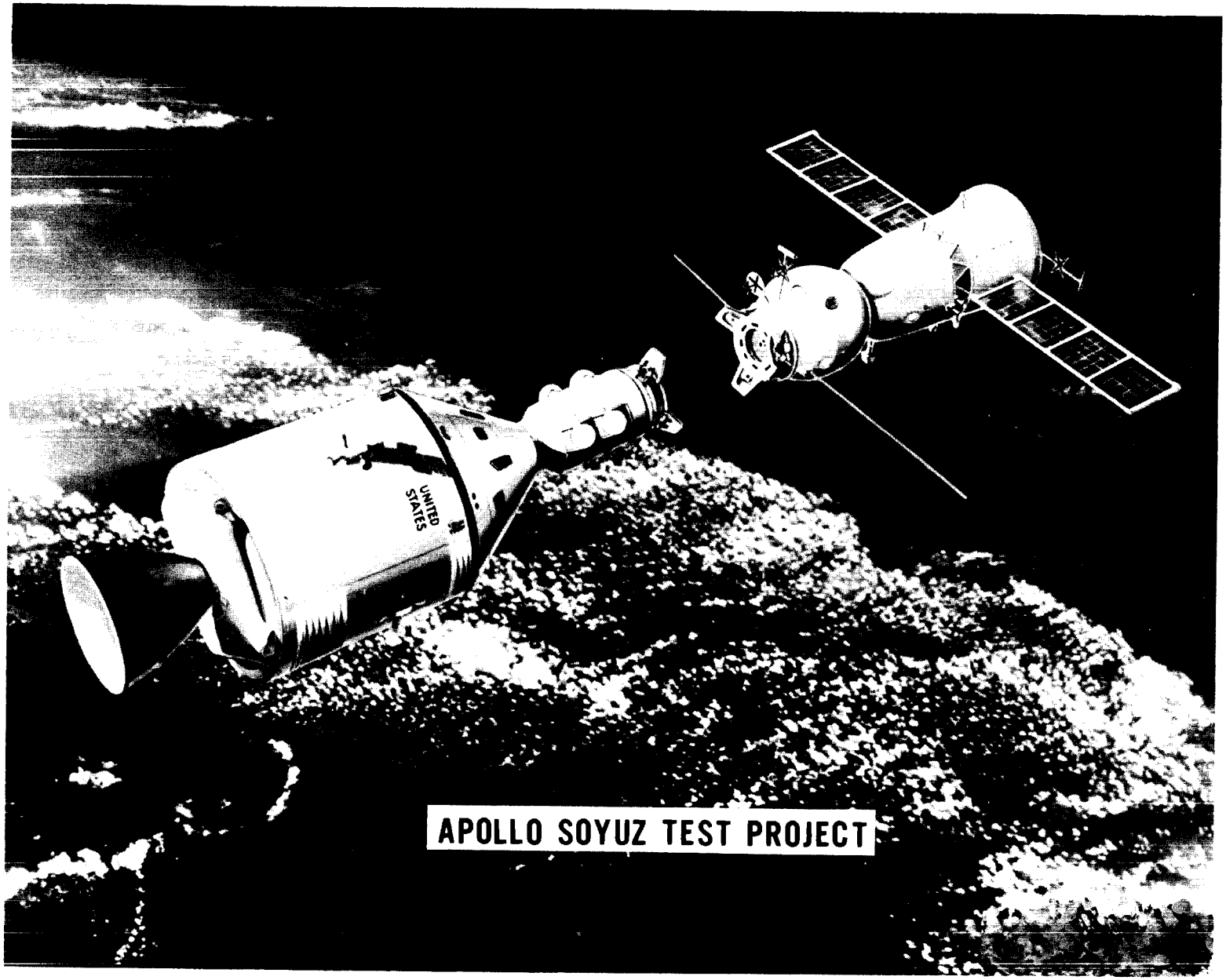
An Apollo spacecraft and a new system consisting of a docking module and docking system will be used for the rendezvous and docking test mission. The Apollo spacecraft will be a modified version of the Command and Service Module flown during the first several lunar landing missions. The modifications will include additional propellant tanks for the reaction control system, heaters for thermal control, and the addition of controls and displays required for the proper operation of the docking module and docking system.

FY 1973 funding provides for initial spacecraft modification design, development, test and engineering work. FY 1973 funding also provides for engineering support, ground support equipment maintenance and operation, and contract administration.

FY 1974 funding will provide for spacecraft modifications; spacecraft launch adapter modifications including a truss to accommodate the docking module during launch; guidance and navigation requirements; and required ground testing. FY 1974 funding also provides for engineering support in the areas of integration, checkout and reliability of the spacecraft; the maintenance and operation of spacecraft ground equipment; and contract administration services provided by the Department of Defense on a reimbursable basis.

Docking Module and Docking System

The docking module is cylindrical in shape and is approximately 1.5 meters (five feet) in diameter and three meters (ten feet) in length. It will serve as an airlock for the internal transfer of crewmen between the different atmospheres of the two spacecraft. In addition, much of the new equipment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will be located in this structure. The docking module will be equipped with radio communications, antennas, stored gases, a thermal control loop, and the displays and controls necessary for safe operations of the two different pressure levels. For this operation, hatches with manual controls will be installed on either end of the module, which is scaled to handle two crewmen simultaneously. Additionally, a new universal docking system will be located on the forward end of the module and will be capable of functioning with identical components on the Soyuz-type spacecraft.

FY 1973 funds provide for initial docking module and docking system design, development, test and engineering efforts including engineering support activities.

FY 1974 funding will provide for fabrication, assembly and checkout of the docking module and docking system test and flight articles; required ground qualification testing; and engineering support in the areas of integration, checkout and reliability.

Experiments

FY 1973 activities are being directed to the identification and definition of candidate ASTP experiments.

FY 1974 funding will provide for the design, development and testing of the experiments selected for the Apollo Soyuz mission.

Launch Vehicle

ASTP will utilize residual Apollo-Skylab Saturn IB launch vehicle hardware. The Saturn IB, consisting of an S-IB stage, S-IVB stage, and instrument unit, will launch the spacecraft from the Kennedy Space Center into earth orbit for rendezvous and docking with the Soyuz spacecraft.

In FY 1974, funding will provide for the definition of required launch vehicle modifications and for design, development, and testing of additional specific hardware required to meet the launch vehicle requirements.

Additionally, FY 1974 funding will provide for launch vehicle support and for the update of launch vehicle ground support equipment and of the system development facility.

Launch Operations

Test and checkout operation of the U.S. space vehicle will be conducted at the Kennedy Space Center with launch being accomplished from Launch Complex 39.

FY 1974 funding will provide for required contractor support to modify, test, and checkout the launch facilities and ground support equipment and to make preparations for the launch operations.

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Flight Support and Operations

Flight Support and Operations provides for a broad range of essential activities which directly support the ASTP mission.

FY 1973 funding provides for: programmatic engineering support activities involving the crew, the CSM, the docking module and the docking system; space suit initial procurement including modifications and required testing; and the procurement of other government furnished equipment needed in support of the mission.

FY 1974 funding will provide for programmatic engineering support for the CSM, docking module and docking system; maintenance of camera systems; food and waste systems, and bioinstrumentation; and CSM fuels and transportation.

Additionally, this funding provides for the procurement of government furnished equipment including space suits, crew provisioning, and television. Communication and docking system tests and evaluations will also be funded, as will the use of automatic checkout equipment utilized previously on Apollo and Skylab.

Development, Test, and Mission Operations

Development, Test, and Mission Operations provides for a variety of common technical activities necessary to support all programs conducted at the Manned Space Flight field centers. These activities include research and test operations, crew training, launch and flight support, and technical services which support the direct program activities of hardware contractors and other program-unique efforts. Support contractors provide the unique skills and capabilities required to support the laboratories and other operational facilities located at the Manned Spacecraft Center, Marshall Space Flight Center, Kennedy Space Center, White Sands Test Facility, Slidell Computer Complex, Mississippi Test Facility, and the Michoud Assembly Facility.

FY 1974 funding will continue to support Skylab checkout, launch, and flight activities in addition to supporting efforts involving subsystem design, development, and testing for the Apollo Soyuz Test Project and the Space Shuttle.

Development, Test, and Mission Operations

	1972	1973	1974
Research and test operations.....	$(85,022,000)	$80,200,000	$49,700,000
Crew and flight operations.....	(84,318,000)	74,900,000	61,700,000
Operations support.....	(59,702,000)	68,600,000	58,400,000
Launch systems operations.....	(81,514,000)	70,300,000	50,400,000
OMSF engineering support.....	(9,325,000)	---	---
Total.....	$(319,881,000)	$294,000,000	$220,200,000

Research and Test Operations

	1972	1973	1974
Engineering and test.....	$(62,852,000)	$60,600,000	$33,300,000
Applications and science.....	(13,162,000)	9,600,000	9,700,000
Reliability, quality and safety..	(9,008,000)	10,000,000	6,700,000
Total.....	$(85,022,000)	$80,200,000	$49,700,000

As in FY 1973, Research and Test Operations provides the NASA in-house technical support capabilities necessary to conduct research and development projects. These efforts cover a wide spectrum of technical, engineering, scientific and biomedical disciplines in support of Manned Space Flight activities and of the efforts of other program offices of the National Aeronautics and Space Administration, and other Government agencies, which are undertaken at Manned Space Flight installations.

Engineering and test support is provided by an experienced in-house research and test staff using sophisticated laboratories and test facilities. FY 1974 funding provides for all the engineering disciplines required to support the technical objectives of space flight programs at the Marshall Space Flight Center and the Manned Spacecraft Center. Examples of these disciplines include propulsion, structures and materials, life support, information systems, guidance and control, and telemetry/communication systems. Activities within these disciplines include studies and research effort as well as planning, analysis, development and testing efforts on various components, systems and subsystems.

FY 1974 funding in the Applications and Science area will include real time support for the Earth Resources Experiment Package to be carried in the Skylab Orbital Workshop, research and development of remote sensing and data processing techniques, and demonstration programs showing the relevance of remote sensing to agriculture, forestry, hydrology, geology, oceanography, and ecology. FY 1974 funding will also provide for support contractor effort at the Manned Spacecraft Center to assist in continuing analysis of lunar samples and data, and for medical research including biomedical support to spacecraft design, operational support related to flight crew health, and space flight medical studies.

In the area of Reliability, Quality and Safety, FY 1974 funding will support efforts involving reliability assurance, risk analysis, tests and checkout of space vehicle and payload systems, subsystems, components and related support equipment to assure technical adequacy and performance of industry in the manufacture, delivery, test and launch of space vehicles and space vehicle payloads. It provides advanced test and checkout equipment and techniques to improve product assurance capability and to keep pace with advancements in manufacturing processes and techniques.

Crew and Flight Operations

	1972	1973	1974
Crew	$(22,061,000)	$16,600,000	$14,100,000
Flight	(18,665,000)	19,800,000	13,900,000
Mission control	(43,592,000)	38,500,000	33,700,000
Total	$(84,318,000)	$74,900,000	$61,700,000

The Manned Spacecraft Center is the headquarters for all crew and flight operations. The astronauts are based at this Center along with most of their essential training equipment including proficiency aircraft, spacecraft mockups and procedures simulators. The Manned Spacecraft Center is also responsible for mission simulation and control of flight operations from shortly after lift-off to recovery. Essentially the same types of activities funded in FY 1973 will be funded in FY 1974, except for program unique items associated with the Apollo Soyuz Test Project.

FY 1974 funding will provide for crew training; hardware update of simulators and trainers; and pilot equipment. Included is the operational cost of mission simulators, part task trainers, and aircraft required for flight proficiency.

In the flight operations area, FY 1974 funds will provide for the broad areas of mission planning, flight control, and operation of the computation facility, including the data reduction complex. Also included are reimbursements to the DOD for the crew and command module recovery costs at the completion of the manned missions; complete update mission planning; computer modifications necessary to convert experiment data to tapes suitable for use by principal investigators; and real time update in crew procedures.

FY 1974 funding will also provide for the maintenance and operation of the Mission Control Center including the Real Time Computer Complex, the display/control system, the communication command and telemetry system, the voice communication system, and the mission simulation, checkout, and training system.

Operations Support

	1972	1973	1974
Operations support	$(59,702,000)	$68,600,000	$58,400,000
Total	$(59,702,000)	$68,600,000	$58,400,000

Operations Support consists of essential technical support, and includes the procurement of material and equipment related to this support. Essentially the same types of activities funded in FY 1973 are to be funded in FY 1974, but at a reduced level.

FY 1974 funding provides for a myriad of technical services at the Kennedy Space Center, Marshall Space Flight Center, and Manned Spacecraft Center. These include such activities as technical facility maintenance and operation; postlaunch refurbishment; renovations; rigging; closed circuit television monitoring directly related to training and test facilities; documentation and technical report preparation; logistics support; chemical purging services; detailed design and drafting effort required for launch equipment and facilities; telecommunications; innovative and conventional fabrication; and still and motion picture processing. Additionally, the Air Force Eastern Test Range, which supplements the Kennedy Space Center operations support by providing test and launch support for both manned and unmanned missions, is reimbursed on a cost-incurred basis. FY 1974 funding will also provide for the maintenance of technical and production facilities at the White Sands Test Facility, the Slidell Computer Complex, the Mississippi Test Facility and the Michoud Assembly Facility.

Launch Systems Operations

	1972	1973	1974
Mechanical ground systems.....	$(48,757,000)	$36,100,000	$27,600,000
Electrical instrumentation systems.....	(32,757,000)	34,200,000	22,800,000
Total.....	$(81,514,000)	$70,300,000	$50,400,000

Launch Systems Operations, performed at Kennedy Space Center, includes the technical services required in support of the test, checkout and launch of space vehicles and payloads. Also included is the operation and maintenance of the launch facilities, complexes, and associated ground support equipment. FY 1974 funding will provide for the same areas of activity provided for in FY 1973, but at a substantially reduced level.

FY 1974 funding provides for mechanical ground system activities involving the operation and maintenance of launch complex facilities and related equipment such as mobile transporters, the converter compressor facility, mobile service structure, altitude chambers, propellant loading systems, pneumatics, and Vehicle Assembly Building adjustable work platforms. Additionally, launch-related services such as propellant handling, life support, technical shops, chemical cleaning and decontamination and systems safety are provided.

FY 1974 funding also provides for the operation and maintenance of electrical/electronic and launch instrumentation systems such as automatic checkout equipment, operational voice and TV communications, computation, measurements, telemetrics, and other electrical/electronic systems.

Space Life Sciences

Space Life Sciences is composed of three primary disciplinary elements: Space Life Research, Life Support and Protective Equipment, and Bioinstrumentation and Man-Machine Technology. Collectively, these elements focus on man's capabilities and limitations in the space environment, and provide the technological base required to support the development of systems which permit man to live and perform effectively in space. This multidisciplinary program, pursued through ground-based and flight research programs, provides for the study of man as an operator and controller in the space environment for fundamental studies of living processes in space, and for advanced technology and development of systems required to support and protect the life of man or to extend his capabilities in space. Major program emphasis is directed to the development of information which can be translated into design data and criteria for advanced manned space systems and mission operations.

Space Life Sciences

	1972	1973	1974
Space life research.....	$8,499,000	$11,040,000	$9,700,000
Life support and protective equipment.....	7,261,000	7,960,000	7,000,000
Bioinstrumentation and man-machine technology.....	4,015,000	4,500,000	4,300,000
Total.....	$19,775,000	$23,500,000	$21,000,000

Space Life Research

The Space Shuttle mode of transportation and operation, with its larger multidisciplinary crews, has generated the requirement to develop new concepts in the component Space Life Research areas of medical, behavioral and biological research, and space flight experiments. These concepts must reflect new standards of medical selection for crew candidates. Innovative concepts for daily medical care while in flight need to be developed, and a more comprehensive integrated coupling of research efforts and operational medical support is required. Investigations of space flight biological (living organism) effects and changes in human body functions are elements of this program, particularly as caused by weightlessness, space radiation and biological rhythm (clock) alterations.

FY 1973 funding provided for the continuation of medical and behavioral investigations involving the critical physiological mechanisms that have been identified as having a direct bearing on man's ultimate performance capability in space flight. Also under investigation are those factors that are suspected (or anticipated with a fair amount of scientific certainty) of having an effect on man's adaptation to space flight stresses. In the biological area of investigation, particular attention has been paid to the

effect of cosmic radiation on biological systems. Actual experiments have been flown on Apollo 16 and 17 to better define these high energy particle effects on living organisms as had been recommended by the National Academy of Sciences.

FY 1974 emphasis in the medical program will continue to be on hormonal control, body fluid and electrolyte balance, and musculoskeletal (muscles, skeleton, etc.), and neurophysiologic (nervous system) systems, as these have been observed to undergo changes as the result of weightlessness. Longer duration flights necessitate a more comprehensive understanding of all of these changes and their interrelationships in order to predict the timing of the changes, interpret their significance, and develop effective preventive techniques.

The closely intertwined fields of behavioral and biological research will have increased demands laid upon them as the environmental challenges to man in prolonged space travel become more precisely defined. The FY 1974 behavioral program takes on new dimensions with the initiation of studies to determine the optimum performance capability of the scientific experimenter passengers. Therefore, human capabilities, performance limitations, relationships of these things to observed physiological changes, and the techniques or mechanisms for coping with adverse effects are all under investigation. Fundamental to understanding the effects of space flight on man is the detailed investigation of basic biological phenomena as they occur in other living systems; hence, the FY 1974 biology program is continuing the pursuit of knowledge in the areas of developmental and genetic biology, regulatory biology, microbiology and radiation biology.

FY 1974 funding will also permit the initiation of design and evaluation of potential flight experiment candidates for the Apollo Soyuz Test Project and the Shuttle program.

Life Support and Protective Equipment

Life Support and Protective Equipment activities focus on the advancement of technology through the development and testing of experimental life support and protective devices essential to a safe, habitable space flight environment.

FY 1973 activities have concentrated on advanced technology of atmospheric revitalization processes, water and waste management and food technology. Components and subsystems have been developed as demonstration models for further testing and evaluation. In the protective equipment area, effort has been directed toward the development of space suit gloves with increased feel and mobility and a regenerable thermal control back pack for space suits.

FY 1974 funding will provide for Environmental Control/ Life Support Systems (EC/LSS), and advanced regenerative life support subsystems development; and crew equipment systems including advanced efforts on space suits and portable life support systems.

FY 1974 activities include the manned testing of the first integrated EC/LSS flight prototype designed for extended closed cycle operation; this effort supports the development and demonstration of Shuttle EC/LSS concepts.

To increase system reliability and to minimize electric control requirements, FY 1974 efforts in the area of advanced regenerative life support subsystems development will concentrate on the minimization of component parts through the use of multifunctional devices and simplification of design.

Crew equipment systems efforts in FY 1974 will focus on advances in space suits and portable life support systems. Included will be the fabrication and evaluation of an advanced prototype extravehicular 8.0 psi space suit; the continuation of component technology development and initial prototype designs for nonregenerative portable life support systems for Space Shuttle applications; the continuation of efforts involving regenerative portable life support subsystems for long term orbital manned space flight; and flame resistant elastic polymer development activities which will lead to fabrication and evaluation of ancillary crew equipment.

Bioinstrumentation and Man-Machine Technology

Bioinstrumentation and Man-Machine Technology includes study and advancement of technology in the development, test, and utilization of bioinstrumentation, bioassay concepts, integrated medical, physiological and performance measurement equipment and procedures; the development of technology for human augmentation devices, such as teleoperators for use by man, and the use of man in other man-machine systems.

FY 1973 funding has provided for the development of a zero-gravity chair and a personal couch/habitat concept for the shuttle orbiter; an advanced manipulator concept to be used in simulation studies of satellite servicing; a laboratory model of a surface teleoperator with adaptive on-board control; a prototype urine volume measurement system utilizing principles of thermal conductivity; and a prototype miniature respiration measurement system for quantification of pulmonary functions.

FY 1974 funding provides for advanced bioinstrumentation technology to detect and measure biological, physiological, and psychological responses of man and/or other selected species to the space flight environment. Specific areas of research include the integration of developed bioinstrumentation into system elements such as the Integrated Medical and Behavioral

Laboratory Measurement System (IMBLMS) to measure medical parameters, and for the delivery of health care to astronauts during manned space flights of extended duration. There will be special emphasis in FY 1974 involving the development of remotely controlled manipulator and sensor systems (teleoperators) technology to augment human sensory and physical control capabilities in space flight. The role of man as an operator, maintainer, and scientific investigator using Shuttle payloads, and the design of manned vehicles for habitability to facilitate work activities will also be studied. Additionally, FY 1974 funding provides for the procurement of an IMBLMS unit for field tests in a remote area of the United States.

Mission Systems and Integration

Mission Systems and Integration program activity is classified into three areas of effort: Mission and Payload Integration, Sortie Laboratory/Concept Verification Testing, and Advanced Development.

Study efforts under Mission and Payload Integration focus on providing data essential to the development of a balanced program of payloads and experiments consistent with the Space Shuttle's configuration and capabilities. Sortie Laboratory studies involve definition effort on a pressurized manned payload carrier and an unpressurized instrument platform suitable for conducting research and applications activities on Shuttle missions. The Concept Verification Testing effort deals with the integration and verification of operational concepts resulting from these definition studies. These activities are intended to support development of a Sortie Laboratory by the European Space Research Organization.

Advanced Development is directed toward development of critical and long lead items, experimental systems and operational techniques, and toward the establishment of design and technology requirements for potential future development programs. In FY 1974, a number of tasks will focus on a Space Tug which would be a reusable propulsive stage designed to be carried by the Shuttle to transport payloads to and from orbits beyond those which the Shuttle can attain.

Mission Systems and Integration

	1972	1973	1974
Mission and payload integration..	$10,500,000	$6,000,000	$5,500,000
Sortie laboratory/concept verification testing.....	---	6,000,000	2,500,000
Advanced development.....	---	9,000,000	7,500,000
Space station.....	7,100,000	---	---
Total.....	$17,600,000	$21,000,000	$15,500,000

Mission and Payload Integration

The broad objective of the Mission and Payload Integration effort is to develop mission and payload requirements for research and applications missions which can be accomplished using the Shuttle in combination with a Sortie Laboratory or a Space Tug. These requirements must support the goals and objectives of prospective users and at the same time assure the compatibility of interfaces between each payload and carrier vehicle. Accomplishing this requires the development of innovative ideas, concepts, system requirements and management procedures to assure efficient and economical utilization of the capabilities of the Shuttle, Sortie Laboratory, and Tug. In recognition of the importance of this activity, the Manned Space Flight organization has been realigned to create a Mission and Payload Integration group.

In FY 1973, funding provides support in the areas of materials science and manufacturing in space, payload integration and technology studies. In the materials science and manufacturing area, efforts are focused on user requirements and their impact upon overall shuttle payload planning. Payload integration includes studies of payload launch support requirements, payload costing criteria, and the impact of the Shuttle on payload and experiment specifications. Technology studies are primarily concerned with contamination monitoring, orbital fatigue, and meteoroid exposure measurements.

In FY 1974, emphasis will be placed on studies designed to provide data for use in the final design of the Shuttle and in the definition of a Sortie Laboratory and a Space Tug. Corollary studies will provide input to payload design concepts for effective Shuttle utilization. The major effort will focus on refining interface requirements. This data is needed to establish valid interface and payload design specifications. Cost trade analyses will also be supported to determine the most economical methods of meeting these requirements, utilizing low cost payload design concepts.

Specific studies and analyses to be funded:

-- The development of low cost payload concepts.

-- The development of payload design criteria and requirements.

-- Studies on retrieval, repair, and refurbishment of payloads.

-- Payload traffic and capture analyses.

-- Analyses of the characteristics of the Shuttle, Sortie Lab, and Tug and their component elements to determine the impact on payload requirements.

-- Analysis of payload characteristics to establish accommodation modes for Shuttle, Sortie Lab, and Tug interfaces.

Sortie Laboratory/Concept Verification Testing

The Sortie Lab will be a flexible and economical pressurized payload module and an unpressurized instrument platform or pallet to be used in conducting short duration Shuttle research and applications missions. The Sortie Lab will permit a scientist to take conventional ground laboratory equipment to orbit, use it in his investigations or observations, and return it to earth for further use. This approach will achieve significant reductions in the cost of orbital research and applications activity. The Sortie Lab will be used in the very early stages of Shuttle operations.

In FY 1973, Sortie Lab efforts are concentrated on in-house definition of low cost concepts at the Marshall Space Flight Center. The European Space Research Organization (ESRO) has been performing similar studies. The current plan is that ESRO will design and develop the Sortie Lab. NASA study efforts in FY 1973 and 1974 will define requirements and provide important design data for use by ESRO in the development effort.

FY 1974 funds will be used for special tasks in support of the in-house Sortie Lab definition study at the Marshall Space Flight Center. Specific tasks include design and construction of engineering mock-ups; design, analysis and testing of atmospheric cooling concepts; and examination of subsystem designs incorporating available components.

Complementing the Sortie Lab activities is the Concept Verification Testing project which will provide an integrated test bed for defining the Sortie Lab crew-to-experiment interfaces and will permit the defining of low cost, high pay-off experiments suitable for Sortie Lab missions. Long duration subsystem concepts will also be evaluated and refined under this project.

FY 1973 and 1974 funds support the design and breadboarding of the Concept Verification Testing subsystems and elements necessary to provide for a full scale integrated testing capability and for experiment apparatus and simulations.

Advanced Development

Advanced Development has as its objective the application of research and advanced technology to the study and development of experiment systems, procedures and operational techniques which form the basis for specifying the elements of future projects. Potential developments indentified in Mission and Payload Integration studies are to be evaluated and tasks implemented when judged to be pacing items for probable new mission projects. Data developed through study and testing is to be applied to the process of component selection, integration into systems, and understanding of overall capabilities and cost. The data also provides support and answers to problems in on-going programs.

Present efforts related to the Space Shuttle include pyrotechnic systems, avionics on-board checkout, vacuum jacketed cryogenic systems technology, internal insulation materials, water impact studies, analysis of bond joint edge stress, crack growth behavior, weld bond tank construction, heat pipe application, seal material, actuator technology and multipurpose optical sensors. Most of these activities, conducted in support of Space Shuttle, are to be completed in FY 1973.

In the area of earth orbital and space systems, activity is devoted to radiator development, on-line checkout of life support systems, autonomous navigation systems, energy storage systems, development of short-pulse laser technology, on-board consumables management functions, and flame resistant fibrous materials. New effort being initiated will include cyrogenic technology and main and auxiliary propulsion systems applicable to a Space Tug.

FY 1974 funding provides for the continuation of many of the above efforts. In addition, new tasks which respond to the challenging technology requirements of a Space Tug will be initiated. Examples of this work are: development of criteria for the structural design; demonstration of the effective use of composite structures, thin metal structures, advanced meteoroid shields and cyrogenic tankage; definition and demonstration of critical fabrication and inspection techniques; and the expansion of the cryogenic technology base required to provide the performance, life and operational versatility required by a Space Tug.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1974 ESTIMATES

BUDGET SUMMARY

OFFICE OF MANNED SPACE FLIGHT — SPACE SHUTTLE PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1972	1973	1974
Orbiter	$15,000,000	$143,500,000	$377,100,000
Main engine	45,100,000	40,900,000	55,500,000
Solid rocket boosters	---	---	18,100,000
External tanks	---	---	24,300,000
Technology and related development	26,100,000	15,600,000	---
Vehicle and engine definition	13,800,000	---	---
Total	$100,000,000	$200,000,000	$475,000,000

Distribution of Program Amount by Installation:

John F. Kennedy Space Center	$300,000	$700,000	$4,100,000
Manned Spacecraft Center	36,100,000	147,300,000	370,000,000
Marshall Space Flight Center	59,200,000	48,000,000	97,900,000
Lewis Research Center	150,000	---	---
NASA Headquarters	4,250,000	4,000,000	3,000,000
Total	$100,000,000	$200,000,000	$475,000,000

HIGHLIGHTS OF BUDGET PLAN

	1972	1973	1974
Orbiter- Continuation of design, development, test and engineering including initiation of structural test article fabrication; testing of structural components; tool fabrication; breadboard testing and preparation of subsystem specifications; mockup fabrication; start of manufacture of ground support equipment; design and development support effort and shuttle integration	$15,000,000	$143,500,000	$377,100,000

	1972	1973	1974
Main engine- Continuation of design and test activities including activation of test facilities for component and subsystem tests; initiation of preburner, turbopump, and thrust chamber tests; release of engine assembly drawings; test engine long lead procurement; related development effort; and propellants to support development testing...	$45,100,000	$40,900,000	$55,500,000
Solid rocket boosters (SRB) Initiation of SRB design and development activities; design and development of thrust termination, separation and recovery subsystems; start of structural and propulsion test article fabrication and assembly; and modification of propellant processing and ground test equipment.....	---	---	$18,100,000
External tanks- External tank design and development activities leading to preliminary design review; tank design including subsystems; and activation of tank manufacutring tooling and equipment.....	---	---	$24,300,000
Technology and related development- No FY 1974 funds requested.....	$26,100,000	$15,600,000	---
Vehicle and engine definition Vehicle and engine definition completed in FY 1972.....	$13,800,000	---	---
Total Space Shuttle.....	$100,000,000	$200,000,000	$475,000,000

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1974 ESTIMATES

OFFICE OF MANNED SPACE FLIGHT

SPACE SHUTTLE PROGRAM

FLIGHT SCHEDULE

PROJECT	MISSION	CALENDAR YEAR
Space Shuttle	First Manned Orbital Flight	1978
	Operational Shuttle	1979

OFFICE OF MANNED SPACE FLIGHT SPACE SHUTTLE PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Space Shuttle will provide an effective and economical means for the United States to utilize and advance its capabilities in space. It will provide routine access to space to meet the foreseeable civilian and defense needs in the decade of the 1980's and will do so at a reduced cost of space operations. This multipurpose space transportation system will open up vast new opportunities to utilize the benefits of space for practical applications on earth and for expanding the frontiers of science.

The major components of the Space Shuttle system are the orbiter, the main engines, an external hydrogen and oxygen tank, and the twin solid rocket boosters.

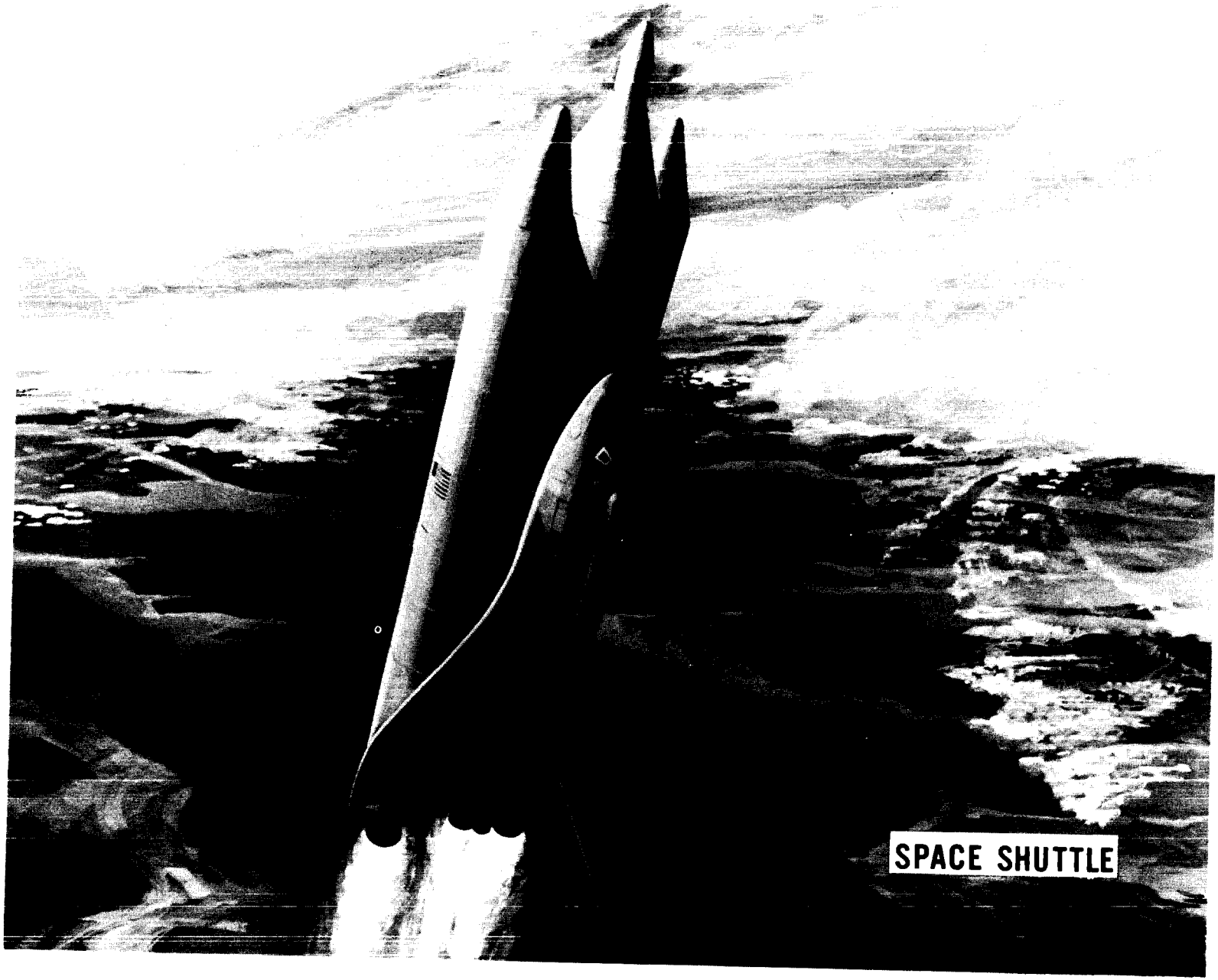
The orbiter will be boosted into space by the simultaneous operation of two solid propellant booster rockets and three high pressure liquid oxygen/liquid hydrogen main engines. The booster rockets will be reusable, detaching at an altitude of about 40 kilometers (25 miles) and descending into the ocean by parachute for recovery and refurbishment. The orbiter, with its three main engines and the hydrogen/oxygen propellant tank will continue into low earth orbit. The external tank, which is expendable, will then be deorbited to a predetermined remote ocean site.

The orbiter will look like a delta winged airplane. It will have a large cargo compartment with doors on top which can be opened in orbit to permit deployment or recovery of large spacecraft. The cargo-carrying capability of the orbiter will lessen weight and volume design constraints which have made payloads very difficult and costly to build. In many cases, it will be possible to use relatively inexpensive standard laboratory equipment in place of specially constructed, highly miniaturized components which are expensive to develop and test.

The orbiter will normally carry a crew of four - the pilot, a co-pilot, a systems monitor, and a payload specialist who will check out the satellite payloads and deploy them in space. The Shuttle can accommodate up to ten persons, including the crew, who will travel in shirt-sleeve comfort without space suits. Passengers will be subjected to no more than 3G forces during launch and landing comparable to today's commercial passenger aircraft which are designed for $2^1/2$ G forces.

Applications

The Shuttle will carry into space virtually all of the nation's civilian and military payloads. These include space research and operational payloads for private industry, universities, research organizations, the United States Government, and national and international organizations.


SPACE SHUTTLE

The Space Shuttle flight crew will be able to check out satellites in space, make adjustments, and calibrate instrumentation to insure successful operations. If necessary, satellites can be retrieved and returned to earth for extensive repair and refurbishment. The Shuttle will also make it possible to repair a malfunctioning satellite while in orbit. Additionally, the Shuttle can be used as a research laboratory to test prototype instrumentation and subsystems in the space environment and then return them to earth for analysis.

The Shuttle will make ground-based space rescue possible with its quick response capability and operational flexibility. In some instances, the Shuttle may eliminate the need for space rescue by the timely delivery of replacement components and equipment.

To augment the Shuttle's capability and to provide for extended space explorations, the development of a Sortie Laboratory is under study. The Sortie Lab will serve as a laboratory for scientists and engineers, making it possible for them to accompany their experiments into space for the first time and to conduct research in a "shirt-sleeve" environment.

Preliminary studies have also been undertaken for a reusable propulsive vehicle that would be transported to earth orbit in the Shuttle cargo bay. The vehicle, a "Space Tug", could be used to transfer shuttle payloads into higher altitude or synchronous earth orbits, or place payloads on a trajectory to the planets. After delivery of a payload to higher orbit, the tug would return to the Shuttle orbiter and be flown back to earth in the Shuttle cargo bay for refueling and reuse.

Launch and Landing Sites

The initial launch and recovery site will be located at the Kennedy Space Center. It will be used for research and development launches and for all due east and medium inclination operational launches.

A second operational site for high inclination and polar missions will be located at Vandenberg Air Force Base in California; this base is expected to be activated in the 1980's.

BASIS OF FUND REQUIREMENTS:

	Orbiter		
	1972	1973	1974
Orbiter.....	$15,000,000	$143,500,000	$377,100,000
Total.....	$15,000,000	$143,500,000	$377,100,000

The orbiter will be a delta-winged airplane-like vehicle capable of landing on conventional runways. It will have a cargo compartment measuring about 18 meters (60 feet) in length and 4.5 meters (15 feet) in diameter, and will be able to place 29,500 kilograms (65,000 pounds) in a 185 kilometer (100 nautical mile) due east orbit.

The prime contractor, North American Rockwell Corporation, will be responsible for design, development, and production of the orbiter vehicle and will support the NASA integration effort involving all elements of the Space Shuttle system. The external tanks, solid rocket boosters, and air breathing engines will be procured when Space Shuttle systems engineering by the orbiter contractor has progressed sufficiently to enable NASA to solicit competitive proposals for these system elements.

Orbiter subsystem contractors are the responsibility of the orbiter prime contractor, subject to approval by NASA. Some subcontracts awarded to date include: American Airlines, Tulsa, Oklahoma, for ground maintenance and operations support; Grumman Aircraft Engineering Company, Bethpage, Long Island, New York, and McDonnell Douglas Company, St. Louis, Missouri, for engineering support at the North American Rockwell facility at Downey, California; MIT, Cambridge, Massachusetts, for guidance and navigation analysis; and Intermetrics, Inc., Boston, Massachusetts, for guidance and navigation systems software development.

Other orbiter subsystems planned for subcontracting include: the vertical stabilizer; wing; mid-fuselage; orbital maneuvering pod and engine, reusable carbon-carbon high temperature surface insulation; reusable silica-based surface insulation; manual flight control system; data processing and software; guidance and navigation systems hardware; environmental control system; space radiator; fuel cell power plant; nacelle and pylon for air breathing engines; reaction control module tank and engines; cryogenic storage system; and the auxiliary power unit.

FY 1973 funding provides for initial orbiter vehicle design, development, test, and engineering activities. Major orbiter vehicle efforts in FY 1973 include: the completion of fact finding and negotiation and the award of the definitive contract for Increment I of orbiter development and system integration which includes completion of technical trade studies and the establishment of a baseline configuration; establishment of program requirements (plans, schedules, funding, manpower, facilities); preparation of systems specifications for government furnished equipment (solid rocket booster, external tank, air breathing engines); initiation of preliminary design, including structural diagrams and substructure layouts, materials selection, cost optimization of fabrication; definition of thermal protection system interface requirements and initiation of procurement of reusable surface insulation materials; definition of subcontractor responsibilities; preparation of specifications for the avionics system configuration; completion of basic wind tunnel tests to support the systems requirements review; testing of structural components; initiation of interaction tests and completion of forward fuselage model tests.

FY 1974 funding will provide for the continuation of design, development, test, and engineering activities. Specific tasks will include: initiation of orbiter structural test article fabrication and related testing of structural components; release of hardware specifications; procurement of structural members; initiation of tool fabrication; start of fabrication of the forward and aft fuselage, crew module, and aeroflight controls; development testing of docking mechanisms, including tooling and fabrication of development test hardware; completion of subsystem design, certification, and test requirements for the orbit maneuver system; start of design and fabrication of tooling for the interface connecting hardware with the main propulsion system; procurement of test components, initiation of breadboard testing and preparation of specifications for operational subsystems including electrical power (fuel cells), guidance and navigation, communication and tracking, displays and controls, operational instrumentation, and auxiliary propulsion units; start of fabrication of mockups to evaluate crew provisions and cabin arrangement; fabrication of development test hardware for the external tank separation system; initiation of ground support equipment manufacture; completion of hardware modification definition for acceptance checkout equipment at Palmdale, California; definition of the integrated ground test plan for the orbiter and Shuttle system; and orbiter and Shuttle vehicle models wind tunnel testing.

There is also a broad range of NASA effort which is necessary to supplement the activities of major design and development contractors. This includes associated development tasks, concept verification, technology and operational studies, simulation requirements, and other program analyses to be performed by NASA or by study contractors. This support also involves in-house testing, evaluation and analysis, related engineering and services support and contract administration services furnished by DOD.

FY 1974 funding is also required to provide subscale and full scale subsystem test articles and mock-ups for design evaluation, wind tunnel testing, simulation and operations planning activities; to provide equipment, components and materials for in-house test, evaluation and analysis; and to provide for other equipment such as: Shuttle training aircraft, horizontal flight test simulator, Shuttle procedures simulator, and KSC control data facility equipment. Funding is also required for logistics support including costs of fuels and propellants for test, checkout, and transportation.

Orbiter development tasks are directed toward selective engineering investigations of critical subsystems or component hardware which have been demonstrated to be feasible in previous technology tasks. These tasks also provide the Shuttle Program Office and the NASA technical staff with an independent capability to critically evaluate and augment contractor system and subsystem developments. These support activities are always keyed to appropriate milestones in the development programs for the orbiter, solid rock boosters and external tanks. These activities include the testing of systems, subsystems, components, and materials to verify design and functional utility prior to program decisions.

FY 1974 development effort also includes: avionics tasks which will be concerned with aeroflight control, guidance and navigation, crew displays and controls, instrumentation, communications, checkout, improvements in fuel cells, cryogenic storage, and related power systems; thermal protection system (TPS) tasks which will provide improved materials for reusable nonmetallic surface insulation, reinforced pyrolyzed plastics, and lightweight ablators. These TPS tasks are concerned with screening candidate materials, developing processes and characterization of the resulting insulation elements in simulated re-entry conditions; recovery system study tasks which examine alternate concepts for deceleration, flotation, retrieval and refurbishment techniques and devices leading to the selection of a final system. Included are studies of the effect of salt water corrosion on the booster case and studies to evaluate preferred systems for booster deceleration, flotation, retrieval and refurbishment techniques and devices; and external tank system tasks which are concerned with developing techniques for producing inexpensive, lightweight tanks. In addition, NASA is reviewing the need to perform Reaction Control System (RCS) developmental support testing. A Manned Spacecraft Center test area is being considered for utilization and a minimum of facility modifications are anticipated. Off-limit operating values and other critical parameters are to be determined to allow NASA to accurately specify the mission characteristics and to fully understand the RCS design requirements.

Main Engine

	1972	1973	1974
Space shuttle main engine..	$45,100,000	$40,900,000	$55,500,000
Total.....	$45,100,000	$40,900,000	$55,500,000

The Space Shuttle orbiter vehicle will use three high chamber pressure engines, designed to operate at a vacuum thrust level of 2,090,560 newtons (470,000 pounds) each. These engines, which use liquid oxygen/liquid hydrogen (LOX/LH_2) propellants, will provide thrust to the orbiter from lift-off through earth orbital insertion. The present development plan provides for delivery of the first engines for certification testing in CY 1976 and a flight readiness review prior to the first manned orbital flight (FMOF) at the end of CY 1978.

The engines have been designed to use a staged combustion cycle in which propellants entering the engine are raised to high pressure by turbopumps powered by preburners. The exhaust from the preburners is supplemented by the fuel used for cooling the engine and by an additional oxidizer and this mixture is then burned in the main combustion chamber. Mixture ratio control and throttling capability are provided.

The contract was awarded to Rocketdyne with authority to proceed being issued on April 5, 1972. A definitive contract was negotiated and signed on August 11, 1972. This contract provides for the delivery of three propulsion tests and 24 flight configured engines. Seven of the flight configured engines will be used during the DT&E phase of the orbiter contract.

FY 1973 effort is being devoted primarily to engine design and the start of major subsystems tests. The overall engine preliminary design review (PDR) was held in September 1972. Specific FY 1973 tasks include: release of component and subsystem design drawings for major test items; preparation of design drawings for fabrication of hydraulic servoactuator mechanisms; laboratory and bench tests involving the preburner oxidizer system, oxidizer turbomachinery, thrust chamber, hot gas manifold, heat exchanger, and interconnect devices; and the start of fabrication of components and subsystems for test programs, including the ignition system, preburners, injection system, nozzle assembly, combustion chamber and nozzle assembly, oxidizer turbopump, fuel turbopump, and controller assembly. Two major subcontracts were awarded in FY 1973 by Rocketdyne to Minneapolis-Honeywell, Inc., for the controller and to Hydraulic Research for the hydraulic actuators and filter assembly. FY 1973 funding is also required for rehabilitation and modification of the Santa Susana and Canoga Park test facilities in the Los Angeles, California, area.

FY 1974 funding will provide for the continuation of design and test activities now underway and the initiation of others including: the activation of Santa Susana and Canoga Park test facilities for component and subsystem tests; installation and checkout of component and subsystem test equipment; assembly and delivery of components and subsystems to test facilities including the LOX/LH_2 turbines, inducers, ignition system, LH_2 bearings, preburner assembly, combustion chamber and nozzle assembly, fuel turbopump, and the controller assembly; ignition system tests; initiation of preburner, turbopump, and thrust chamber subsystems testing; release of engine assembly drawings; procurement of long-lead hardware for deliverable test engines; start of fabrication of the engine controller subsystem and hydraulic servoactuator mechanism; start of fabrication of the engine test units for the first hot firing in early CY 1975; design and procurement of servoactuators to support engine contractor testing at the Mississippi Test Facility; and the construction and operation of the engine avionics breadboard. The first test engine will be delivered to the Mississippi Test Facility in preparation for the first engine test firing in 1975. Additionally, FY 1974 funding provides for propellants to support development and component testing. NASA development tasks are primarily concerned with instrumentation, increased high chamber pressure, study of thermal properties of cryogenic propellants under very high pressure, and monopropellant and biopropellant reaction control system engine studies. These tasks will be directed toward extending engine life and reusability.

Solid Rocket Boosters

	1972	1973	1974
Solid rocket boosters.....	---	---	$18,100,000
Total.....	---	---	$18,100,000

The booster elements of the vehicle system will consist of two reusable solid rockets attached to the external propellant tank. The solid rocket boosters (SRB) burning in parallel with the orbiter's main engines, will provide the impulse necessary to thrust the orbiter from lift-off to booster staging. A thrust termination capability will be provided as a safety factor in case of abort. The SRB's will be designed for water recovery, refurbishment and reuse. The present development plan provides for delivery of the first SRB's for qualification testing in 1976, and delivery of initial flight hardware in 1978.

FY 1973 funding provides for pre-contract award activities. This allows effort to determine preliminary design concepts and system specification data leading to a procurement specification. This will insure that the procurement of long-lead items (case materials) will be started on time.

During FY 1974 the SRB contractor will be selected. FY 1974 funding will provide for initiation of design and development of the SRB and for completion of the preliminary design review. Design and development of the major SRB subsystems such as thrust termination, separation and recovery are also included. FY 1974 funding will also provide for the start of fabrication and assembly of the structural and propulsion test articles; and modification of propellant processing and ground test equipment.

External Tanks

	1972	1973	1974
External tanks.....	---	---	$24,300,000
Total.....	---	---	$24,300,000

The external tank supplies hydrogen and oxygen propellants for the orbiter main engines from lift-off to earth orbit insertion. After termination of main engine firing, the expendable tank is separated from the orbiter vehicle and re-enters the earth's atmosphere in a predetermined, remote location. Major tank subsystems include the pressurization, feed, separation, and retro-rocket reentry systems, associated electronic controls and mounting brackets for the orbiter and SRB. The present development plan provides for delivery of the initial test articles in late 1975 and delivery of the first flight configured tank in 1977.

During FY 1974 the tank contractor will be selected. FY 1974 funding will be required for design and development of the tank, leading to a preliminary design review late in FY 1974. The design of the external tank and tank subsystems will progress to the point where it will be possible to begin fabrication of the structural and propulsion test articles in the first quarter of FY 1975. FY 1974 funding also provides for activation of tank manufacturing, tooling and equipment.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1974 ESTIMATES

BUDGET SUMMARY

OFFICE OF MANNED SPACE FLIGHT — ADVANCED MISSIONS PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1972	1973	1974
Advanced mission studies.....	$1,500,000	$1,500,000	$1,500,000
Total.....	$1,500,000	$1,500,000	$1,500,000
Distribution of Program Amount by Installation:			
John F. Kennedy Space Center.....	$150,000	---	$200,000
Manned Spacecraft Center.....	200,000	---	800,000
Marshall Space Flight Center.....	1,150,000	$1,500,000	300,000
NASA Headquarters.....	---	---	200,000
Total.....	$1,500,000	$1,500,000	$1,500,000

HIGHLIGHTS OF BUDGET PLAN

Advanced missions

Advanced missions studies of: programs which can be accomplished using the space transportation system; Shuttle performance uprating and operational cost reduction; safety guidelines for manned space systems; and development of cost analysis techniques.....	$1,500,000	$1,500,000	$1,500,000

OFFICE OF MANNED SPACE FLIGHT — ADVANCED MISSIONS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objectives of the Advanced Missions program are: (1) to perform analyses of possible new manned space flight missions and systems; (2) to conduct those studies necessary to support near-term and far-term integrated program planning; and (3) to assess future programs and requirements for the purpose of establishing the requirements for technological advances needed for the conduct of the future missions.

BASIS OF FUND REQUIREMENTS:

Advanced Mission Studies

	1972	1973	1974
Advanced mission studies.....	$1,500,000	$1,500,000	$1,500,000
Total.....	$1,500,000	$1,500,000	$1,500,000

The future course of this nation's manned space flight program is not only contingent on the development of new program concepts and requirements for future space systems, but also on the safe and cost effective utilization of space system hardware already available or in the development cycle. Advanced mission activities are dedicated to this end and involve the continual in-house review and study of current and proposed manned space flight programs. These efforts are directly supported by industry through the performance of conceptual design studies and system analyses. Technical data resulting from contractor efforts coupled with in-house study results provides the base for assessing, directing, and assuring the existence of a viable manned space flight program.

FY 1973 funding is being used to continue studies of the Space Tug element of the Space Transportation System and Tug applications. Alternative upper stage concepts are being assessed against time-related mission requirements and programmatic constraints. Cryogenic and earth storable propellant interim Tug system studies dominate the FY 1973 program.

FY 1974 funding will provide for advanced mission studies in the following areas:

Programs and Systems for the 1980's - Based on the mode of space transportation envisioned for the 1980's, studies will be conducted to examine new programs which can be implemented utilizing the space transportation system. These studies will be supported by investigation of the feasibility of Shuttle performance uprating and operational cost reduction.

Safety - Proposed manned systems will be studied to provide guidelines in the planning for safety provision in those systems.

Cost/Performance Studies - Cost performance studies will be continued to improve the agency's ability to estimate the cost of new programs.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1974 ESTIMATES

BUDGET SUMMARY

OFFICE OF MANNED SPACE FLIGHT — APOLLO PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1972	1973	1974
Spacecraft	$120,006,000	$50,400,000	---
Saturn V	157,996,000	26,300,000	---
Operations	310,326,000	a/	---
Advanced development	12,872,000	a/	---
Total	$601,200,000	$76,700,000	---

Distribution of Program Amount by Installation:

John F. Kennedy Space Center	$145,600,000	$3,000,000	---
Manned Spacecraft Center	233,925,000	44,300,000	---
Marshall Space Flight Center	204,205,000	24,300,000	---
Goddard Space Flight Center	130,000	---	---
Jet Propulsion Laboratory	38,000	---	---
Ames Research Center	100,000	---	---
Langley Research Center	370,000	---	---
Lewis Research Center	165,000	---	---
NASA Headquarters	16,667,000	5,100,000	---
Total	$601,200,000	$76,700,000	---

HIGHLIGHTS OF BUDGET PLAN

The planned objectives of the Apollo program have been accomplished. FY 1974 funding is not required.

a/ Funded under Space Flight Operations.

PROGRAM ACCOMPLISHMENTS

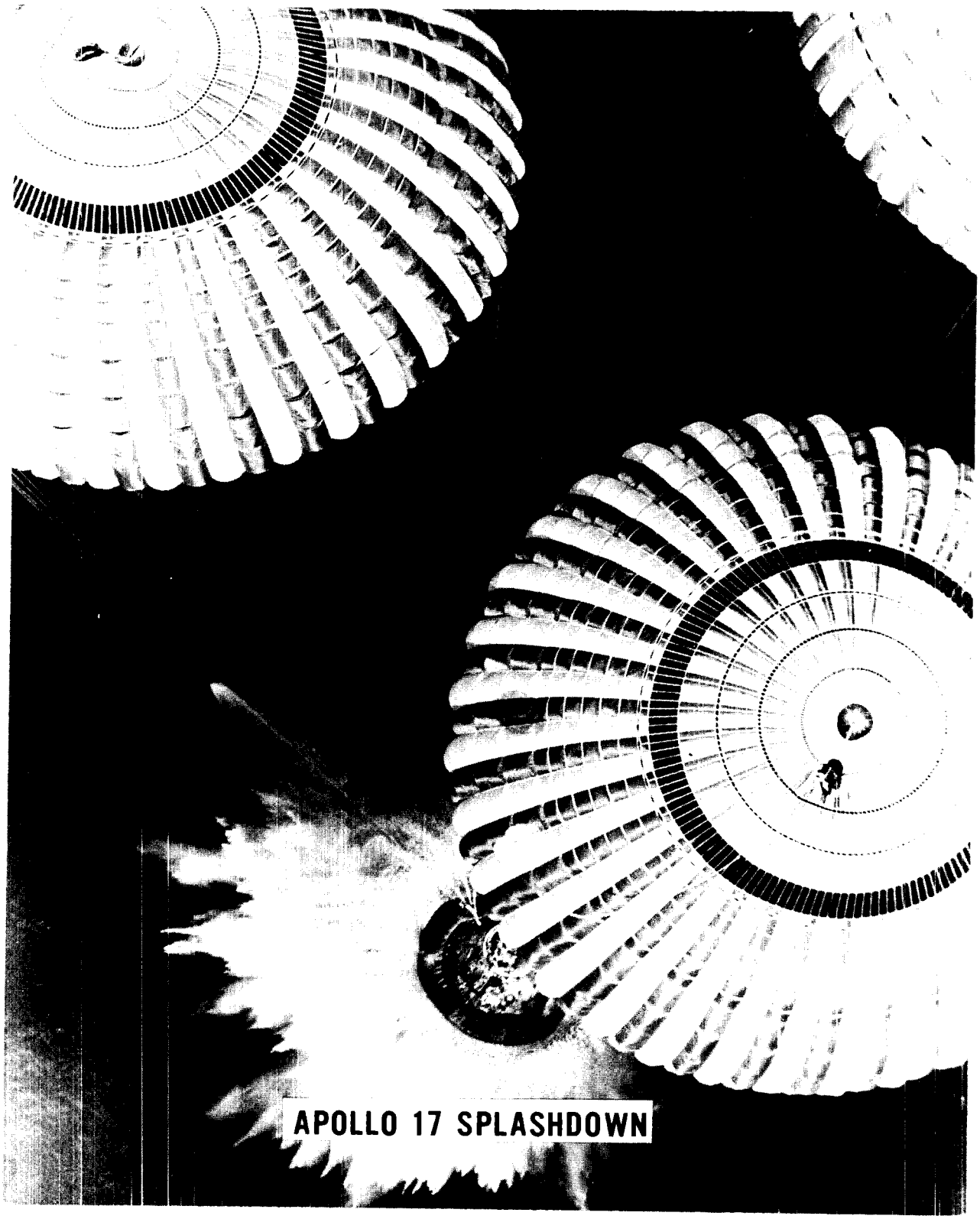
The Apollo misssions came to a safe and successful conclusion with the splashdown of Apollo 17 on December 19, 1972. The completion of Apollo ushers in a new era of unlimited opportunities to multiply the returns from space operations and to extend the frontiers of knowledge about our own planet and our solar system. Apollo represented a giant step forward in exploring outer space and bringing the benefits of space down to earth. The capabilities required to reach into outer space created new knowledge and skills, improved techniques and products, and provided unparalleled advances in science and technology. The impact of these achievements has already been reflected throughout society--in science, medicine, aviation, computers, industry, communications, and management--and will continue to spur advances in the years to come.

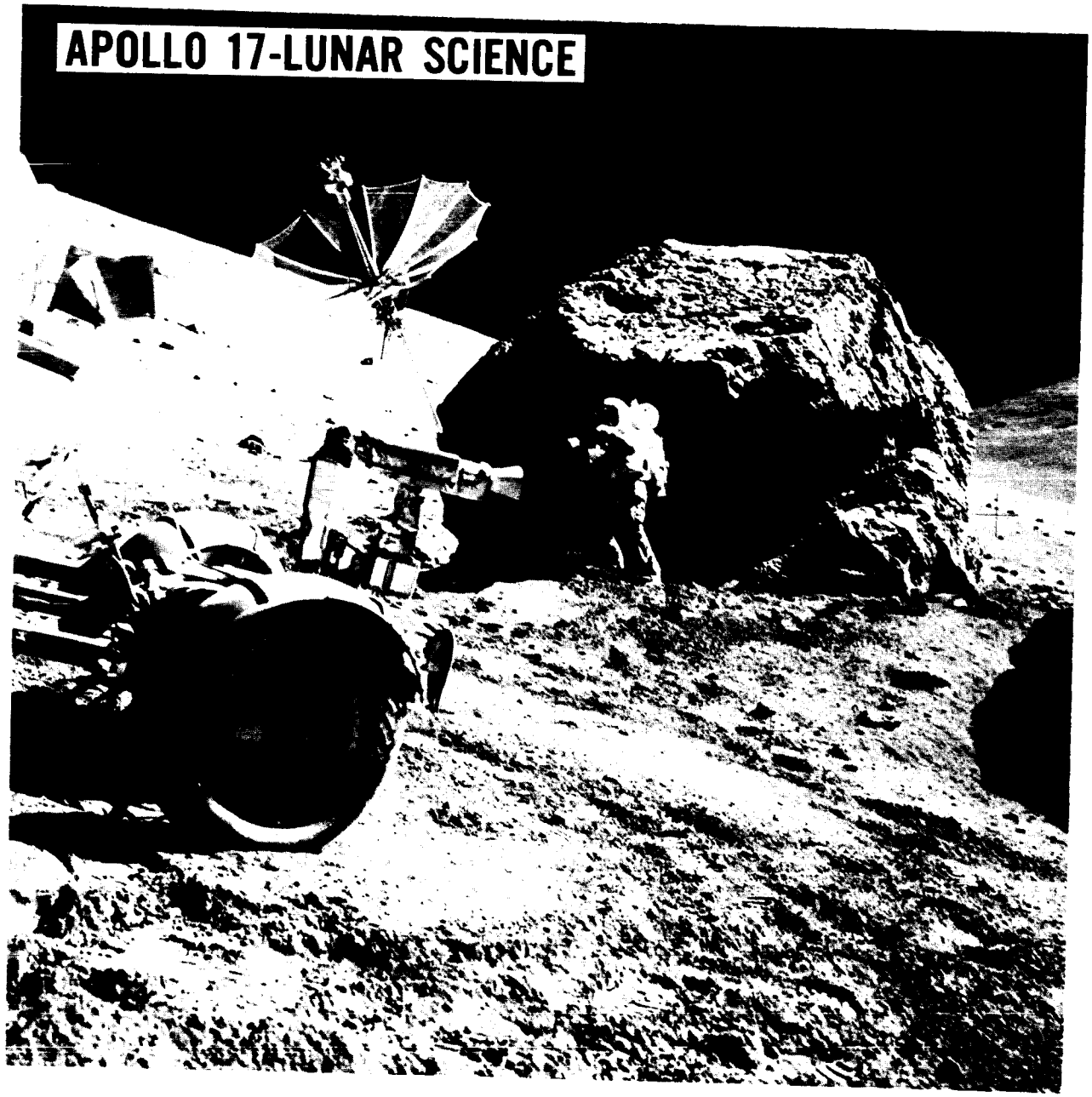
The roots of the Apollo accomplishments go back to the pioneering predecessor programs, Mercury and Gemini. Mercury, which began in 1958, demonstrated that man could survive in space. Six successful Mercury flights were conducted in 1960 and 1961. The Gemini program proved that men and equipment could maneuver, link up in space, and conduct productive activities. Ten manned Gemini flights of increasing complexity were conducted during 1965 and 1966. The national commitment to accomplish a manned lunar landing and return by the end of 1969 was made on May 25, 1961. This goal set in motion the most challenging scientific and engineering feat ever attempted by a society, and marshalled the skills and talents of over 300,000 men and women in 20,000 firms and universities across the nation. Despite the magnitude of the challenge and the early setbacks, a dedicated Apollo team moved steadily toward a common goal. From the first Saturn V flight in November 1967, to the first circumlunar mission in December 1968, and on to the lunar landing missions beginning in July 1969, with Apollo 11, the momentum built up at a rapid rate.

After Apollo 11, man returned to the moon another five times. Each successive Apollo mission capitalized on the previous flights and improved the quality of the scientific information acquired. These missions created a reservoir of data that scientists will continue to analyze for many years in the future. It is anticipated that the results of these scientific investigations will substantially advance our knowledge and aid in solving the mysteries of our solar system.

Following are some of the significant highlights of the Apollo program:

Total flights to the Moon	9
Landings on the lunar surface	6
Astronauts on the lunar surface	12
Lunar distance traversed--Rover	90 km (Approx. 55 mi.)
Lunar samples returned	387 kg (Approx. 851 lbs.)
Laser reflectors emplaced and in use	3
Seismometers emplaced and functioning	4


APOLLO 17 SPLASHDOWN


APOLLO 17-LUNAR SCIENCE

The scientific data acquired by the Apollo program are so abundant and varied that their full value can not yet be accurately assessed and appreciated. It can be stated that man now has a first order understanding of another planet. Not only do we know much more about the moon, but we have gained important new information about the earth and the sun. Based on preliminary analysis of the Apollo 17 data and the results of previous missions, a few major scientific conclusions can be stated:

1. The moon is a complex heterogeneous body that has been partly or wholly melted to form different mineral layers.

2. The highlands of the moon are made up of rocks composed largely of the mineral anorthite. These calcium-aluminum rich rocks contrast chemically with the mare basin basalts.

3. Very old rock material, representing pieces of the lunar crust formed very soon after the formation of the moon, is evidenced in several samples.

4. The ages of soil samples from all Apollo and Luna missions are clustered in the range of 4.2 to 4.7 billion years. However, the Apollo 16 crew obtained rock samples which were in the 3.9 billion year age bracket.

5. An Apollo 16 soil sample taken from the bottom of a trench, where it was protected, appears to contain a relatively high abundance of the materials, water, methane, and hydrogen cyanide, thought to be the remains of interaction of the moon with a comet.

6. Seismic velocities at the Descartes landing site are characteristic of breccia terrain and support the contention that there are no layered volcanic rocks near the surface at this site.

7. We can now say with high confidence that internal moonquakes arise from great depth, 800-1,000 km (500-620 miles), indicative of a relatively cool interior at that depth.

8. Preliminary analysis of an impact event which occurred on August 28, 1972, on the lunar farside, and which sent seismic waves through the moon, shows evidence of the possible presence of molten rock in the deep interior of the moon-approximately 1,000 km (620 miles)- possibly in association with a small lunar core.

9. During times of solar flare activity, there is an increased abundance of solar iron and other heavy elements leaving the sun at low energies relative to the light elements such as hydrogen and helium.

10. The western maria are unusually high in near surface radioactivity.

11. Measurement of the potassium-to-uranium ratio indicated that the entire lunar surface appears to be characterized by a value ranging from 2,500 to 5,000 clearly distinct from a terrestrial value of about 10,000. This supports the argument that the moon did not separate from the Earth.

12. An increase in the amount of polonium (a product of the radioactive decay of radon) over the Sea of Fertility, as detected by the Apollo 16 particle spectrometer, may indicate very recent volcanic gas venting in that region.

13. Analysis of the laser altimetry profiles from Apollo 16 confirms the earlier observation of the offset of the lunar center of mass (about 2 km, 1.2 miles, towards the earth and about 1 km eastward), and gives the mean lunar radius as 1,737.8 km (about 1,080 miles).

14. The role of meteorite impacts in creating ancient lunar landforms has been underestimated. In addition, we now have the first, and largely unexpected, evidence that impact processes are capable of creating surfaces with many of the same characteristics as those created by volcanic processes.

15. The indigenous lunar fossil magnetism is lunar-wide, but it is not represented by a simple dipole field as in earth's magnetism. The lunar magnetic field is contained in crustal rocks that have been subsequently broken and reoriented.

16. The lunar surface was used as an astronomical observatory on Apollo 16 for an instrument called a far ultraviolet camera/spectrometer. The data show a huge amount of dissociated oxygen in the outer portions of the earth's atmosphere that may represent an important source of the atmosphere's free oxygen.

The voyage of Apollo 17 was indeed a fitting culmination to the beginning of mankind's exploration of space. Apollo leaves a lasting legacy of commitment, competence and challenge as testimony to the creative capacity of this nation. Consistent with the national commitment made in 1961, the Apollo program succeeded in creating a broad-based capability in the skills, facilities, and equipment necessary to conduct operations in space, to expand the frontiers of science and technology, and to use the benefits of space for all mankind.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1974 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR

SPACE SCIENCE PROGRAMS

(Thousands of Dollars)

Programs	Budget Plan FY 1972	Budget Plan FY 1973	Budget Plan FY 1974	FY 1973 Funds Applied to FY 1974 Program	FY 1974 Budget Authority Requested
Physics and astronomy.	110,100	126,200	95,000	30,400	64,600
Lunar and planetary exploration.....	291,500	331,969	312,000	---	312,000
Launch vehicle procurement.....	151,300	221,000	177,000	600	176,400
Total.....	552,900	679,169	584,000	31,000	553,000

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RESEARCH AND DEVELOPMENT

FISCAL YEAR 1974 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE — PHYSICS AND ASTRONOMY PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1972	1973	1974
Large observatories	$45,400,000	$47,815,000	$18,100,000
OSO	(18,600,000)	(20,300,000)	(10,000,000)
OAO	(13,400,000)	(5,700,000)	(3,100,000)
HEAO	(13,400,000)	(21,815,000)	(5,000,000)
Orbiting explorers	22,600,000	33,151,000	33,100,000
Sub-orbital programs	21,690,000	25,100,000	25,000,000
Supporting activities	20,410,000	20,134,000	18,800,000
Total	$110,100,000	$126,200,000	$95,000,000
FY 1973 funds applied to FY 1974 program			-30,400,000
Budget authority requested			$64,600,000

Distribution of Program Amount by Installation:

Manned Spacecraft Center	$626,000	$130,000	$125,000
Marshall Space Flight Center	14,438,000	23,330,000	8,785,000
Goddard Space Flight Center	67,266,000	68,106,000	55,535,000
Jet Propulsion Laboratory	490,000	677,000	660,000
Wallops Station	2,620,000	2,670,000	2,640,000
Ames Research Center	5,005,000	6,895,000	6,730,000
Langley Research Center	1,575,000	4,555,000	2,783,000
NASA Headquarters	18,080,000	19,837,000	17,742,000
Total	$110,100,000	$126,200,000	$95,000,000

HIGHLIGHTS OF BUDGET PLAN

Large Observatories

Orbiting Solar Observatories (OSO)

Spacecraft design, development, and testing; OSO-I to be launched in 1974	$12,150,000	$15,322,000	$6,800,000
Experiment development for OSO-I, data analysis for OSO-7 and prior missions, and future missions	6,450,000	4,978,000	3,200,000

	1972	1973	1974
Delta (Launch Vehicle Procurement).....	(---)	($1,100,000)	($3,000,000)
Total, OSO.....	$18,600,000	$20,300,000	$10,000,000
Orbiting Astronomical Observatories (OAO)			
Spacecraft testing and support for launch of OAO-C, 8/21/72.....	8,697,000	2,069,000	---
Experiments including data analysis, orbital operations, and Guest Observer Program.....	4,703,000	3,631,000	3,100,000
Atlas/Centaur (Launch Vehicle Procurement).....	(2,200,000)	(100,000)	(---)
Total, OAO.....	$13,400,000	$5,700,000	$3,100,000
High Energy Astronomy Observatories (HEAO)			
Spacecraft design and development of HEAO A and B for launch in 1976 and 1977.....	2,900,000	8,500,000	---
Experiment design and development for missions A and B and predefinition studies for Mission C. The HEAO series will study the universe in the high energy range of the electromagnetic spectrum.....	10,500,000	10,315,000	---
Redefinition of HEAO program.....	---	3,000,000	5,000,000
Total, HEAO.....	$13,400,000	$21,815,000	$5,000,000
Total, Large Observatories.....	$45,400,000	$47,815,000	$18,100,000

	1972	1973	1974
Orbiting Explorers			
Atmospheric Boundary Explorers			
Three missions in the Atmosphere Explorer (AE) series schedule for launch in 1973 and 1975.....	$8,350,000	$16,000,000	$13,000,000
Delta (Launch Vehicle Procurement).....	(800,000)	(5,000,000)	(2,800,000)
Interplanetary and Magnetospheric Boundary Explorers			
Interplanetary Monitoring Platform (IMP) series; includes IMP-H launched in 1972 and IMP-J development; also includes an international cooperative effort with ESRO--Magnetospheric Mother/Daughter mission and Heliocentric near-earth interplanetary probe; analysis of data from prior missions and advanced studies of potential future missions..	5,310,000	2,800,000	2,500,000
Delta (Launch Vehicle Procurement).....	(---)	(---)	(---)
Magnetospheric Explorers			
Dual Air Density and Hawkeye missions, a cooperative mission with West Germany (AEROS-launched in Dec. 72) and analysis of data from other missions previously launched.....	2,581,000	5,061,000	3,950,000
Scout (Launch Vehicle Procurement).....	(400,000)	(2,400,000)	(500,000)
Astronomy and Astrophysics Explorers			
Small Astronomy Satellite (SAS) and Radio Astronomy Explorer (RAE) series;			

	1972	1973	1974
also includes international cooperative missions with the Netherlands (ANS), United Kingdom (UK-5), and ESRO (IUE). Analysis of data from other missions launched prior to FY 1973 and for advanced studies of potential future missions.....	$6,359,000	$9,290,000	$13,650,000
Delta (Launch Vehicle Procurement).....	(1,300,000)	(3,500,000)	(---)
Scout (Launch Vehicle Procurement).....	(2,700,000)	(4,200,000)	(900,000)
Total, Orbiting Explorers..	$22,600,000	$33,151,000	$33,100,000
Sub-Orbital Programs			
Sounding Rockets-Continuation of sub-orbital rocket-borne experiments.....	$18,000,000	$20,000,000	$20,000,000
Airborne Research-Operation of an infrared telescope in a C-141 aircraft, and continued studies in infrared astronomy from other aircraft.....	2,690,000	4,100,000	4,000,000
Balloon Program-Support for balloon-borne experiments of various types.....	1,000,000	1,000,000	1,000,000
Total, Sub-Orbital Programs	$21,690,000	$25,100,000	$25,000,000
Supporting Activities			
Supporting Research and and Technology (SRT) - Support for the development of theory, instrument development, supporting laboratory studies, and ground-based observations...	15,402,000	14,826,000	13,300,000

	1972	1973	1974
Data Analysis-Continuation of studies of data obtained from various missions and for the preparation and storage of data in the National Space Science Data Center (NSSDC)..	$5,008,000	$5,000,000	$5,000,000
Payload Definition-for Shuttle Research Laboratory/ Observatory.....	---	308,000	500,000
Total, Supporting Activities.....	$20,410,000	$20,134,000	$18,800,000

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1974 ESTIMATES

OFFICE OF SPACE SCIENCE — PHYSICS AND ASTRONOMY PROGRAM

FLIGHT SCHEDULE

PROJECT	MISSION	CALENDAR YEAR
Large Observatories:		
Solar Observatories	OSO-I	1974
High Energy Astronomy Observatories	Under study	First flight no earlier than 1976
Explorers (Including International Cooperative Satellites)	2 - 4 launches per year	
Suborbital Programs:		
Sounding Rockets	80 - 90 launches per year	
Balloon Flights	50 - 60 launches per year	

OFFICE OF SPACE SCIENCE — PHYSICS AND ASTRONOMY PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The major objective of the Physics and Astronomy program is to increase our knowledge and understanding of the earth's space environment, the sun, the stars, and other celestial bodies. Under this program, research is being conducted to investigate the earth's upper atmosphere and ionosphere; the magnetosphere and the interplanetary medium. Space-based investigations of cosmic ray, X-ray, gamma ray, ultraviolet, infrared, and radio emissions, not possible from ground-based observatories because of the obscuring effect of the earth's atmosphere, give us a unique opportunity to study the sun and other celestial bodies. These investigations are the basis for increasing our knowledge of the fundamental laws of nature, especially those which control the environment of the earth.

To achieve the objectives of the Physics and Astronomy program, NASA uses techniques ranging from theoretical and laboratory research through aircraft, balloon and sounding rocket flights to small explorer spacecraft, large automated observatories, and manned spacecraft. Research teams involved in this program are located at NASA field centers, other Government laboratories, universities, and industrial laboratories. Foreign participation is encouraged with the participating country providing its share of the costs.

The information obtained and the technology developed in the program are made available to the scientific and technical community for applications and for advancement of scientific research, education, and technology.

BASIS OF FUND REQUIREMENTS:

Large Observatories

	1972	1973	1974
Orbiting Solar Observatories (OSO)			
OSO Spacecraft.....	$12,150,000	$15,322,000	$6,800,000
OSO Experiments.....	6,450,000	4,978,000	3,200,000
Subtotal OSO.....	$18,600,000	$20,300,000	$10,000,000
Orbiting Astronomical Observatories (OAO)			
Spacecraft.....	$8,697,000	$2,069,000	---
Experiments.....	4,703,000	3,631,000	$3,100,000
Subtotal OAO.....	$13,400,000	$5,700,000	$3,100,000
High Energy Astronomy Observatories (HEAO)			
Spacecraft.....	$2,900,000	$8,500,000	---
Experiments.....	10,500,000	10,315,000	---
Redefinition of HEAO program	---	3,000,000	$5,000,000
Subtotal HEAO.....	$13,400,000	$21,815,000	$5,000,000
Subtotal Large Observatories.....	$45,400,000	$47,815,000	$18,100,000
(Launch Vehicle Procurement program):			
Delta (OSO).....	(---)	(1,100,000)	(3,000,000)
Centaur (OAO).....	(2,200,000)	(100,000)	(---)
Total (Including Launch Vehicles).....	($47,600,000)	($49,015,000)	($21,100,000)

Orbiting Solar Observatories (OSO)

The objective of the OSO program is to obtain new knowledge of the sun, the solar interactions with the earth's atmosphere, and sun-activated terrestrial phenomena over a broad range of the electromagnetic spectrum not detectable by ground-based observatories.

The OSO's have provided significant discoveries about the sun and the earth, and have expanded man's understanding of the nearest star and its effects on the earth.

OSO-7, launched in 1971, continues to provide detailed studies of the solar corona, and the spectrum of solar and cosmic X-rays.

Fiscal Year 1973 funds are being used for in-orbit operations and reduction and analysis of data from the OSO-7 mission and for development of the OSO-I spacecraft and scientific instruments.

Fiscal Year 1974 funds will be used to continue the development and fabrication effort on the OSO-I spacecraft including the basic structure, interfaces for experiments, power systems, telemetry, control and data handling systems as well as observatory integration and environmental tests. FY 1974 funds will also be used to continue the development and fabrication of the individual instruments for the OSO-I mission, to continue the OSO-7 in-orbit operations,and to provide for the analysis of the data obtained from that mission.

Orbiting Astronomical Observatories (OAO)

The OAO program has provided astronomers with accurately stabilized, automated space observatories for telescopic observations of celestial objects primarily in the ultraviolet region of the electromagnetic spectrum.

More than four years after launch, OAO-2 continues to make major contributions to our understanding of the universe by providing the first extended observations of the ultraviolet spectra of the brighter and nearer celestial objects.

The last of this series of observatories, OAO-3 (Copernicus), was launched in August 1972. OAO-3 carries the Princeton University 81 centimeter (32 inch) telescope system and the University College of London instrument to investigate celestial X-ray sources. These instruments provide higher spectral resolution than those flown on OAO-2 in order to study in detail the composition, the abundance, and the temperature distribution of the interstellar gas from which stars are formed.

Fiscal Year 1973 funds supported the launch and operation of OAO-3 and analysis of data obtained by the Princeton experiment; in addition, OAO-2 operation and data analysis was continued for the Wisconsin experiment, and the data from the Smithsonian Astrophysical Observatory Telescope experiment was published.

Fiscal Year 1974 funds will support OAO-2 and OAO-3 in-orbit operations and provide for data processing and analysis of data obtained by the scientific experiments. Support is also provided for a Guest Observer program to provide an opportunity for additional astronomers to use OAO to study celestial objects.

High Energy Astronomy Observatories (HEAO)

The basic scientific objective of the High Energy Astronomy Observatory program is to explore the previously inaccessible regimes of the celestial X-ray and gamma ray sources and of cosmic ray flux. This program has the potential for a major impact on our understanding of newly discovered energy processes and creation of matter. The understanding of observed phenomena such as quasars, pulsars, novas, and supernovas will be greatly increased. This program of investigations has been given the highest priority by various advisory boards, including the President's Scientific Advisory Council and the National Academy of Sciences (Woods Hole Summer Study).

The FY 1973 budget request included funding to continue development on two observatory-class spacecraft and related experiments, and definition studies on two additional missions. As part of the actions required to reduce Government spending in FY 1973, development effort on the HEAO project has been suspended. The action taken was limited to suspension because of the importance of the program objectives, and action was immediately initiated to redefine and redirect the specific approach. Fiscal Year 1974 funds will be used for definition and design activity pursuant to the effort to achieve the approved HEAO objectives through a lower cost approach.

Orbiting Explorers

	1972	1973	1974
Atmospheric boundary explorers.....	$8,350,000	$16,000,000	$13,000,000
Interplanetary and magnetospheric boundary explorers...	5,310,000	2,800,000	2,500,000
Magnetospheric explorers.....	2,581,000	5,061,000	3,950,000
Astronomy and astrophysics explorers.....	6,359,000	9,290,000	13,650,000
Subtotal, Orbiting Explorers.....	$22,600,000	$33,151,000	$33,100,000
(Launch Vehicle Procurement program):			
Delta.....	(2,100,000)	(8,500,000)	(2,800,000)
Scout.....	(3,100,000)	(6,600,000)	(1,400,000)
Total (including Launch Vehicles).....	($27,800,000)	($48,251,000)	($37,300,000)

The Explorer program makes use of relatively small spacecraft, each dedicated to specific, problem-oriented objectives, thus enabling the design of the spacecraft and the parameters of the orbit to be optimized to meet each objective. Problems in X-ray, gamma ray and radio astronomy, atmospheric and ionospheric physics, radiation belts, magnetospheric boundaries, and interplanetary space are being investigated in this way. This program also provides a major means for cooperative missions with other Government agencies and other countries, where mutual program objectives can be met with the cooperating party paying its own costs.

Explorer spacecraft are launched at a rate of about two to four missions per year, with both Delta and Scout launch vehicles.

In FY 1974, funds will be used for the following Explorer missions:

Atmospheric Boundary Explorers

Atmosphere Explorers (AE) are aimed at investigating the detailed processes which occur as a result of solar energy absorption by the earth's upper atmosphere. Three missions are planned for launch during the 1973-1975 time period, each of which will be equipped with an on-board propulsion system to permit variations in orbital altitude at the upper limits of the earth's atmosphere. This will permit the AE's to dip lower into the earth's atmosphere than any previous satellite, thus making possible, for the first time, systematic studies of the region where most of the solar radiation is absorbed and where most of the sun-induced photochemistry occurs. This region has previously been investigated only by sounding rockets, which are limited by the duration of the flight and the area of coverage.

Fiscal Year 1974 funds will be used for launch and in-orbit operation of AE-C, analysis of data from AE-C experiments, and continuation of work on AE-D and E.

Interplanetary and Magnetospheric Boundary Explorers

The Interplanetary Monitoring Platform (IMP) series was established for the purpose of long-term observations of earth-sun relations, particularly the outer magnetosphere, the magnetosheath, and the interplanetary medium. The most recent spacecraft in the IMP series (IMP-H - Explorer 47) was successfully launched in September 1972. System definition studies are underway for both a planned magnetospheric physics mission and a heliocentric near-earth interplanetary probe. These two projects, which together form an interrelated mission, involve a cooperative effort with the European Space Research Organization (ESRO).

Fiscal Year 1974 funds will provide for analysis of data from IMP-H and IMP-I (Explorer 43 launched in March 1971), continuation of work on IMP-J and for selection of payload and initial hardware work for the magnetospheric Mother/Daughter spacecraft and the heliocentric near-earth interplanetary probe.

Magnetospheric Explorers

Magnetospheric explorers are used for investigations of the uppermost layers of the earth's atmosphere, the Van Allen radiation zones, and electric and magnetic fields around the earth. These missions also study questions such as how charged particles enter and leave the earth's magnetosphere, and how changes in the energy output from the sun affect the near-earth environment.

This category of Explorer-class missions includes the newly launched AEROS (December 1972), a cooperative mission with West Germany, as well as the Dual Air Density and Hawkeye missions which are in the hardware phase of development. Also included for FY 1974 funding is the analysis of data from other missions previously launched.

Astronomy and Astrophysics Explorers

These explorers provide the means for carrying out astronomical studies relating to the sun, stars, galaxies and planets which do not require complex astronomical observatories. Included here are the Small Astronomy Satellites (SAS); the Radio Astronomy Explorers; the International Ultraviolet Explorer (IUE), which is an international cooperative effort with the United Kingdom and ESRO; and cooperative astronomy missions with the United Kingdom and the Netherlands (UK-5 and ANS). The most recent mission was Explorer 48 (SAS-B), which was successfully launched in November 1972. RAE-B is scheduled for launch in 1973.

Fiscal Year 1974 funds will support the continuation of work on SAS-C; the continuation of acquisition, processing, reduction and analysis of data from operational satellites; the development and construction of the IUE; and continuation of work on UK-5 and ANS.

Suborbital Programs

	1972	1973	1974
Sounding rockets.....	$18,000,000	$20,000,000	$20,000,000
Airborne research.....	2,690,000	4,100,000	4,000,000
Balloon program.....	1,000,000	1,000,000	1,000,000
Total.....	$21,690,000	$25,100,000	$25,000,000

Sounding Rockets

As in past years, sounding rockets will be utilized as a valuable and versatile tool for scientific research in the space environment. Studies will continue in the traditional scientific disciplines, including cosmic dust and interplanetary matter studies, magnetospheric physics, stellar astronomy and solar astronomy.

The specific objectives of the Sounding Rocket program are as follows:

1. To conduct a coordinated program to study the nature, characteristics, and composition of the upper atmosphere, ionosphere, and near space up to one earth radius; the effects of incoming energetic particles, and solar and stellar radiation on the upper atmosphere and ionosphere; and the nature, characteristics, and spectra of radiation of the sun, stars, and other celestial objects, with flight requirements which cannot be covered by or do not require long duration satellite observations.

2. To support the basic objectives of the Physics and Astronomy programs by providing the means for obtaining measurements at altitudes too low for satellites but too high for balloons; for flight testing instruments and experiments being developed for flight on satellites, observatories, and space probes; and for calibrating or obtaining vertical profiles in correlation with currently orbiting spacecraft.

3. To provide means for improving the technical competence in space techniques of new experimenters, and support personnel in space science experimentation, both on a domestic and an international cooperative basis at minimum expense.

The current level of funding in the Sounding Rocket program provides for 80 to 90 flights per year.

In the magnetospheric physics area, continued emphasis has been placed on lower ionospheric measurements (low altitude measurements which can only be done with sounding rockets) and vertical scans correlated with satellite measurements. Increasing emphasis is being placed on the coordination of near-simultaneous launching of individual rocket payloads.

In the interplanetary dust/cometary physics area, several rockets were launched during the Giacobinid meteor showers in October 1972.

Continuing emphasis is placed on stellar astronomy in both the ultraviolet and X-ray regions. Many observations will extend the earlier measurements on satellites such as UHURU and OAO-2.

Of significant interest to solar astronomy will be the launch of sounding rockets during the Skylab mission. They will be used for correlative measurements and for the calibration of solar instruments aboard the Skylab spacecraft.

New effort has been initiated on payload development of a gravity probe which will measure the gravitational red shift by comparing the frequency shift of two hydrogen maser clocks, one located on the ground and one placed in a ballistic trajectory as a rocket probe.

Fiscal Year 1974 will see a continuation of these efforts with emphasis on the coordination of rocket launches and on correlation with satellite observations. Specific efforts of this type include an expedition to Australia for southern sky observations and a series of coordinated launches from Wallops Station to study in detail the atmospheric structure and dynamics in the upper atmosphere between 70 and 160 km (43 and 100 miles).

Airborne Research

Airborne research with instrumented jet aircraft bridges the gap between ground-based experiments and those requiring balloons, rockets, and space vehicle systems. The operational flexibility, the direct participation of scientists, and the large payload capacity with the ability for extended observations over any geophysical area have made possible excellent scientific results and correlations with NASA's satellite systems. The Airborne Research program is demonstrating an approach which may be applicable to space shuttle operations in the future.

The Physics and Astronomy Airborne Research project emphasizes the support of infrared astronomy and investigations of the physics of the aurora and airglow. Infrared (IR) astronomy of the sun, planets, and galaxies with small telescopes has been undertaken from the CV-990 and Lear Jet aircraft. A larger IR telescope, 91 cm (36 inches), has been built for observations from a C-141A jet aircraft. This IR observatory is a full-scale, manned facility. The telescope will operate through an open port, and will be separated from the astronomers by a pressurized wall. This will permit the astronomers to work in a comfortable, shirt-sleeve environment. The Airborne IR Observatory will become a dedicated national facility for infrared astronomy in late 1973.

Infrared astronomers have actively participated in the Lear Jet program utilizing a 30-cm (12 inch) telescope. This program currently involves ten groups of astronomers. Based on the large number of proposals for the use of the 91-cm Airborne IR Observatory, as many as 20 groups will probably be using this facility.

The FY 1973 Airborne Research program funds have been used to complete the construction and operational testing of the Airborne IR Observatory on the C-141A. FY 1973 funds also provided for continuation of the Lear Jet astronomical program and the support of the CV-990 Giacobinid Meteor Shower Expedition.

The FY 1974 airborne research budget will be used mainly to operate the Airborne IR Observatory. These operations require the support for the astronomical groups, the acquisition of subsystems, and the operation of the C-141A. A study of the comparison of the operation of the Airborne IR Observatory in relation to the Sortie Mode operation of an observatory placed in orbit by the Space Shuttle is also planned. The Lear Jet program will be continued, and special geophysical expeditions for polar regions, auroral and airglow studies and coordinated observations with satellites are planned.

Balloon Program

In the development of scientific experiments for space flight and other independent scientific missions, it is necessary to test the instrumentation in the space environment and to make observations at altitudes which are not accessible to rockets and spacecraft. In many instances, it is less expensive and more efficient to fly these payloads on balloons. Approximately one million dollars has been expended annually to support 50 - 60 balloon flights a year. This estimate includes balloons, launch services, tracking, and recovery. Funding for the experiments is provided from Supporting Research and Technology (SR&T). The FY 1974 request will support a level of effort approximately equal to FY 1973, although some decrease in total number of flights may be experienced due to the increased emphasis on larger balloons and correspondingly higher altitude requirements.

Supporting Activities

	1972	1973	1974
Supporting research and technology (SR&T).....	$15,402,000	$14,826,000	$13,300,000
Data analysis.....	5,008,000	5,000,000	5,000,000
Payload definition.....	---	308,000	500,000
Total.....	$20,410,000	$20,134,000	$18,800,000

Supporting Research and Technology (SR&T)

This effort enhances the overall scientific and technological return from NASA flight projects and helps assure the continued viability of the future

research program in space science. The objectives can be stated in the following three broad categories: (1) enhancement of the value of current space missions by supplementary simultaneous ground-based observations; (2) development of theories to explain observed phenomena and predict new ones; and (3) optimization of the return expected from future missions by problem definition, development of advanced experiments and concepts, and the careful definition of proposed new missions.

The work in space physics is largely devoted to support of research related to physics of the earth's environment. It includes study of the sun-earth environmental factors, as well as extrasolar factors such as cosmic rays. Research supported in the field of astronomy involves the study of the sun and objects outside the solar system. Research tasks include studies of the solar spectrum and the influence of the sun on interplanetary and planetary environments, instrument development, and laboratory and theoretical studies of basic physical processes peculiar to the sun. Also included are solar radio astronomy, research tasks related to objects outside of the solar system including observation by ground-based and balloon-borne telescopes, and radio astronomy and instrument development. Theoretical studies of stars, galaxies, interstellar and intergalactic matter, and advanced development work on experimental tests of the validity of Einstein's Theory of Relativity are also supported in this area.

About 200 tasks are being supported at universities, nonprofit and industrial research institutions, NASA centers and other Government agencies in 25 states and the District of Columbia.

During FY 1974, continued support will be given to those tasks which are critical to maintaining a firm base for a viable Physics and Astronomy program. Of special significance is the continuation of studies for advanced astronomical instrumentation involving large optical systems. The Large Space Telescope (LST), a multiple-purpose 3-meter (118 inch) telescope, will provide the capability for pursuing a very broad range of problems. Because of its high resolution and large light collecting area, this instrument will be able to reach galaxies at distances as much as ten times those available to the 5-meter (200 inch) telescope at the Hale Observatory on Mt. Palomar. Definition studies are in progress. These include the optical telescope assembly and the support systems module. Continuation of the work started on the mirror blank will provide verification that the surface can be polished to the extent required for the LST. Experiment definition will involve the scientific community in defining the instruments to be placed behind the primary mirror. It is also planned to continue advanced technological development, such as third generation gyros for the precise pointing and stabilization requirements.

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Data Analysis

The purpose of this effort is to obtain the maximum return on our investment in Space Science represented by the large data base acquired and the continued operability of a number of spacecraft well beyond their planned lifetimes. Support is provided to research using existing data with emphasis on studies involving the correlation of data from simultaneous observations obtained from several satellites, sounding rockets or ground-based observatories. Limited operation of older spacecraft is authorized for special investigations and for the exploitation of unusual opportunities such as unexpected encounters with comets or extraordinary solar flare activity.

Fiscal Year 1974 funds will provide support for about 80 principal investigators at approximately 45 institutions, including NASA field centers.

The operation of the National Space Science Data Center (NSSDC) is also supported under this project. The NSSDC, located at the Goddard Space Flight Center (GSFC), was established to serve as a central repository and clearinghouse of scientific data in its reduced form resulting from space investigations. Investigators are expected to prepare data, complete with calibrations, in a form suitable for deposit in the NSSDC. The amount of data to be handled has increased steadily each year.

Payload Definition

Plans are being prepared for operating national Physics and Astronomy research facilities on the Space Shuttle by providing the capability for conducting unique experiments or observations of specific phenomena. These facilities will encompass both laboratories and observatories configured as shuttle payloads and operated by scientists on the shuttle. Each payload could be flown several times per year and have an operational lifetime comparable with traditional ground-based facilities.

The payloads are oriented to the conduct of basic research in the discipline areas of astronomy, solar physics, astrophysics, magnetospherics and atmospheric physics. The proposed research will require space observations and can be conducted most easily from the Space Shuttle. At present, seven specific dedicated payloads have been identified covering infrared astronomy, optical astronomy, X- and Gamma ray astronomy, solar physics, high energy cosmic ray physics, plasma physics and environmental perturbation, and atmospheric sciences.

This program will build on the experience and accomplishments of on-going flight projects, including the Skylab mission. FY 1974 funding will be used for payload studies and experiment definition.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1974 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE — LUNAR AND PLANETARY EXPLORATION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1972	1973	1974
Mariner	$61,600,000	$38,953,000	$8,900,000
Viking	176,200,000	229,381,000	201,200,000
Outer planets missions	9,165,000	7,000,000	32,200,000
Pioneer/Helios	15,264,000	12,235,000	7,700,000
Supporting research and technology/ advanced studies	19,218,000	18,900,000	16,500,000
Planetary astronomy	4,800,000	4,800,000	3,700,000
Data analysis	3,053,000	3,500,000	9,700,000
Planetary quarantine	2,200,000	2,200,000	1,500,000
Planetary flight support	---	15,000,000	22,000,000
Lunar sample analysis	---	---	4,600,000
Lunar science operations	---	---	4,000,000
Total	$291,500,000	$331,969,000	$312,000,000

Distribution of Program Amount by Installation:

Manned Spacecraft Center	$425,000	$350,000	$11,398,000
Marshall Space Flight Center	247,000	---	25,000
Goddard Space Flight Center	4,804,000	4,791,000	4,441,000
Jet Propulsion Laboratory	75,952,000	64,771,000	59,689,000
Wallops Station	50,000	65,000	65,000
Ames Research Center	17,537,000	15,756,000	12,407,000
Langley Research Center	173,680,000	226,541,000	191,008,000
NASA Headquarters	18,805,000	19,695,000	32,967,000
Total	$291,500,000	$331,969,000	$312,000,000

HIGHLIGHTS OF BUDGET PLAN

	1972	1973	1974
Mariner			
Mariner Mars 1971			
Mission operations for basic 90 day orbital period and extended mission operations for an additional nine months.....	$13,420,000	$3,871,000	---
Project management and project integration.....	3,390,000	3,575,000	---
Hardware development of two spacecraft launched in May 1971....	190,000	---	---
Subtotal, Mariner Mars 1971....	$17,000,000	$7,446,000	---
Mariner Venus/Mercury 1973			
Spacecraft design, development, and test leading to delivery to KSC in June 1973.....	38,100,000	26,600,000	1,900,000
Science instruments to return ultraviolet and visual television pictures, atmosphere and ionosphere data, and thermal maps from both Venus and Mercury.....	5,400,000	3,300,000	1,500,000
Mission operations preparations for mission beginning in November 1973.....	1,100,000	1,607,000	5,500,000
Subtotal, Mariner Venus/Mercury 1973	$44,600,000	$31,507,000	$8,900,000
Atlas/Centaur (Launch Vehicle Procurement).....	(7,800,000)	(6,000,000)	(300,000)
Total, Mariner.....	$61,600,000	$38,953,000	$8,900,000
Viking			
Orbiter			
Spacecraft design, development, and test leading to delivery of two spacecraft to KSC in early 1975.....	$31,400,000	$65,600,000	$61,300,000
Science instruments to obtain planetary data, including water vapor and thermal mapping, for at least three months.....	5,600,000	8,700,000	8,800,000

	1972	1973	1974
Lander			
Spacecraft design, development, and test leading to delivery of three spacecraft to KSC early in 1975.....	$88,800,000	$103,900,000	$85,000,000
Science instruments to transmit biological, geological, meteorological, and other data from the surface of Mars to earth for 90 days.....	39,400,000	38,700,000	23,700,000
Project Management and Project Integration.....	11,000,000	12,481,000	22,400,000
Titan/Centaur (Launch Vehicle Procurement).....	(10,100,000)	(35,500,000)	(29,500,000)
Total, Viking.....	$176,200,000	$229,381,000	$201,200,000
Outer Planets Missions			
Spacecraft Design and Development			
Spacecraft system design, using existing Mariner/Viking subsystems where possible; required design modification and new technology developments; procurement of spacecraft subsystems.....	$6,100,000	$4,200,000	$19,900,000
Science - Instruments to collect data on composition and structure of atmospheres, radiation belts and magnetic fields of Jupiter and Saturn; nature of Saturn's rings and its satellite, Titan.....	1,600,000	1,600,000	9,100,000
Project Management and Mission Design			
Detailed mission design, coordinated with selected science investigations.....	1,465,000	1,200,000	3,200,000
Titan/Centaur (Launch Vehicle Procurement).....	(---)	(---)	(9,700,000)
Total, Outer Planets.....	$9,165,000	$7,000,000	$32,200,000

	1972	1973	1974
Pioneer/Helios			
Pioneer 6-9			
Operations.....	$600,000	$400,000	$200,000
Receipt and reduction of scientific data on magnetic tapes...	$600,000	$400,000	$200,000
Pioneer F/G			
Spacecraft			
Fabrication and acceptance testing of Pioneer G systems.....	7,164,000	5,270,000	1,700,000
Science			
Analysis of scientific data collected during the F and G missions.....	2,900,000	2,400,000	1,800,000
Operations			
Support of the F and G missions at the Space Flight Operations Facility and Deep Space Network by controlling the spacecraft, tracking it, and recording data on magnetic tapes...	2,100,000	1,900,000	2,500,000
Subtotal, Pioneer F/G.....	$12,164,000	$9,570,000	$6,000,000
Helios A and B			
Science			
Test and integration into spacecraft of experiments for first mission. Assembly and test of experiments for second mission.....	1,720,000	1,525,000	660,000
Operations			
Software design for mission operations and data analysis.....	780,000	740,000	840,000
Subtotal, Helios A and B.....	$2,500,000	$2,265,000	$1,500,000
Centaur (Launch Vehicle Procurement).....	(12,200,000)	(16,500,000)	(30,000,000)
Total, Pioneer/Helios.....	$15,264,000	$12,235,000	$7,700,000

	1972	1973	1974
Supporting Research and Technology/ Advanced Studies			
Lunar Science Scientific studies to understand the origin of the moon and the earth.....	$2,347,000	$2,900,000	$2,300,000
Planetary Science Supports research in planetary atmospheric phenomena; planetary geology, including geochemistry, geophysics, and photogeology.....	4,936,000	4,700,000	4,500,000
Planetary Advanced Technical Development Assures technological readiness and performs detailed advanced planning for candidate planetary missions.....	6,835,000	6,200,000	5,200,000
Planetary Advanced Studies Evaluates feasibility of potential future scientific missions to planets; develops up-to-date mission opportunity catalog.	1,200,000	1,200,000	1,200,000
Exobiology Supports research toward understanding the controlling factors in the origin of life, and determining the uniqueness of life on earth.....	3,900,000	3,900,000	3,300,000
Total, Supporting Research and Technology/Advanced Studies.....	$19,218,000	$18,900,000	$16,500,000
Planetary Astronomy Ground-based astronomy support of the planetary exploration program objectives.....	4,800,000	4,800,000	3,700,000
Data Analysis Support of scientists analyzing data of flight programs after the initial period funded in the basic mission.....	3,053,000	3,500,000	9,700,000
Planetary Quarantine All feasible measures to avoid the transfer of viable terrestrial life forms to the planets.....	2,200,000	2,200,000	1,500,000

	1972	1973	1974
Planetary Flight Support			
Basic computer processing and display capability to support telemetry, tracking, and command functions for all planetary spacecraft.....	---	$15,000,000*	$22,000,000
Lunar Sample Analysis			
Support scientific analysis of the lunar materials returned to earth by Apollo.....	---	---	4,600,000**
Lunar Science Operations			
Operate the still functioning Apollo ALSEP's and subsatellite, and the Lunar Laser Ranging experiment.....	---	---	4,000,000**

* Fiscal Year 1972 and prior funding included under Tracking and Data Acquisition program. Responsibility for this activity was transferred to the Office of Space Science during FY 1973.

** Fiscal Year 1973 and prior funding included in the Apollo program.

OFFICE OF SPACE SCIENCE — LUNAR AND PLANETARY EXPLORATION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objective of the Lunar and Planetary Exploration program is the scientific exploration of the moon, the planets and their satellites, asteroids, comets, and the particles and fields of interplanetary space. The goal of this exploration is to understand the origin and evolution of the solar system, the origin and evolution of life, and the dynamic processes that shape man's terrestrial environment. The planetary program employs ground-based astronomy as well as automated spacecraft which fly by, orbit, and land on other bodies in our solar system. The lunar program utilizes ground-based astronomy and data from the Apollo series to investigate the composition and nature of lunar materials and phenomena.

The planetary and interplanetary flight missions undertaken to date have been highly successful, beginning with the first visit to another planet, the Mariner 2 flyby of Venus in 1962, and continuing with the first successful orbiting of Mars in November 1971 by the Mariner 9. In March 1972, Pioneer 10 was launched and has provided the first measurements of the interplanetary medium beyond Mars and through the Asteroid Belt. It will continue on for the first flyby of the mysterious giant planet Jupiter. Pioneer G is planned to follow with launch in April 1973. In late 1973, another Mariner spacecraft will be launched to fly by Mercury, utilizing the increased velocity achieved by a close swingby of Venus. Two cooperative US/German spacecraft, Helios A&B, will be launched in 1974 and 1976 to investigate the properties in interplanetary space in close proximity to the sun. Knowledge of Mars and its environment will be expanded by the two Viking spacecraft to be launched in 1975 which will orbit and land on the Martian surface in 1976. In 1977, two Mariner spacecraft will be launched to fly by Jupiter and its satellites and then continue on to study Saturn with its rings and satellites, thereby extending man's frontier of knowledge about the solar system to the outer planets.

BASIS OF FUND REQUIREMENTS:

Mariner

	1972	1973	1974
Mariner Venus/Mercury 1973.....	$44,600,000	$31,507,000	$8,900,000
Mariner Mars 1971.....	17,000,000	7,446,000	---
Total, Spacecraft and Support...	$61,600,000	$38,953,000	$8,900,000
Atlas Centaur (Launch Vehicle Procurement program).....	($7,800,000)	($6,000,000)	($300,000)
Total, (including launch vehicle).....	($69,400,000)	($44,953,000)	($9,200,000)

The Mariner series of spacecraft has been and continues to be a most important tool in planetary exploration. These spacecraft have evolved from the 204 kg. (450 lb.) Mariner 2, used for man's first successful flyby mission to another planet, to the 1,000 kg. (2,200 lb.) Mariner Mars 1971 (Mariner 9) which was successfully inserted into Mars orbit in November 1971. During FY 1973, Mariner 9 completed its extended mission, operating successfully over 259 days in orbit after completion of its 90 day primary mission. Mariner 9 has proven Mars to be a highly active planet, both meteorologically and geologically and has mapped 100% of its surface to a resolution of 1 km. (0.6 miles).

Mariner Venus/Mercury 1973

Spacecraft.....	$38,100,000	$26,600,000	$1,900,000
Science instruments.....	5,400,000	3,300,000	1,500,000
Mission operations.....	1,100,000	1,607,000	5,500,000
Total.....	$44,600,000	$31,507,000	$8,900,000

A single modified Mariner spacecraft, to be launched in late 1973, will fly by both Venus and Mercury in 1974. Using the same rocket needed to launch it to Venus, the MVM 1973 spacecraft will utilize Venus' gravity to receive an increase in speed and change in trajectory so that it will also fly by Mercury, the closest planet to our Sun. The spacecraft, launched by an Atlas Centaur, will transmit ultraviolet and visual television pictures, atmospheric data, and thermal maps from both planets. Additionally, it will investigate the space environment in the unexplored region between Venus and Mercury, and will provide valuable experience for future multi-planet gravity-assist trajectories. Following initial Mercury encounter, the spacecraft

will go into a heliocentric orbit in which it will again encounter Mercury 176 days after the first encounter. This will afford a valuable opportunity to verify and expand the initial science measurements, and to investigate their time dependence.

Funds requested will be used as follows:

Spacecraft - The major activities during FY 1973 will be the assembly of both the test and flight spacecraft, and the system level testing of these spacecraft by the system contractor, the Boeing Company, in Kent, Washington. System level testing verifies the compatibility of the subsystems and instruments, and checks overall spacecraft system performance. Complete assembly of the flight spacecraft is scheduled for early May 1973, followed by system level and environmental testing during June-July 1973, which will provide final verification of the spacecraft's readiness to perform its mission.

Major activities in FY 1974, following environmental testing, include preshipment reviews in August 1973, and transfer of the flight spacecraft to Kennedy Space Center for launch preparation. The spacecraft will be launched during the October-November 1973 opportunity, and will encounter Venus in early February and Mercury in late March 1974.

Science Instruments - FY 1973 efforts focus on fabrication and acceptance testing of the science instruments, and assembly into the test and flight spacecraft.

After launch, scientific data will be returned during the interplanetary transit and encounter phases of the mission. Over 5,000 TV pictures will be returned to provide good coverage of both Venus and Mercury. Fiscal Year 1974 science funds will be used for analysis of these data, and to produce scientific papers and reports by the science investigators.

Mission Operations - During FY 1973, activities in mission operations include detail design, software development, and definition of tracking and data systems requirements. Detail design includes the definition of a detailed mission sequence and definition of operational procedures. Documentation will be published and computer programs will be developed for test, support, and control of the spacecraft systems.

During FY 1974, Mission Operations System (MOS) activities will concentrate on training for and conduct of flight operations. After the training cycle from July through mid-October 1973, the MOS team will support launch operations; track, command, and receive data from the spacecraft during the transit period between planets; and support 24 hour operations during encounters of Venus and Mercury.

Viking

	1972	1973	1974
Orbiter spacecraft.....	$31,400,000	$65,600,000	$61,300,000
Orbiter science.....	5,600,000	8,700,000	8,800,000
Lander spacecraft.....	88,800,000	103,900,000	85,000,000
Lander science.....	39,400,000	38,700,000	23,700,000
Project management and project integration.....	11,000,000	12,481,000	22,400,000
Total.....	$176,200,000	$229,381,000	$201,200,000
Titan Centaur (Launch Vehicle Procurement program).....	($10,100,000)	($35,500,000)	($29,500,000)
Total (including launch vehicles).....	($186,300,000)	($264,881,000)	($230,700,000)

The objective of the Viking program is to significantly advance our knowledge of the planet Mars by means of observations from Martian orbit and direct measurements in the atmosphere and on the surface. The Viking 1975 mission will greatly expand the exploration of Mars initiated by the earlier Mariners. Emphasis will be placed on obtaining biological, chemical, and environmental factors relevant to the existence of life on the planet.

Two Viking spacecraft will be launched in 1975 by Titan/Centaur launch vehicles. Each spacecraft will consist of an Orbiter and a Lander. When the spacecraft arrive at Mars in the summer of 1976, each Orbiter will place itself and the attached Lander into an orbit around Mars. The Lander will separate from the Orbiter about 10 days after arrival at Mars and descend through the atmosphere to the surface. After soft landing, the Lander will transmit biological, geological, meteorological, and other scientific data to earth for at least 90 days. Instruments on the Orbiters will obtain data on dynamic planetary processes and will relay Lander data back to earth.

During FY 1973, funds were used to complete the designs of the Lander and Orbiter, purchase all parts and materials, fabricate and test development models of the subsystems and instruments, fabricate and test a complete functional model of the spacecraft, and begin the detailed planning necessary to conduct the mission. The peak manpower point in the program was passed in December 1972.

Funds requested for FY 1974 will be used as follows:

Orbiter

Spacecraft Development - Qualification tests will be completed on all of the subsystems, proving that they will perform properly under the expected environmental conditions. A complete proof-test Orbiter will be assembled and tested to prove the adequacy of the design as a whole.

A special proof-test launch of the Titan/Centaur vehicle will be held early in 1974 to test the combined performance of the launch vehicle with a simulated Viking spacecraft.

The subsystems for the two flight spacecraft will be assembled and started through their acceptance tests. Assembly effort will begin on the first complete Orbiter for the flight mission.

Science Instruments - Orbiter science instruments are two television cameras, an infrared spectrometer for water vapor mapping, and an infrared radiometer for thermal mapping. During this period, the prototype instruments will receive their final qualification tests. All flight instruments will be assembled and subjected to acceptance tests, in preparation for being integrated into the flight spacecraft.

Lander

Spacecraft Development - Tests will be completed for the prototype Lander models used in system integration, static loading, and dynamic loading tests.

The Proof Test Lander Capsule (PTC) will complete assembly operations and start through its tortuous tests to show full compliance with all design requirements. The first fueled Radioisotope Thermoelectric Generator (RTG) will be received from the Atomic Energy Commission and undergo compatibility tests with the Lander models. Two RTG's will supply power to each flight Lander.

The first Lander flight capsule will be assembled completely and begin its final acceptance tests.

Science Instruments - Lander science instruments are primarily directed toward determining whether life exists, has existed, or can exist on Mars. To that end, a number of instruments are being developed to measure various Martian phenomena, investigation of which will contribute to the basic questions of life on the planet. Three separate biology experiments will subject a soil sample to environments which stimulate organic growth. Using radioactive carbon compounds and gas chromatography, gas exchanges will be monitored to determine if metabolic processes are taking place.

Other scientific instrumentation includes a gas chromatograph/mass spectrometer for molecular analysis of the soil and atmosphere, two facsimile cameras, an X-ray fluorescent spectrometer for inorganic analysis of the soil, meteorology instruments, a seismometer, a mass spectrometer and retarding potential analyzer for upper atmosphere composition, and pressure and temperature sensors for atmospheric structure.

All instruments will complete individual qualification tests during this period. In general, the subcontractors building the instruments will deliver in FY 1974 the specific instruments used in the PTC and first flight capsules. Thus, effort on the instruments will be nearly completed, leaving only the assembly and delivery of the instruments for the last two flight capsules.

Project Management and Project Integration

The Office of Space Science, NASA Headquarters, is responsible for overall management of the Viking program. The Langley Research Center is responsible for project management. The Jet Propulsion Laboratory is responsible for the Orbiter and the Martin-Marietta Corporation is the prime contractor for the Lander and systems integration. The Lewis Research Center is responsible for the launch vehicle.

In FY 1974, project management will be primarily concerned with overseeing the qualifying and proof testing of all spacecraft hardware. The various subsystems and systems must be shown to function together properly under all expected conditions.

The important final design review will be held for the launch and flight operations systems. Work will continue in mission planning for developing the detailed rules, sequences, and organizations needed for conducting the missions. Final certification will occur for the flight operations software. System testing of the ground data system will begin.

Outer Planets Missions

	1972	1973	1974
Project management, mission design, and operations	$1,465,000	$1,200,000	$3,200,000
Spacecraft design and development	6,100,000	4,200,000	19,900,000
Science	1,600,000	1,600,000	9,100,000
Total	$9,165,000	$7,000,000	$32,200,000
Titan Centaur (Launch Vehicle Procurement program)	(---)	(---)	($9,700,000)
Total (including launch vehicles)	($9,165,000)	($7,000,000)	($41,900,000)

The Outer Planets Missions program ("Mariner Jupiter-Saturn 1977") is directed toward the exploration of Jupiter and Saturn using two modified Mariner-type spacecraft. The Space Science Board of the National Academy of Sciences has endorsed the Outer Planets Missions program as "a strong and flexible program which is a reasonable next step in planetary exploration."

In addition to obtaining information on the two giant planets and on the interplanetary medium, the trajectories of these spacecraft will be designed to yield close flybys of Saturn's rings and of various massive satellites of both planets. One target will be Saturn's satellite, Titan, which is comparable in size to the planet Mercury and is the only satellite in the solar system known to possess an atmosphere.

The spacecraft will be launched in 1977 and will encounter Jupiter about 1 1/2 years after launch. Using the gravity-assist swingby technique, the spacecraft will be accelerated by Jupiter's gravity to attain the velocity required for the trip to Saturn. Saturn encounter will occur about 3 1/2 to 4 years after launch. The dual-spacecraft mission plan will have the flexibility to allow a different flyby trajectory at Saturn for the second spacecraft, based on data acquired from the first flyby. This strategy proved extremely beneficial on the Mariner 1969 mission.

Two identical spacecraft based primarily on Mariner/Viking Orbiter designs will be used making maximum use of leftover Viking hardware where possible. The spacecraft are 750 kg. (1,650 lbs.) class vehicles, three-axis stabilized, utilizing the Atomic Energy Commission's Multi-Hundred Watt Radioisotope Thermoelectric Generators (MHW-RTG's) for power, and carrying approximately 75 kg. (165 lbs.) of instruments. The launch vehicle will be the Titan Centaur.

During FY 1973, the detailed design of the mission is continuing, along with refinement of the spacecraft system design. In response to an "Announcement for Flight Opportunity" to the scientific community, some 77 proposals were received from which a complement of flight investigations has been selected involving 11 separate investigation areas. Those investigation teams which were selected are carrying out a more detailed science definition and cost negotiation phase after which the final science selection will be made.

Funds requested in FY 1974 will be used as follows:

Project Management and Mission Design - Effort will continue on the detailed design of the mission at the Jet Propulsion Laboratory, which is responsible for project management.

Spacecraft Design and Development - Detailed spacecraft system design effort will be continued within the constraint of using, where possible, existing Viking subsystems. Additions will be made to Viking procurements for common

or near-common subsystems, thereby acquiring subsystems at minimum cost. Development of essential new subsystem designs will continue.

Science - The detailed science definition phase for the 11 selected investigations will be completed and the final science selection confirmed. Final implementation contracts for the science investigations will be executed.

Pioneer/Helios

	1972	1973	1974
Pioneer 6-9	$600,000	$400,000	$200,000
Operations	600,000	400,000	200,000
Pioneer 10 and G	12,164,000	9,570,000	6,000,000
Spacecraft	7,164,000	5,270,000	1,700,000
Science	2,900,000	2,400,000	1,800,000
Operations	2,100,000	1,900,000	2,500,000
Helios A and B	2,500,000	2,265,000	1,500,000
Science	1,720,000	1,525,000	660,000
Operations	780,000	740,000	840,000
Subtotal	$15,264,000	$12,235,000	$7,700,000
Centaur (Launch Vehicle Procurement program)	($12,200,000)	($16,500,000)	($30,000,000)
Pioneer 10 and G	(6,800,000)	(600,000)	(100,000)
Helios A and B	(5,400,000)	(15,900,000)	(29,900,000)
Total (including launch vehicles)	($27,464,000)	($28,735,000)	($37,700,000)

Pioneer 6-9

The Pioneer 6, 7, 8, and 9 spacecraft, launched 1965-1968, are continuing to obtain data on the nature of the interplanetary environment in the region 0.75 and 1.1 AU from the sun. (One Astronomical Unit, or AU, is 93 million miles, the mean distance between the earth and the sun.)

Operations - Fiscal Year 1973 funds and the funds requested for FY 1974 are needed to support flight operations and to prepare magnetic data tapes. These data represent the information necessary to continue the study of the nature of the interplanetary environment near earth as well as to provide a correlation with similar information obtained from Pioneer 10 on its trip to Jupiter.

Pioneer 10 and G

Objectives of the Pioneer 10 and G missions are to conduct exploratory investigations of the interplanetary medium beyond the orbit of Mars, to determine the nature (distribution, size and velocity of asteroids and meteroids) of the Asteroid Belt and measure the environmental and atmospheric characteristics of the planet Jupiter. As the Pioneer spacecraft passes near Jupiter, instruments will measure the magnetic fields, electromagnetic emissions, charged particles and thermal balance associated with this largest planet of the solar system. Pioneer F was launched in March 1972 and has been renamed Pioneer 10. The spacecraft is essentially through the Asteroid Belt, and data received thus far from meteroid hit counts indicate no concentration of dust and small particles in the Belt. Pioneer G is scheduled for launch in April 1973.

Spacecraft - Fiscal Year 1973 funds are being used to analyze the flight performance of Pioneer 10 and to complete the construction and test of Pioneer G. These funds will also support launch operations for Pioneer G. During FY 1974, funding will support the analysis of flight performance of both Pioneer 10 and G.

Science - Fiscal Year 1973 funds are being used to complete construction and testing and to support the launch of the Pioneer G instruments. These funds also support the analysis of the Pioneer 10 scientific data. During Fiscal Year 1974, funding will support analysis of data from both Pioneer 10 and G.

Operations - Fiscal Year 1973 funds are being used for flight operations of Pioneer 10 and to support preparation and test of systems for Pioneer G. They will be used to continue flight operations for both Pioneer 10 and G in FY 1974.

Helios A and B

The Helios project is an international cooperative project between the Governments of the United States and West Germany. Its scientific objectives are to investigate the properties of and processes in interplanetary space in the direction of and close to the sun to within about 0.3AU. The spacecraft will be developed and built in West Germany utilizing consultants from the United States, will weigh about 364 kg. (800 lbs.) and will carry about 55 kg. (120 lbs.) of scientific instruments. Three of the ten scientific instruments will be supplied by U.S. investigators. NASA will provide the

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launch vehicle and the tracking and data systems for the first phase of the mission. West German technical personnel will control the spacecraft operations and operate the tracking systems and acquire the data during the later mission phases.

Science - Fiscal Year 1973 funds are being used to support testing of the engineering models, construction and testing of the prototype models, and support of the effort necessary to integrate the three U.S. experiments with the spacecraft and the ground data systems. During FY 1974 these efforts will continue and, in addition, fabrication and test of flight hardware will be supported.

Operations - Mission operations planning and development of the necessary procedures and software are being supported in FY 1973. These efforts will continue in FY 1974.

Supporting Research and Technology/Advanced Studies

	1972	1973	1974
Lunar science	$2,347,000	$2,900,000	$2,300,000
Planetary science	4,936,000	4,700,000	4,500,000
Exobiology	3,900,000	3,900,000	3,300,000
Planetary advanced studies	1,200,000	1,200,000	1,200,000
Planetary advanced technical development	6,835,000	6,200,000	5,200,000
Total	$19,218,000	$18,900,000	$16,500,000

The Supporting Research and Technology (SR&T) and Advanced Studies programs furnish essential support for planning and conducting the flight missions. They provide a base for defining scientific objectives and mission concepts, and establish scientific competence which can be drawn upon for flight experiments, and the assurance of technological and planning readiness at the time of project starts.

Lunar Science - With the successful completion of the Apollo program, emphasis for Lunar Supporting Research and Technology has shifted from flight mission support to analysis and interpretation of the wealth of scientific data that has been acquired from Apollo as well as the earlier Ranger, Surveyor and Orbiter projects. SR&T funding in FY 1974 will be directed to providing the necessary science base for more effective analysis and synthesis of the data acquired from the lunar experiments. Activities to be supported include theoretical and analog studies, petrogenetics, and laboratory simulations. These activities will be carried out at a number of the NASA centers, other federal laboratories and universities around the country. Research and supporting activities of the Lunar Science Institute (Houston, Texas), established through the National Academy of Science and the University Space Research Association are also supported under this project.

Planetary Science - The planetary atmospheres project supports research in atmospheric phenomena of the planets, including the earth's upper atmosphere, and of the gaseous phenomena associated with comets. In FY 1974, emphasis will be placed on developing experiments for spacecraft exploration of the outer planets, and the laboratory and theoretical studies required to support the flight experiments. Work will be continued on the direct-entry probe investigation of the atmospheres of Venus and Jupiter.

Another area financed under Planetary Supporting Research and Technology is the planetology project, which supports research in the increasingly important field of planetary geology, including geochemistry, geophysics and photogeology. As the planetary program progresses from earth-based observational data to flyby and orbiter data, and in 1975 to data from Mars landers, planetology research will play a more important role in determining the nature and properties of the planets. In FY 1974, emphasis will be placed on the development of instrumentation for remote sensing, and on geological, geochemical and geophysical studies of Mars and the outer planets.

Exobiology - The exobiology research project has the dual objectives of understanding the controlling factors in the origin of life, and determining the uniqueness of life on earth. The research ranges from the analysis of fossil remains and simulation of planetary atmospheres and other environmental extremes, to the development of automated life detection equipment for experimentation on planetary surfaces. In addition to the biological interest in Mars, laboratory experiments now suggest that organic synthesis may be occurring on Jupiter. The development of prototype instrumentation for exobiologic studies on the Martian surface is needed as a precursor to flight instruments for future Mars landers. Some of the life detection and organic analytical techniques developed in various laboratories are now being converted into engineering models of flight instruments for testing and flight in missions such as the 1975 Viking mission to Mars. Second-generation experiments for post-Viking missions are also being investigated.

Planetary Advanced Studies - In the Planetary Advanced Studies project, the feasibility of potential future scientific missions is evaluated, new approaches to mission implementation are examined, and an up-to-date catalogue of mission opportunities is developed. In FY 1973, studies are being conducted on: (1) solar-electric missions to comets and asteroids; (2) outer planet orbiter and probe missions; (3) radar mapping spacecraft for Venus; (4) Mars surface sample return missions; (5) space shuttle implications for planetary spacecraft; and (6) methods for reducing the cost and weight of planetary spacecraft. In FY 1974, it is planned to continue investigation of solar-electric comet and asteroid missions, Mars surface sample return missions, and outer planet orbiter and probe missions, and to intensify investigation of space shuttle implications for the planetary program. Additional candidate

studies for FY 1974 include: small roving vehicles for post-Viking Mars exploration, missions to the satellites of the outer planets, and the potential for cost reduction in enforced commonality in future spacecraft subsystems.

Planetary Advanced Technical Development (ATD) - These funds are used to assure technological readiness and to perform detailed advance planning for candidate planetary missions. ATD is closely keyed to project start schedules and to advanced studies for identification of long-lead critical technologies. Timely identification and advanced development of critical technologies tied to foreseeable mission requirements permits more accurate estimating of mission funding requirements and more efficient use of project funds during development.

The major emphasis in FY 1973 has been on preparation for probe and orbiter missions to Venus and on the technologies for future low-cost Mariner and Pioneer class missions to the outer planets. Plans for FY 1974 are to continue emphasis on the technologies for the optimum utilization of spinning and three-axis stabilized spacecraft to achieve cost-effective probe and orbiter missions.

Planetary Astronomy

	1972	1973	1974
Planetary astronomy.....	$4,800,000	$4,800,000	$3,700,000
Total.....	$4,800,000	$4,800,000	$3,700,000

This continuing program makes important contributions to the scientific exploration of the solar system by observations of the planets and other solar system objects from the vicinity of earth. New observation techniques, instruments, and platforms make it possible to acquire information about the planets from the vicinity of earth that was previously possible to obtain only by probes to the planets themselves. Observations are now made from airplanes, balloons, rockets, and earth-orbiting satellites as well as from ground-based observatories. Using the techniques of optical, infrared, radio and radar astronomy, observations can be made at almost all wavelengths. Results from the planetary astronomy program both supplement and complement the planetary flight programs.

The objectives of the program are accomplished through research projects which are carried out by astronomers and other scientists located at NASA centers, universities, observatories, and other organizations. In FY 1974, approximately 40 research projects will be conducted, ranging in size from the work of a single investigator to large multifaceted research projects at major observatories. The majority of the research projects are of a continuing nature and are supported over several years.

Major emphasis will be on studies of the planet Mercury and the outer planets from Jupiter through Pluto. This emphasis reflects our increased knowledge of Venus and Mars and a need for additional information on the other planets to support upcoming flight programs.

In the area of instrument development, a NASA-supported addition of a high power radar system at the National Astronomy and Ionosphere Center at Arecibo, Puerto Rico, a National Science Foundation (NSF) facility operated by Cornell University, is underway. Completion of the radar system will increase the planetary astronomy radar capability to the point where scientists will be able to "map" the surfaces of Mercury, Venus, and Mars in considerably greater detail than presently possible, as well as studying the surface properties of several Jovian satellites.

Data Analysis

	1972	1973	1974
Lunar data analysis.....	$1,653,000	$2,100,000	$8,300,000
Planetary data analysis.....	1,400,000	1,400,000	1,400,000
Total.....	$3,053,000	$3,500,000	$9,700,000

The Data Analysis program provides for the support of scientists analyzing the results of flight experiments after the expiration of the period of funding by the flight project. It also provides support for scientists not associated with the flight project to analyze data obtained from flight investigations.

The long term objective of Data Analysis is to interpret the scientific data acquired by spacecraft missions and to incorporate the results into the the growing body of knowledge about the characteristics and history of the moon and the planets. During FY 1974, the effort will be heavily concentrated on analysis of the wealth of data returned from Mariner 9 during its very active 11 months in Martian orbit.

Lunar Data Analysis and Synthesis - With the successful completion of Apollo 17, the Apollo program has ended. Initial, limited data reduction and analysis by principal investigators has been funded by the Apollo program (Apollo funding for this activity in FY 1973 amounted to $12,760,000). However, the vast body of acquired Apollo data, as well as continuing additional data from the still operating Apollo lunar experiments, and data from the past automated lunar flight programs, require a major program of studying, analyzing, and synthesizing. During the flight phase of the program, the primary scientific effort was expended in reducing and analyzing the results of individual experiments. There is an increased need now for researchers with broad scientific backgrounds to utilize the data from many different experiments, including the results of

the sample analysis program, to synthesize or put together all these results in order to better understand the major problems of the origin, history, and present environment of the moon and, ultimately, the solar system. This synthesis program will be the major scientific payoff from the lunar flight programs. Well qualified scientists at NASA centers, in other Federal agencies and throughout the university systems are already actively studying and interpreting the data as it becomes available to them. Additional scientists will be added to this program by means of an "Announcement of Research Opportunities" to be circulated in the Spring of 1973.

Data analysis through mid-FY 1974 by Apollo principal investigators is funded under the Apollo program; continuation for the remainder of FY 1974 of their analysis and reporting is a part of this budget item in FY 1974. Appropriate reduction of photographic data and production of cartographic products for study and for use by lunar investigators are significant supporting functions.

Planetary Data Analysis - In FY 1974, Planetary Data Analysis will provide for reduction of data from Mariner missions to Mars and Venus, including in particular the results obtained by the very successful orbiter mission to Mars completed in late October 1972. These results will be used in the preparation of a set of maps describing the geology of the surface of Mars. Data interpretation work will also be continued on the results from Pioneer missions in interplanetary space, and earth satellite and sounding rocket missions investigating the upper atmosphere of earth.

Planetary Quarantine

	1972	1973	1974
Planetary quarantine.....	$2,200,000	$2,200,000	$1,500,000
Total.....	$2,200,000	$2,200,000	$1,500,000

The search for life, its origin or its remnants on the other planets of our solar system, is a high priority goal of space exploration. Essential to this search is the prevention of large scale replication on the target planets of terrestrial life forms carried there by our spacecraft. To accomplish this objective all outbound automated planetary exploration missions must conform to biological constraints based on international agreements.

Research in prior years has emphasized the development of techniques for achieving and maintaining sterility of launched spacecraft. These techniques do, however, add to mission cost and increase risk. Research in FY 1974, as in FY 1973, will focus on utilization of the natural environment through which the spacecraft must pass to aid in achieving sterility.

To provide adequate support for flight projects, planetary quarantine monitoring operations will continue to increase with a matching decrease in research. Thorough evaluation of the microbial population on all the space flight hardware of the Pioneer G and Mariner Venus/Mercury missions will be conducted and evaluations of the biological populations of Viking hardware will be initiated. Detailed knowledge of the number and species of the microbes on and in spacecraft before sterilization or launch is essential to maximum economy in quarantine operations.

Planetary Flight Support

	1972	1973	1974
Planetary flight support.....	---	$15,000,000	$22,000,000
Total.....	---	$15,000,000	$22,000,000

Planetary Flight Support is a new item in the Space Science budget in FY 1974. In FY 1973, and prior years, funding requirements for acquisition and operation of the computers, display devices and other equipment necessary to conduct planetary program operations was included in the Tracking and Data Acquisition budget request. Because of the specific nature of these requirements in support of planetary programs, responsibility was transferred to the Office of Space Science on July 1, 1972, and a funding transfer was made in the FY 1973 Operating Budget to align funding responsibility with program responsibilities.

The funding provides for activities and equipment associated with mission test, simulation, and training; the control of spacecraft and mission operations during flight; and the processing, display, analysis and distribution of data received from the spacecraft.

Fiscal Year 1973 funds are being used to support activities primarily associated with the Pioneer, Mariner Mars 1971 and Mariner Venus/Mercury 1973 projects, and to initiate an expansion of ground support capability. This augmentation of computing and data display equipment is required to provide not only simultaneous support to these Pioneer and Mariner but also to more complex future missions. The Viking missions, in particular, will require simultaneous operation of and data acquisition from four high-data-rate spacecraft (two Orbiters and two Landers).

During FY 1974, the mission control computing facility will continue to support the flight operations of Pioneer 6 through 10, in addition to the Pioneer G and Mariner Venus/Mercury 1973 missions. The facility's flight operations capability for Helios A will be implemented; training for the support of Viking flight operations will be initiated, and the detailed design and initial implementation of the Viking mission control computing support will be accomplished.

Lunar Sample Analysis

	1972	1973	1974
Lunar sample analysis.....	---	---	$4,600,000
Total.....	---	---	$4,600,000

The scientific research associated with the analysis of lunar materials is directed toward answering three major unsolved problems: (1) formation and early bombardment of the moon; (2) differentiation and thermal history of the moon; and (3) history of the sun and possibly of other objects in the Galaxy, as recorded in the lunar surface. All of these are related to the origin of earth and other planets.

The analysis of the returned samples is a worldwide effort, but only domestic institutions are funded through this project. Because the yield, both of samples and scientific results, has been of even greater magnitude than anticipated, the first generation of analysis has not yet been completed. Even with this limited analysis, the lunar science community has already acknowledged that their scientific viewpoint concerning the nature of the origin, the age, and the properties of the moon has been thoroughly transformed.

Sample analysis focuses on four areas: mineralogical and petralogical; geochemical and nuclear (aging and deterioration); physical measurements, or body properties; and biochemical.

A scientific competence has been established, both in scientists and research facilities, that will be applicable and beneficial to other studies of our environment. The essential knowledge and data required to answer the unsolved problems requires orderly and continued analysis of the samples. The funding requested for FY 1974 is necessary to continue the progress that has already produced so much new scientific knowledge.

Lunar Science Operations

	1972	1973	1974
Lunar science operations.....	---	---	$4,000,000
Total.....	---	---	$4,000,000

Three sets of lunar scientific experiments continue in operation: laser ranging which provides data for the study of the dynamics of the earth-moon system, the physics of the earth and the moon, and the processes of gravitation and relativity; and the ALSEP (Apollo Lunar Science Experiment Packages) and orbital subsatellite experiments which provide data for study of the internal structure, gravity and figure of the moon, the internal temperature and

radioactivity, the chemical composition of the interior, the seismicity, and the magnetic fields.

In one area alone, that of magnetic properties, the experimental data has changed completely the hypotheses concerning lunar magnetic fields through two major discoveries: that there exists fossil magnetism on the moon, and that electromagnetic induction of the moon leads to the formation of a well defined, time-dependent magnetosphere.

Through the laser ranging, it has been possible to develop a more accurate ephemeris of the moon, as well as a more precise libration model of the moon. Through these, we will eventually be able to deduce the interior makeup of the moon. The laser ranging information also contributes importantly to the analysis of the tectonic plate movement of the earth. In support of this ranging activity, observations will continue at McDonald Observatory on a regular basis, and the second ranging station, on Mt. Haleakala in Hawaii, will become operational in 1973. The understanding of the plate movements is basic to forecasting seismic disturbances, or any activity resulting from movements of the earth's crust.

The ALSEP experiments are continuing to produce useful data. The operation of the science instruments requires continued funding in FY 1974.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1974 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE — LAUNCH VEHICLE PROCUREMENT PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1972	1973	1974
Scout	$15,100,000	$15,700,000	$12,000,000
Centaur	82,200,000	120,700,000	115,000,000
Delta	41,000,000	76,000,000	46,000,000
Titan IIIC	9,000,000	5,500,000	---
Supporting research and technology/advanced studies	4,000,000	3,100,000	4,000,000
Total	$151,300,000	$221,000,000	$177,000,000
FY 1973 funds applied to FY 1974 program			-600,000
Budget authority requested			$176,400,000

Distribution of Program Amount by Installation:

John F. Kennedy Space Center	2,786,000	2,651,000	3,600,000
Marshall Space Flight Center	921,000	502,000	1,800,000
Goddard Space Flight Center	40,257,000	74,315,000	44,540,000
Jet Propulsion Laboratory	852,000	760,000	800,000
Langley Research Center	14,722,000	15,158,000	12,080,000
Lewis Research Center	80,523,000	119,012,000	111,900,000
NASA Headquarters	11,239,000	8,602,000	2,280,000
Total	$151,300,000	$221,000,000	$177,000,000

HIGHLIGHTS OF BUDGET PLAN

Scout

Incremental funding of hardware procurement in support of SAS, UK, MTS, Dual Air Density, German, ANS, Hawkeye, and Gravity Probe missions	$5,600,000	$7,000,000	$1,400,000

	1972	1973	1974
Scout (Cont'd)			
Management and engineering support, test and checkout, launch operations, maintenance, and field support.....	$9,200,000	$8,700,000	$10,600,000
Major improvements to the fourth stage guidance and upper stage motor. No improvements are planned for FY 1973 and FY 1974.....	300,000	---	---
Total Scout.....	$15,100,000	$15,700,000	$12,000,000
Centaur			
Incremental funding of hardware procurement in support of Viking, Mariner Venus/Mercury 1973, Helios and Pioneer.....	32,300,000	58,100,000	69,500,000
Management and engineering support, test and checkout, launch operations, maintenance, and field support.....	16,000,000	23,100,000	33,700,000
Major improvements encompassing the improved Centaur, Titan Centaur integration and proof flight, and selective redundancy.....	33,900,000	39,500,000	11,800,000
Total Centaur.....	$82,200,000	$120,700,000	$115,000,000
Delta			
Incremental funding of hardware procurement in support of RAE, Atmosphere Explorers, Nimbus, GEOS, OSO, Tiros N, ERTS, SMS, and CTS missions.	9,600,000	23,500,000	14,500,000

	1972	1973	1974
Delta (Cont'd)			
Management and engineering support, test and checkout, launch operations, maintenance, and field support.....	$14,600,000	$36,800,000	$26,200,000
Reliability improvements to first and second stage pneumatics, second stage hydraulics, guidance components, POGO suppression.....	16,800,000	15,700,000	5,300,000
Total Delta.....	$41,000,000	$76,000,000	$46,000,000
Titan IIIC			
Incremental funding of hardware procurement and related services from USAF for the ATS-F mission.....	9,000,000	5,500,000	---
Total Titan IIIC.....	$9,000,000	$5,500,000	---
Supporting Research and Technology/Advanced Studies			
Exploratory and applied research and specific studies in the following launch vehicle technological disciplines:			
Advanced studies.....	$1,535,000	$1,235,000	$1,535,000
Propulsion and energy conversion.....	1,187,000	1,275,000	1,369,000
Guidance, control, and navigation.....	803,000	112,000	596,000
Instrumentation and electronics.....	125,000	90,000	115,000
Structures and materials.....	350,000	100,000	100,000
Vehicle engineering....	---	288,000	285,000
Total Supporting Research and Technology/Advanced Studies	$4,000,000	$3,100,000	$4,000,000

OFFICE OF SPACE SCIENCE

LAUNCH VEHICLE PROCUREMENT PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Launch Vehicle Procurement program objective is to provide launch vehicles and launch services to support automated space mission requirements. Program activities include the procurement of vehicle hardware, launch services, engineering and maintenance support, and the development, as required, of improved vehicle systems and ground support equipment. In addition, efforts are undertaken in the areas of Supporting Research and Technology/Advanced Studies to define future mission requirements and to investigate new technological developments. Vehicles currently procured are: Scout, Delta, Centaur, and Titan IIIC.

The FY 1974 budget request for the Launch Vehicle Procurement program is comprised of three major categories: (1) Vehicle hardware, (2) Supporting activities, and (3) Product improvement. Funding related to vehicle hardware is identifiable with specific missions and includes such items as solid rocket motors, boosters, upper stages, shrouds, adapters and mission peculiar hardware. The supporting activities category includes preparation of hardware for launch, guidance and control services, prelaunch and postlaunch engineering analysis, transportation, propellants, and range support costs. The supporting activities funding effort differs from the vehicle hardware category in that resource requirements are directed to recurring costs which are operational in nature, rather than to the procurement of a specific number of end items of hardware produced. Product improvement, the third category, provides support to insure the reliability of the launch vehicle system and its associated ground support equipment.

BASIS OF FUND REQUIREMENTS:

	Scout		
	1972	1973	1974
Hardware.....	$5,600,000	$7,000,000	$1,400,000
Supporting activities.....	9,200,000	8,700,000	10,600,000
Major improvements.....	300,000	---	---
Total.....	$15,100,000	$15,700,000	$12,000,000

Scout is a four-stage, all solid propellant launch vehicle. It is the smallest launch vehicle employed by NASA, and is used to launch lighter-weight payloads on a wide variety of missions, such as atmospheric and space probes, high speed reentry experiments and small satellites. The vehicle is approximately 22.4 meters in length (73 feet) and the first stage booster has a diameter of 1.14 meters 3.75 feet. It is capable of placing a 180 kilogram (400 pound) payload in a 556 kilometer (300 nautical miles) orbit. Since September 1967, the Scout has sustained a 100% successful launch record in the last 28 launches.

Funds requested for FY 1974 will be used as follows:

Hardware- Funds will be utilized to initiate and/or continue hardware procurement to support SAS-C, Dual Air Density, Hawkeye/Neutral Point Explorer, and Gravity Probe missions.

Supporting Activities- Engineering and technical support, vehicle test and checkout, launch operations, and maintenance of launch facilities and ground equipment will be funded to support the launch schedule.

Improvements- No improvements are planned in FY 1973 and FY 1974.

Centaur

	1972	1973	1974
Hardware.....	$32,300,000	$58,100,000	$69,500,000
Supporting activities.....	16,000,000	23,100,000	33,700,000
Major improvements.....	33,900,000	39,500,000	11,800,000
Total.....	$82,200,000	$120,700,000	$115,000,000

Centaur is a high performance upper stage, the most powerful upper stage used by NASA for automated missions. It is currently being used with the Atlas booster for high energy missions, particularly lunar, planetary, and synchronous orbits. The Atlas Centaur vehicle is 40 meters (131 feet) in length and has a diameter of 3.1 meters (10 feet).

A new configuration, the Titan Centaur, is being developed to support the Viking mission and for other heavy payload or high energy missions beyond the lifting capability of Atlas Centaur. This Titan Centaur, planned for operational use in 1974, will be 49 meters (160 feet) and will have a payload shroud diameter of 4.3 meters (14 feet).

Funds requested for FY 1974 will be used as follows:

Hardware- Incremental funding of hardware procurement for the Viking, Helios, and Mariner Venus I Mercury 1973 missions will be continued. Atlas and Titan III boosters as well as the Centaur second stages are procured with these funds.

Supporting Activities- Funding will be utilized to purchase management and engineering support, launch support operations, field services, and to maintain facilities and ground equipment.

Improvements- A major product improvement effort for Centaur, and the integration effort with the Titan III booster, are being continued during FY 1973 and FY 1974. The Centaur improvement program centers primarily on a new electronic and electrical system which is aimed at increasing overall vehicle reliability, mission flexibility, and performance. A second improvement effort being continued is the integration of the Centaur stage with the USAF Titan III booster family, and the establishment of an operational capability at the Eastern Test Range to provide a vehicle with the payload capability for missions such as Viking. To provide confidence for the Viking mission, a Titan Centaur proof flight is planned for early 1974, to be followed by use of this vehicle combination for the Helios-A mission prior to the Viking missions.

Delta

	1972	1973	1974
Hardware.....	$9,600,000	$23,500,000	$14,500,000
Supporting activities.....	14,600,000	36,800,000	26,200,000
Major improvements	16,800,000	15,700,000	5,300,000
Total.....	$41,000,000	$76,000,000	$46,000,000

The Delta launch vehicle is the most used vehicle in the NASA launch vehicle family. It is presently operational with two and three stage configurations and a multiburn second stage capability. The first stage is an elongated Thor booster with 3, 6 or 9 strap-on solid motors for thrust augmentation.

The second-stage Delta, improved to provide a multiple restart capability, uses an inertial guidance system for guiding the first stage booster and the second stage Delta. The third stage utilizes the Thiokol TE-364 spherical solid motor which is spin stabilized. This vehicle in its three stage configuration is approximately 35.05 meters in length (115 feet) and has a diameter of 2.44 meters (8 feet). It is capable of placing a 1,772 kilogram payload (3,900 pound) into a 556 kilometer (300 nautical mile) orbit.

Funds requested for FY 1974 will be used as follows:

Hardware- Funds will be used to continue and/or initiate hardware procurement to support the OSO-I, Tiros-N, ERTS-B, SMS-B, Nimbus-F, CTS-C, and AE missions.

Supporting Activities- Necessary technical and engineering support, to sustain vehicle test and checkout and launch operations and to support maintenance of launch facilities and ground equipment, will be provided.

Improvements- Product improvement will be limited to reliability improvements only and will include attitude control and hydraulics for the second stage, the inertial guidance system, suppression of POGO effects on the first stage, and minor miscellaneous hardware improvements. These improvement efforts were initiated in prior years and are being continued in FY 1974.

Titan IIIC

	1972	1973	1974
Hardware.....	$9,000,000	$5,500,000	---
Total.....	$9,000,000	$5,500,000	---

The Titan III is a four-stage solid and liquid fuel vehicle developed and managed by the United States Air Force. NASA is using this vehicle for the synchronous altitude Applications Technology Satellite (ATS F) mission to take advantage of its performance for direct injection into synchronous orbit.

No FY 1974 funds are required to complete the vehicle procurement and support of the remaining ATS mission which is planned for launch in 1974.

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Supporting Research and Technology/Advanced Studies

	1972	1973	1974
Advanced studies.....	$1,535,000	$1,235,000	$1,535,000
Propulsion and energy conversion	1,187,000	1,275,000	1,369,000
Guidance, control and navigation	803,000	112,000	596,000
Instrumentation and electronics.	125,000	90,000	115,000
Structures and materials.....	350,000	100,000	100,000
Vehicle engineering.....	---	288,000	285,000
Total.....	$4,000,000	$3,100,000	$4,000,000

Through technical research and studies, the Supporting Research and Technology/ Advanced Studies project provides the information required by NASA Management for decisions concerning future launch vehicle developments and improvements to support new automated missions.

In FY 1973, new studies have been directed at determining the applicability of existing expendable launch vehicle upper stages for the space shuttle. An advanced study continuing from FY 1972 has as its objective the definition of a solar electric propulsion stage for potential application to both expendable launch vehicles and the space shuttle.

Funds requested for FY 1974 will be utilized as follows:

Advanced Studies- Studies of optimum launch vehicle families, stages, and low cost design concepts will be continued to identify future automated launch vehicle development required to maintain an economical and reliable transportation system. The most promising concepts identified in the FY 1973 study program will be investigated in greater depth. The application of chemical and nonchemical propulsion systems to launch vehicle upper stages will also be considered.

Propulsion and Energy Conversion- Effort will be continued on the design, fabrication, and test firing of a dual mode rocket motor capable of two different thrust levels by the use of monopropellant and bipropellant systems. Analysis of solar electric propulsion system capabilities will be identified and critical technological problems will be investigated.

Guidance, Control and Navigation- Development, test, and evaluation of strapdown guidance system components will continue. Further research will be done in the area of astrionic-spacecraft interfaces, and the utilization of new electronic techniques will be investigated.

Instrumentation and Electronics- Research will be continued in nondestructive testing techniques for electro-explosive devices, including both squibs and fuses.

Structures and Materials- Development and evaluation of concepts to thermally decouple insulation penetrations in cryogenic propellant tanks caused by valving and structural supports will be continued.

Vehicle Engineering- Analytical studies aimed at precise identification of the impact of unmanned launch vehicles on the environment will be continued.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1974 ESTIMATES

BUDGET SUMMARY

OFFICE OF APPLICATIONS — SPACE APPLICATIONS PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1972	1973	1974
Weather and climate	$45,451,000	$60,450,000	$51,100,000
Pollution monitoring	2,369,000	4,400,000	13,900,000
Earth resources survey	74,746,000	56,900,000	42,600,000
Earth and ocean physics	4,163,000	7,500,000	10,700,000
Space processing	---	---	3,100,000
Communications	59,771,000	58,450,000	22,100,000
Earth observatory satellite studies	1,000,000	1,000,000	3,000,000
Shuttle experiment definition	---	---	4,500,000
Application studies	---	---	2,000,000
Total	$187,500,000	$188,700,000	$153,000,000
FY 1973 funds applied to FY FY 1974 Program			-6,000,000
Budget Authority Requested			$147,000,000

Distribution of Program Amount by Installation:

John F. Kennedy Space Center	$25,000	$150,000	$300,000
Manned Spacecraft Center	12,385,000	14,482,000	18,959,000
Marshall Space Flight Center	345,000	310,000	5,580,000
Goddard Space Flight Center	152,086,000	147,424,000	94,251,000
Wallops Station	2,829,000	6,022,000	4,689,000
Jet Propulsion Laboratory	1,100,000	681,000	1,847,000
Ames Research Center	1,542,000	3,030,000	6,986,000
Langley Research Center	3,595,000	6,996,000	8,552,000
Lewis Research Center	3,520,000	3,994,000	4,450,000
NASA Headquarters	10,073,000	5,611,000	7,386,000
Total	$187,500,000	$188,700,000	$153,000,000

HIGHLIGHTS OF BUDGET PLAN

	1972	1973	1974
Weather and Climate			
All Weather Atmospheric Soundings Experiment Satellite (NIMBUS 5&F)			
Spacecraft design, fabrication and test leading to the launch of NIMBUS F in 1974	$9,969,000	$15,440,000	$10,165,000
Advanced instruments for determination of the vertical structure of the atmosphere	7,637,000	11,778,000	5,050,000
Ground control operations for missions beginning in late 1972	519,000	1,082,000	1,185,000
Delta (Launch Vehicle Procurement)	(1,300,000)	(4,000,000)	(400,000)
Total, NIMBUS 5&F	$18,125,000	$28,300,000	$16,400,000
Operational Temperature Sounding Satellite (TIROS-N)			
Spacecraft design and development initiation leading to launch in 1977	---	$1,500,000	$6,740,000
Sensor development to provide capability for making advanced atmospheric soundings and sea-surface temperature measurements	---	2,550,000	2,760,000
Ground station equipment fabrication	---	200,000	500,000
Delta (Launch Vehicle Procurement)	(---)	(---)	(3,000,000)
Total, TIROS-N	---	$4,250,000	$10,000,000

	1972	1973	1974
Cloud Imaging from Synchronous Satellites (SMS A&B)			
Spacecraft design, development and test leading to launch of one spacecraft in 1973 and one in 1974.....	$11,892,000	$12,809,000	$5,849,000
Sensors to provide continuous high resolution day and night cloud cover data.....	3,524,000	2,447,000	628,000
Fabrication and installation of ground station equipment.....	1,484,000	1,044,000	523,000
Delta (Launch Vehicle Procurement).....	(1,700,000)	(1,000,000)	(3,500,000)
Total, SMS.....	$16,900,000	$16,300,000	$7,000,000
Operational Satellite Improvements			
Advanced sensor design work and studies to improve susbsystem and operational procedures for TIROS and SMS operational system including advanced instruments to provide vertical temperature soundings from synchronous altitudes.....	$1,948,000	$1,640,000	$3,000,000
Postlaunch support for TIROS-M mission.....	202,000	---	---
Total, Operational Satellite Improvements.....	$2,150,000	$1,640,000	$3,000,000
Global Atmospheric Research Program (GARP)			
Data systems test support.....	$100,000	$1,500,000	$3,500,000
Simulation studies.....	800,000	1,160,000	1,750,000

	1972	1973	1974
GARP Atlantic tropical experiment support (GATE).....	---	$300,000	$1,000,000
Technology development.....	$850,000	700,000	750,000
Total, GARP.....	$1,750,000	$3,660,000	$7,000,000
Meteorological Soundings Rocket Programs			
Procurement and launch of research sounding rockets.....	$700,000	$200,000	$500,000
Development of sounding rocket systems.....	300,000	350,000	800,000
Field experiment support.....	500,000	950,000	200,000
Total, Meteorological Soundings.....	$1,500,000	$1,500,000	$1,500,000
Design and Development of Advanced Experimental Instruments			
Design and development of future experimental flight instruments to meet future instrument requirements. This includes the fabrication of engineering models.....	$412,000	$400,000	$500,000
Advanced techniques in observing and forecasting.....	$4,614,000	$4,400,000	$5,700,000
Total, Weather and Climate...	$45,451,000	$60,450,000	$51,100,000
Pollution Monitoring			
Oceanographic and Air Pollution Observing Satellite (NIMBUS G)			
Spacecraft design and development for launch in 1977.....	---	---	$5,000,000

	1972	1973	1974
Initiation of sensor development which will allow measurements of atmospheric and oceanographic parameters on a global basis.....	---	---	$4,000,000
Total, NIMBUS G.....	---	---	$9,000,000
Design and Development of Advanced Experimental Instruments			
Design and development of future experimental flight instruments to meet future instrument requirements. This includes the fabrication of engineering models.....	$391,000	$2,100,000	$2,200,000
Sensor definition and feasibility evaluations.....	$1,978,000	$2,300,000	$2,700,000
Total, Pollution Monitoring..	$2,369,000	$4,400,000	$13,900,000
Earth Resources Survey			
Earth Resources Technology Satellites (ERTS)			
Spacecraft development and fabrication for ERTS-B mission in 1976	$19,383,000	$5,582,000	$2,200,000
Sensor development to provide imagery and earth resources data for agriculture, geology, hydrology, oceanography and geography	14,742,000	4,391,000	3,970,000
Ground data handling and mission operations and generation of image products.....	15,616,000	5,575,000	700,000
Support of investigators conducting experiments and developing techniques to utilize ERTS data.....	2,339,000	17,052,000	5,530,000

	1972	1973	1974
Delta (Launch Vehicle Procurement.....	($3,500,000)	($3,400,000)	($200,000)
Total, ERTS.....	$52,080,000	$32,600,000	$12,400,000
Earth Observations Aircraft Program			
Aircraft operations and logistics in support of ERTS, EREP and regional programs.....	$5,540,000	$6,710,000	$7,425,000
Aircraft sensor development and procurement.....	1,790,000	1,100,000	1,650,000
Aircraft equipment maintenance and modification.....	2,725,000	3,050,000	2,300,000
Data handling and processing..	2,295,000	2,140,000	4,625,000
Total, Aircraft Program.....	$12,350,000	$13,000,000	$16,000,000
Design and Development of Advanced Experimental Instruments			
Design and development of future experimental flight instruments to meet future instrument requirements. This includes the fabrication of engineering models.....	$427,000	$1,550,000	$1,600,000
Data processing and interpretation, investigations and sensor definition.....	$9,889,000	$9,750,000	$12,600,000
Total, Earth Resources Survey	$74,746,000	$56,900,000	$42,600,000
Earth and Ocean Physics			
GEOS 1&2 - Completion of operations and data reduction and analyses..	$1,125,000	$1,300,000	---

	1972	1973	1974
Ocean Dynamics Monitoring Satellite (GEOS-C)			
Spacecraft design, development and test leading to launch in 1974.....	$1,232,000	$2,400,000	$2,400,000
Instrumentation to provide more accurate geometric measurements of the earth's surface and gravitational field.....	443,000	1,800,000	700,000
Ground support preparation for mission beginning in 1974.....	---	200,000	300,000
Delta (Launch Vehicle Procurement).....	(1,000,000)	(2,700,000)	(---)
Total, GEOS-C.....	$1,675,000	$4,400,000	$3,400,000
Terrestrial Measurement Referencing Satellite (LAGEOS)			
Spacecraft design and development leading to launch in 1976.....	---	---	$1,200,000
Development of instrumentation for more precisely determining point locations on the earth's surface.....	---	---	300,000
Total, LAGEOS.....	---	---	$1,500,000
Experiment Data Analysis			
Data analysis of GEOS, LAGEOS and related ground-based experiments.....	---	---	$2,700,000
Design and Development of Advanced Experimental Instruments			
Design and development of future experimental flight instruments to meet future instrument requirements. This includes the fabrication of engineering models.....	$261,000	$300,000	$400,000

	1972	1973	1974
Measurement systems, forecasting techniques and modeling.....	$1,102,000	$1,500,000	$2,700,000
Total, Earth and Ocean Physics	$4,163,000	$7,500,000	$10,700,000
Space Processing.....	---	($3,100,000)*	$3,100,000

*Funded under Space Flight Operations

Communications

ATS 1-5 - Operations and data analysis.....	$1,450,000	$1,200,000	---
Multi-User Communications Experiment Satellite (ATS-F)			
Spacecraft design, development and test leading to launch of the spacecraft in 1974.....	$26,443,000	$35,846,000	$12,500,000
Instrumentation development for communications experiments at synchronous altitudes such as user health and education telecommunications experiments and advanced spacecraft subsystems demonstrations.....	18,543,000	13,512,000	3,000,000
Procurement and modification of ground station equipment.....	2,726,000	2,742,000	500,000
Titan III-C (Launch Vehicle Procurement).....	(9,000,000)	(5,500,000)	(---)
Total, ATS-F.....	$47,712,000	$52,100,000	$16,000,000
Cooperative Applications Satellites (CAS)			
CAS-A - Completion of operations, data reduction and analysis.....	$100,000	$100,000	---
Scout (CAS-A Launch Vehicle Procurement).....	($1,400,000)	(---)	(---)

	1972	1973	1974
Canadian Cooperative Satellite (CAS-C)			
Spacecraft studies.....	$100,000	$500,000	$500,000
Development of experiments, primarily high power broadcast tube and related components.....	2,400,000	2,275,000	1,950,000
Ground system studies.....	---	425,000	650,000
Delta (Launch Vehicle Procurement).....	(---)	(2,800,000)	(1,600,000)
Total, CAS-C.....	$2,500,000	$3,200,000	$3,100,000
Experiments Coordination and Operations Support to users in communications experiments validation and operations for ATS-F and CAS-C.....	---	---	$3,000,000
Traffic Management Studies - Studies in Support of DOT/FAA..	---	$200,000	---
Radio Interference & Propagation Program.....	$1,600,000	---	---
Design and Development of Advanced Experimental Instruments			
Design and development of future experimental flight instruments to meet future instrument requirements. This includes the fabrication of engineering models.....	$909,000	$650,000	---
Systems Technology and Studies...	$5,500,000	$1,000,000	---
Total, Communications.....	$59,771,000	$58,450,000	$22,100,000
Multidisciplinary Earth Observing Satellite (EOS) - Definition Studies.....	$1,000,000	$1,000,000	$3,000,000
Shuttle Experiment Definition....	---	---	$4,500,000
Application Studies.....	---	---	$2,000,000

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1974 ESTIMATES

OFFICE OF APPLICATIONS — SPACE APPLICATIONS PROGRAM

FLIGHT SCHEDULE

PROJECT	MISSION	CALENDAR YEAR
Weather and Climate:		
All Weather Atmospheric Sounding Experiments	Launch of NIMBUS F	1974
Operational Temperature Sounding	Launch of TIROS-N	1977
Cloud Imaging from Synchronous Satellites	Launch of SMS-A	1973
	Launch of SMS-B	1974
Meteorological Sounding Rockets	Launch about 280 annually	
Pollution Monitoring:		
Oceanographic and Air Pollution Observing Satellite	Launch of NIMBUS G	1977
Earth Resources Survey:		
Earth Resources Technology Satellites	Launch of ERTS-B	1976
Earth and Ocean Physics:		
Ocean Dynamics Monitoring Satellite	Launch of GEOS-C	1974
Terrestrial Measurement Referencing Satellite	Launch of LAGEOS	1976
Communications:		
Multi-User Communications Experiment Satellite	Launch of ATS-F	1974
Canadian Cooperative Satellite	Launch of CAS-C	1975

PROJECT	MISSION	CALENDAR YEAR
INTELSAT*	Launch of INTELSAT-IV series	1973-1975 (Subject to call-up by COMSAT)
ITOS**	Launch of ITOS D-G	1973-1974 (Subject to call-up by NOAA)

* Communications Satellite Corporation (COMSAT) Funded

** National Oceanographic and Atmospheric Administration (NOAA) Funded

OFFICE OF APPLICATIONS SPACE APPLICATIONS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The goal of the Office of Applications is to conduct research and development activities that demonstrate the application of space techniques for the benefit of mankind. Generally these R&D activities are part of one of the following discipline areas: Weather and Climate; Pollution Monitoring; Earth Resources Survey; Earth and Ocean Physics Applications; Space Processing; Communications; or Multidisciplinary Activities. In each of these areas, programs are being planned to make substantive contributions to solving pressing national problems and meeting national needs.

Weather and Climate: Reliable short- and long-term weather forecasts mean savings of life, property, and money through effective disaster warning systems and proper planning in many activities such as agricultural and transportation enterprises. To enhance the achievement of accurate prediction capabilities, the Weather and Climate program objectives are to: (1) improve the capability for precision temperature measurements to higher altitudes; (2) demonstrate a new class of satellites that will provide continuous viewing, day and night, of clouds and weather conditions from synchronous orbits; (3) develop improved instrumentation for the National Oceanographic and Atmospheric Administration (NOAA) operational satellites to extend the capability for making accurate global temperature measurements at varying altitudes. The achievement of these objectives will help provide the foundation for a long-range forecasting capability utilizing numerical models of the atmosphere. In addition, improved short-term predictions will result from the real time viewing of severe atmospheric disturbances such as tornadoes and hurricanes and associated weather conditions.

Pollution Monitoring: Man must learn to achieve progress while living in harmony with his environment. Pollution monitoring is an important aspect of this task. Within this area, the Applications program has set the following objectives: (1) determine the present composition of the atmosphere for use as a baseline against which the long-term trend of atmospheric pollutants can be measured; (2) monitor changes in the composition from established norms with respect to time and place; (3) incorporate the data describing atmospheric constituents and their behavior into circulation and related environmental quality models. Meeting these objectives will contri-

bute to our knowledge of how to control man's impact on his environment for the preservation of a wholesome standard of living on this planet.

Earth Resources Survey: The effective utilization of the world's natural resources requires that their extent be surveyed and that systems for wisely managing their exploitation be constructed. In the Earth Resources Survey area, three objectives have been established: (1) to develop the capabilities for remotely sensing earth resources from aircraft and spacecraft in order to perform comprehensive ecological and environmental surveys; (2) to apply this new technology to meeting user requirements in agriculture, forestry, oceanography, geology, hydrology, geography, and cartography; and (3) to develop the technology for managing large quantities of remotely sensed data -- transmission, processing, interpretation, and dissemination. Achieving these objectives will provide an information base for use in management of the world's resources.

Earth and Ocean Physics Applications (EOPAP): Earthquakes are one of nature's most terrifying phenomena causing large scale destruction and loss of life when they occur with great intensity near large population centers. EOPAP involves the application of space techniques to obtain important data for understanding earthquakes that cannot be obtained by conventional surface measurements. For example, a major contributor to earthquakes is the motion of the large solid plates that make up the earth's crust. The use of space techniques will permit monitoring these crustal motions over regional and intercontinental distances. Space techniques will also permit monitoring variations in the earth's polar motion as well as variations in the earth's rotation rate.

Very important to the maritime industries and communities is accurate information on sea state and surface conditions. EOPAP is also concerned with developing the basic technology to monitor, report, and predict ocean dynamic conditions on a global scale.

Space Processing: The ultimate objective of this program is to exploit the unique characteristics of space flight to prepare and process materials in ways that are not possible or economically practical on earth. The eventual benefits of the program are expected to include new knowledge of materials and technology improvements directly applicable to industrial processes on the ground as well as unique high-technology products produced in space for use on earth.

Communications Applications: Having recognized the potential benefits of communications satellites from the inception of the space age, the NASA Applications program has engaged in a vigorous research and development effort for the past decade that has clearly demonstrated the viability of satellite-

based communications systems. Private industry is now in a position to carry forward the research and development necessary for future communications satellites. Under these circumstances, the FY 1974 Communications program is characterized by NASA gradually phasing out its research and development activities in Communications Applications; however, the ATS-F flight project will be continued through its initial demonstration of educational and health care program using the community broadcast capabilities of the ATS-F system.

BASIS OF FUND REQUIREMENTS:

Weather and Climate

	1972	1973	1974
All weather atmospheric sounding experiment satellites (NIMBUS 5&F).....	$18,125,000	$28,300,000	$16,400,000
Operational temperature sounding satellite (TIROS-N).....	---	4,250,000	10,000,000
Cloud imaging from synchronous satellites (SMS A&B).....	16,900,000	16,300,000	7,000,000
Operational satellite improvements.....	2,150,000	1,640,000	3,000,000
Global atmospheric research program (GARP).....	1,750,000	3,660,000	7,000,000
Meteorological soundings rocket program.....	1,500,000	1,500,000	1,500,000
Design and development of advanced experimental instruments.....	412,000	400,000	500,000
Advanced techniques in observing and forecasting.....	4,614,000	4,400,000	5,700,000
Total.....	$45,451,000	$60,450,000	$51,100,000

The convergence of three mainstreams of activity has opened up new possibilities for extending the period of weather forecasting to as much as two weeks. These are: (1) the development of more precise atmospheric forecasting models; (2) the development of the satellite capability to provide the worldwide observations of the weather needed in the forecasting models; and (3) the development of high speed computing techniques to provide the long-range forecasts.

From the early 1960's when the first TIROS weather satellite was launched, improved satellite capabilities have been developed which daily serve the

weather services of the United States and of the entire world. The launch of NOAA-2 Operational Satellite on October 15, 1972, added the capability to obtain measurements of the atmospheric temperature over areas of the entire globe wherever clouds do not interfere with the measurements. The launch of NIMBUS 5 on December 11, 1972, demonstrated for the first time the capability of measuring the atmospheric temperature and of mapping land and ocean surface features through cloud cover. It will be followed in the summer of 1974 with the launch of NIMBUS F to continue the development of improved all-weather atmospheric temperature measuring capabilities. The Synchronous Meteorological Satellite (SMS) will soon introduce another satellite operational system designed for continually surveying weather systems. This system will monitor short-term phenomena such as serious storms, i.e., hurricanes, tornadoes, and large thunderstorms. In addition, all these satellite systems will serve the World Weather program and the Global Atmospheric Research program (GARP), an international experiment to demonstrate the capability of extending weather forecasting from two days to as much as two weeks.

NASA participation in the World Weather program and GARP, with NOAA as the lead agency, includes the development of space weather instruments and the development of techniques for handling the large quantities of data required for extension of weather forecast periods.

During FY 1974, NASA programs in pursuit of these objectives will include the development and launch of NIMBUS F to continue the R&D flight activities and of the pre-operational Synchronous Meteorological Satellite (SMS) for the day-and-night observation of cloud cover on a near continuous basis with the capability of detecting severe storms; further development of space related segments of the Global Atmospheric Research program and the United States participation in this program; and development of an advanced operational meteorological satellite (TIROS-N) for the improvement of long-range weather prediction which will serve as a basic observational platform for GARP.

All Weather Atmospheric Sounding Experiments (NIMBUS 5&F)

	1972	1973	1974
Spacecraft	$9,969,000	$15,440,000	$10,165,000
Sensor and data analysis	7,637,000	11,778,000	5,050,000
Ground operations	519,000	1,082,000	1,185,000
Total	$18,125,000	$28,300,000	$16,400,000
Delta (Launch Vehicle Procurement program)	(1,300,000)	(4,000,000)	(400,000)
Total (including launch vehicles)	($19,425,000)	($32,300,000)	($16,800,000)

The objectives of the NIMBUS 5&F missions are to flight test sensors designed to extend satellite measurements of the atmosphere's vertical temperature and moisture content to cloud covered areas and to higher altitudes than have heretofore been possible. These spacecraft carry a combination of newly developed and proven sensors operating at infrared and microwave frequencies. These atmospheric soundings are needed for better understanding of atmospheric processes and interactions to improve long-term weather forecasting. The NIMBUS F experiments data are especially well suited for use with the Global Atmospheric Research program (GARP) which will make major contributions to precise weather forecasting.

Fiscal Year 1973 funds were utilized to complete the integration and test of the NIMBUS 5 spacecraft systems and experiments and for checkout activities leading to the successful launch of the spacecraft in December 1972. Fiscal Year 1973 funds also provide for acquisition and analysis of NIMBUS 4&5 data and continued development and assembly of the NIMBUS F spacecraft and experiments.

Fiscal Year 1974 funds will provide for integration and test of NIMBUS F experiments and spacecraft systems and for activities leading to launch of this spacecraft in 1974. Funds are also required for continued acquisition and analysis of the data from instruments aboard the NIMBUS 5 spacecraft.

Operational Temperature Sounding Satellite (TIROS-N)

	1972	1973	1974
Spacecraft.....	---	$1,500,000	$6,740,000
Sensors.....	---	2,550,000	2,760,000
Ground operations.....	---	200,000	500,000
Total.....	---	$4,250,000	$10,000,000
Delta (Launch Vehicle Procurement program).....	(---)	(---)	(3,000,000)
Total (including launch vehicles).....	---	($4,250,000)	($13,000,000)

After the mid-1970's, the Improved TIROS Operational Satellite (ITOS) will no longer be able to meet the data requirements of the National Operational Meteorological Satellite system in terms of accuracy and data gathering capability. TIROS-N, the third generation operational prototype, will meet

these requirements by giving higher resolution imagery covering a larger portion of the spectrum. Specifically, TIROS-N will provide data on atmospheric temperature and moisture profiles as well as space environment monitoring data. The TIROS-N innovations will involve reduced data reception times, more reliable space-to-ground communications links, improved digital handling of onboard data, and an increased operational lifetime.

During FY 1973, design studies have been in progress on key instruments of the TIROS-N system; the advanced, very high resolution radiometer (AVHRR) and TIROS-N Operational Vertical Sounder (TOVS).

In FY 1974, development of the sensor and hardware subsystems will continue and, in addition, spacecraft development will be initiated.

Cloud Imaging from Synchronous Satellites (SMS A&B)
(Synchronous Meteorological Satellites)

	1972	1973	1974
Spacecraft	$11,892,000	$12,809,000	$5,849,000
Sensors	3,524,000	2,447,000	628,000
Ground operations	1,484,000	1,044,000	523,000
Total	$16,900,000	$16,300,000	$7,000,000
Delta (Launch Vehicle Procurement program)	(1,700,000)	(1,000,000)	(3,500,000)
Total (including launch vehicles)	($18,600,000)	($17,300,000)	($10,500,000)

Short-term forecasting in relatively local areas can be helped immeasurably by near-continuous observation of short-duration and often severe weather features and phenomena. These phenomena are frequently of such a size and have such a brief lifetime in comparison to the large-scale systems that they pass through the relatively coarse mesh of the conventional, land-based observational network and low altitude satellites. Such short-term weather forecasting requirements will be met by the SMS as a result of the capability of its Visible and Infrared Spin-Scan Radiometer (VISSR) to provide day-and-night pictures of nearly the entire Western Hemisphere every half-hour. Additionally, the SMS system provides for the collection of environmental data from sensing platforms at remotely located sites. Both raw and processed environmental data can be distributed to small regional forecasting or warning stations by using the data relay capabilities of SMS. SMS-A is planned for launch in late 1973. SMS-B will follow by approximately four months. During FY 1973, the SMS flyable prototype model (SMS-A) will be

fabricated, assembled, integrated, and tested. The assembly, integration, and testing of the Visible and Infrared Spin-Scan Radiometer (VISSR) prototype model and first flight model will also be accomplished. SMS-B will be fabricated, assembled, and integrated. In FY 1974, SMS-A and SMS-B will be tested and launched from the Easter Test Range (ETR).

Operational Satellites Improvements

	1972	1973	1974
Operational satellites improvements.....	$2,150,000	$1,640,000	$3,000,000
Total.....	$2,150,000	$1,640,000	$3,000,000

As in past years, this program will continue to provide the necessary resources to permit NASA to cope with technical problems encountered in the Improved TIROS Operational Satellite (ITOS) series for the National Operational Meteorological Satellite system. This includes engineering analyses of flight data in areas such as the brushless motors, spacecraft data handling systems, and attitude control. In addition, FY 1974 funds will be used to maintain and update the ITOS checkout center as well as continue to support activities associated with improvements to the operational meteorological satellite system, both spacecraft and ground system. Recent experimental results show that accuracy of data incorporated in mathematical atmospheric models used in numerical weather prediction must be increased if the forecast service to the public is to be improved. Better, near-continuous observations are an absolute necessity to the achievement of an improved atmospheric model for local areas, short-term forecasts and environmental warning services covering these short lived and often severe weather phenomena. NOAA has stated the necessity of having an atmospheric temperature measuring instrument located aboard a geostationary satellite positioned over the Western Hemisphere. This essential instrument would permit the probing of the atmosphere once each hour and would be of invaluable assistance in developing improved predictions and warnings of severe, short-period weather events such as hurricanes and tornado-producing cloud systems. Accordingly, in FY 1973, the feasibility of adding a temperature sounder capability to the present Visible and Infrared Spin-Scan Radiometer (VISSR) will be studied. Fiscal Year 1974 funds will be used to initiate the development of an engineering model of the VISSR.

Global Atmospheric Research Program (GARP)

	1972	1973	1974
Data systems test support.....	$100,000	$1,500,000	$3,500,000
Simulation studies.....	800,000	1,160,000	1,750,000
GARP Atlantic tropical experiment support.....	---	300,000	1,000,000
Technology support.....	850,000	700,000	750,000
Total.....	$1,750,000	$3,660,000	$7,000,000

The major objectives of the Global Atmospheric Research program (GARP) are improving the accuracy and the length of time over which weather forecasts realistically can be made, assessing the feasibility of large-scale weather modification, and determining the long-term effects of pollutants on the atmosphere. In pursuing these objectives, the program will center on the following tasks: (1) the design and testing of a series of mathematical models of the atmosphere's behavior to permit an increasingly precise description of significant atmospheric processes and their interactions; and (2) measurement and experimental studies of the atmosphere to provide the data that are required for the design of such models and the testing of their validity. An interagency and international effort is necessary to execute these tasks providing for the use of both conventional ground-based data gathering techniques and satellites. The National Oceanic and Atmospheric Administration (NOAA) is coordinating U.S. activities in GARP with the World Meteorological Organization (WMO). NASA is supporting NOAA in the conduct of the U.S. portion of the program. The most significant FY 1974 activity for which NASA has been assigned primary responsibility is the design and implementation of the Data Systems Test (DST). The elements of the DST are: (1) the design and implementation of an experimental worldwide Observing System integrating operational satellites, conventional observing systems, experimental satellites, balloons, and other nonconventional observing capabilities programmed for the 1973-1975 time frame; (2) the development of a GARP Integrated Processing System (GIPS) consisting of large-scale computing and display capabilities to process the enormous amounts of data obtained during the DST as well as during the First GARP Global Experiment (FGGE); (3) the development and implementation of a DST Management System incorporating experimental and operational data from the Global Observing System to be processed by the GIPS; and (4) the planning for a data utilization program. Planning and associated research will be accelerating toward the FGGE, scheduled for 1977. NASA will provide detailed planning for this program as well as space-related technology development in support of this experiment.

During FY 1974, simulation studies will concentrate on the assimilation of satellite data in general circulation models and operational forecast models and will test the effectiveness of combinations of data from satellites and other sources, with specific application to the Data Systems Test and the First GARP Global Experiment. NASA will provide observational support to the GARP Atlantic Tropical Experiment during June-August 1974. Meteorological data from the geostationary SMS satellite will provide essential data both for research purposes and for the operational deployment of project ships and aircraft during the conduct of the experiment. NASA will also provide an aircraft for in situ observations in support of the GARP Atlantic Tropical Experiment. Technology development during FY 1974 will concentrate on the establishment of a reference level in the Southern Hemisphere and the determination of wind profiles in the tropics. The

Tropical Winds Energy Conversion Reference Level Experiment (TWERLE) on NIMBUS F is the most promising method for obtaining significant tropical winds data. Development of a satellite-carrier balloon subsystem, for the measurement of wind profiles in the tropical regions, will be continued with the National Center for Atmospheric Research. Further efforts to develop techniques for the determination of wind fields from sequential satellite cloud pictures are planned.

Meteorological Soundings Rocket Programs

	1972	1973	1974
Research sounding rockets.....	$700,000	$200,000	$500,000
Sounding rocket systems.....	300,000	350,000	800,000
Field experiment support.....	500,000	950,000	200,000
Total.....	$1,500,000	$1,500,000	$1,500,000

Upper air pollution and its effect on man's health and on the stratosphere requires exploration of the composition and chemical processes in the upper atmosphere. This research is urgently needed to obtain information on the effect of high altitude vehicles on the upper atmosphere. In FY 1974 about 30 Nike Cajun, Arcas, and Boosted Dart type sounding rockets will be launched at widely separated sites to obtain the necessary data.

Expansion of the worldwide upper atmosphere climatological data base and knowledge of the global upper atmosphere circulation are required. The US/USSR agreements for space cooperation include an agreement on the establishment of an Eastern and Western Hemispheric Meridional Network of meteorological rocket stations, exchange of data and investigation of the processes characterizing the physical state of the stratosphere and mesosphere. To meet the intent of this agreement, the program includes efforts toward the establishment of an expanded Western Hemispheric Meridional Rocket Network. New sites are planned to be established in Brazil and in Argentina in a cooperative program. Action will also be initiated leading to the establishment of a site at McMurdo Sound, Antarctica.

Rocket data are required also for comparison with data obtained from satellite remote sensors to assist users of satellite data to determine the accuracy with which satellite instrumentation can sense radiation temperatures within the upper regions of the atmosphere. In FY 1974 about 250 rockets of the Boosted Dart type will be launched from Wallops Station and foreign sites to obtain the required data. There will also be continued effort on the development and flight test of a solid state pressure transducer and thin film temperature sensor. These two items are for use on the improved economical rocket system that will provide better observations to a higher altitude.

Design and Development of Advanced Experimental Instruments

	1972	1973	1974
Design and development of advanced experimental instruments.....	$412,000	$400,000	$500,000
Total.....	$412,000	$400,000	$500,000

The objectives of this program are to develop candidate instruments for future flight missions on aircraft, manned and unmanned spacecraft, and to develop the requirements for future NASA missions. These activities minimize problems, cost and lead time on flight projects by developing the necessary instruments prior to commitment to a flight project.

These activities provide a number of major program benefits, e.g., it facilitates timely selection of payloads with proven concepts for future missions; it permits design and concept evaluation at minimum cost; the solution of design problems under this effort reduces the likelihood of flight schedule delays and costs escalations during the project development.

In this program, a number of experiments are now being developed to meet objectives and missions in weather and climate for the mid and late 1970's. These experiments will improve measurement of the earth's atmosphere and ocean surface properties. One instrument developed in the program is capable of measuring the temperature of the earth's atmosphere from the surface to an altitude of 80 Km (50 miles). The instrument permits measurements to be made regardless of the cloud cover, since the microwave emissions utilized are insensitive to clouds.

Two other developments have provided the key for measuring oceanographic parameters essential to understanding ocean atmosphere interactions. The importance of these developments is that predictive weather models for the future will have to treat the oceans and atmosphere as a single system. A microwave instrument is being developed to study the properties of the ocean surface in conjunction with the natural thermal emissions. One result of this work has been experimental substantiation of the theory that wind direction as well as speed can be measured from space.

The Lower Atmospheric Composition and Temperature Experiment (LACATE) will measure globally the vertical and horizontal distribution of water vapor, ozone, nitric acid, nitrous oxide, methane, and nitrogen dioxide in the upper troposphere and lower stratosphere. The experiment will also provide vertical temperature profiles with improved accuracy and resolution. The

improved profiles will meet GARP requirements for global numerical weather prediction.

In FY 1974, we will continue the above developments and initiate experiments for measuring additional atmospheric parameters from geostationary altitude on a continuous basis.

Advanced Techniques in Observation and Forecasting

	1972	1973	1974
Advanced techniques in observation and forecasting.....	$4,614,000	$4,400,000	$5,700,000
Total.....	$4,614,000	$4,400,000	$5,700,000

The focus in FY 1974 will be the establishment of a basis for specification of remote sensing techniques to improve the capability of observational systems to meet meteorological requirements. An additional important activity will be the development of remote sensing techniques for the measurement of the atmospheric structure, suspended matter, air surface interactions, and surface conditions such as soil moisture with the proper resolution and frequency of observations. A necessary requirement will be the development of sensors for the detection and surveillance of severe storms primarily from geostationary satellites with special emphasis on the identification of tornado-producing thunderstorm cells. This capability is expected to be an important step toward the identification and early warning of severe storms.

In support of this development, the required research to understand and determine the atmospheric effects and processes involved in the atmospheric behavior is being done. The processes to be studied include the dynamics of the atmosphere on different scales ranging from global, long-term behavior to local severe storms of short duration. The knowledge derived from these studies will be applied to the design and development of sensor and observational techniques which will best characterize the state of the atmosphere and to the development of satellite systems to meet the requirements of the national community.

In FY 1974, we will also continue development of global circulation models, including model simulation of severe storms and determination of the energy coupling between the ocean surface and the atmosphere and the atmospheric energy balance. The development of models of the atmosphere are requisite to the understanding of atmospheric processes and to development of satellite observing techniques and satellite systems. These models will also provide a basis for the development of the proper types of sensors and satellite systems and the determination of the frequency of observation.

Pollution Monitoring

	1972	1973	1974
Oceanographic and air pollution observation satellite (NIMBUS G).....	---	---	$9,000,000
Design and development of advanced experimental instruments.....	$391,000	$2,100,000	2,200,000
Sensor definition and feasibility evaluations.....	1,978,000	2,300,000	2,700,000
Total.....	$2,369,000	$4,400,000	$13,900,000

The quantities of waste products that can be dispersed or dissipated in the earth's atmosphere are not presently known and need to be established. Man and nature both contribute significant quantities of materials to the atmosphere. The types and amounts of materials in the atmosphere can affect the heat balance of the earth and the ability of the atmosphere to support life forms.

The present composition of the atmosphere needs to be measured as a baseline, and the trends in its variation need to be established to begin to understand the long-term trend of atmospheric constituents. A knowledge of atmospheric constituents can contribute to climatological prediction and the determination of requirements for pollution control.

Current laboratory and aircraft instrumentation developed under the NASA programs have demonstrated that constituents such as carbon monoxide, carbon dioxide, nitrogen dioxide, methane, sulfur dioxide and others can be remotely measured accurately in the presence of other constituents. Instruments capable of detecting some of the important constituents have been developed. Such instruments are now in use on aircraft and at ground-based stations to measure the effluents with particular concentration on jet aircraft effects. This measurement program is coordinated throughout NASA in the Distribution and Effects of Minor Atmospheric Constituents (DEMAC) program.

Global baseline data on most constituents are not available. These data are needed to determine changes with time and local variations from normal conditions. Global and regional monitoring systems are needed. These will require both spacecraft and aircraft platforms. The Oceanographic and Air Pollution Observing Satellite (NIMBUS G) will make a first step in global atmospheric composition measurements. Future earth orbiting missions will provide the capability to measure the vertical distribution of these gases.

Oceanographic and Air Pollution Observing Satellite (NIMBUS G)

	1972	1973	1974
Spacecraft.....	---	---	$5,000,000
Sensors and data analysis.....	---	---	4,000,000
Total.....	---	---	$9,000,000

Oceanography and atmospheric pollution investigations require the global acquisition of regularly repeated remote sensor measurements which will be provided for the first time by the NIMBUS G mission. The oceanographic data will be applicable to the problems of determing the basic ocean dynamics and defining the interaction between the ocean and atmosphere and the sun. Present oceanographic data are obtained sporadically over widely scattered areas with repetition measured in weeks, months, or years rather than in days as scientists and user agencies consider necessary. The mission will provide the first opportunity to study the ocean in the same way the atmosphere has been studied. A substantial emphasis will be placed on observations of the air-sea boundary. Modelling and forecasting of the ocean/atmosphere dynamics are directly dependent upon such understanding and have direct impact upon commercial fishing, shipping, and ocean pollution. Sensors already being developed will obtain data concerning many of the following oceanographic parameters: currents, sea state, surface wind, sea surface temperature, water mass, and ocean color.

Atmospheric pollution research will relate to detection, monitoring, and measurement of atmospheric constituents and particle sizes. These data are required to determine pollutant sources and life cycles. Measurement of the earth's heat balance are required to establish temperature baselines and to detect changes in the balance.

The sensors for NIMBUS G have largely been identified and developed to the aircraft engineering model stage in the Design and Development of Future Experimental Instruments program, insuring the ability to begin satellite fabrication based on the proven NIMBUS spacecraft. System developments will be initiated in FY 1974 consistent with a launch in the first quarter of 1977.

Design and Development of Advanced Experimental Instruments

	1972	1973	1974
Design and development of advanced experimental instruments.....	$391,000	$2,100,000	$2,200,000
Total.....	$391,000	$2,100,000	$2,200,000

The objectives of the program in the area of polluting monitoring are the development of remote sensing techniques for detecting and monitoring the concentration and distribution of natural and man-made atmospheric and water pollution on a global and regional basis. The advanced experiments relating to pollution monitoring include a carbon dioxide pollution experiment, a sensor to map the distribution of gaseous pollutants in the troposphere on a global scale, and an instrument to map the distribution, concentration and type of organic matter on the ocean surface. Many of these experiments are being considered in advanced planning for flights on satellite and aircraft missions to monitor pollution on a regional basis. In FY 1974, we will continue the above developments and will initiate development of sensors to detect and monitor atmospheric and water pollution.

Sensor Definition and Feasibility Evaluation

	1972	1973	1974
Sensor definition and feasibility evaluation.....	$1,978,000	$2,300,000	$2,700,000
Total.....	$1,978,000	$2,300,000	$2,700,000

This research is directed toward the application of space techniques to the monitoring and measurement of atmospheric environmental quality in the troposphere and stratosphere. In atmospheric pollution sensing, we are investigating passive ultraviolet, infrared, and microwave techniques for remote sensing of atmospheric gaseous constituents from aircraft and satellites and defining the instruments required. The research also includes the development of remote and in situ techniques for the determination, distribution, and composition of gases and particles in the atmosphere. The laboratory research will provide the spectroscopic data needed to detect and determine the amounts of such substances as nitrogen dioxide, sulfur dioxide, and carbon monoxide in the atmosphere.

The purpose of studying the stratospheric constituents is to obtain an understanding of stratospheric air chemistry and physics for the evaluation and interpretation of satellite measurements in terms of atmospheric quality. This research will establish a baseline of contaminants, evaluate the effect of contaminants on the stratospheric structure and behavior, and evaluate the effect of artificial perturbations such as high altitude vehicle flights.

Some of the techniques that are being developed for aircraft measurements of the upper atmosphere composition are an electron scattering spectrometer coupled with a gas chromatograph for measurement of trace constituents, a means of using resonance scattering and fluorescence for observing nitric oxide and optical and chemical/luminscent methods for the measurement of ozone.

In addition, there is the improvement of ground-based remote measurement techniques of stratospheric ozone.

In support of this program are definition and planning studies to define atmospheric quality measurement systems requiring the NASA capabilities to the development and demonstration of a global atmospheric environmental quality monitoring and measurement system required to meet the needs of the community in the control and prediction of the environmental effects of natural and human activities. This will involve sensor modification and development, contaminant source analyses, mission analyses, calibration standards development and systems engineering.

Earth Resources Survey

	1972	1973	1974
Earth resources technology satellites (ERTS 1&B).....	$52,080,000	$32,600,000	$12,400,000
Earth observations aircraft program.....	12,350,000	13,000,000	16,000,000
Design and development of advanced experimental instruments.....	427,000	1,550,000	1,600,000
Data processing and interpretation investigations and sensor definition.....	9,889,000	9,750,000	12,600,000
Total.....	$74,746,000	$56,900,000	$42,600,000

Balancing man's resource requirements and the preservation of his environment is becoming progressively more difficult. The key to continued progress is in the wise management and carefully planned use of resources. The preservation of the environment depends on using resources with acceptable alteration of natural features. At present there is no adequate inventory of resource and environmental information to provide a basis for assessing suitability of land uses. Ocean productivity depends on how man impacts marine life through pollution, harvest, and modification of spawning grounds; a thorough knowledge of these relationships is critical. Earth resources satellites will contribute important information in these areas needed by Federal, State and local agencies to better manage the uses of natural resources.

The Earth Resources Technology Satellite (ERTS-1), launched in July 1972, is providing data for investigations being conducted in forestry, agriculture, geology, oceanography, ecology and environmental quality. Repetitive satellite coverage provided by ERTS-1 permits inventories of resources and determination of surface changes resulting from human and natural activities. Results from

these investigations will form the basis for follow-on applications of ERTS-type information by user agencies.

The ERTS-B capability to sense heat radiated by surface features will be valuable in locating, mapping, and measuring pollution in large lakes, bays, and estuaries. Data on suitability of soil for cultivation and the earth's geological structure will also be provided.

The Earth Observations Aircraft activities are primarily to provide ground truth imagery for Skylab and ERTS investigations. In addition, the aircraft support sensor development and fly disaster survey missions for which NASA's unique capabilities are required.

The capability to provide ocean color, ocean temperature, and sea state measurements for earth resources purposes will be initiated by the Oceanographic and Air Pollution Observing Satellite (NIMBUS G). The Earth Observing Satellite (EOS) which is currently in the definition phase is expected to provide improved measurements in all discipline areas of earth resources survey.

Earth Resources Technology Satellite (ERTS 1&B)

	1972	1973	1974
Spacecraft	$19,383,000	$5,582,000	$2,200,000
Sensors	14,742,000	4,391,000	3,970,000
Ground operations	15,616,000	5,575,000	700,000
Investigations	2,339,000	17,052,000	5,530,000
Total	$52,080,000	$32,600,000	$12,400,000
Delta (Launch Vehicle Procurement program)	(3,500,000)	(3,400,000)	(200,000)
Total (including launch vehicles)	($55,580,000)	($36,000,000)	($12,600,000)

The ERTS-1 satellite, launched in July 1972, is acquiring images of the earth for applications in areas such as agriculture, forestry, geology, oceanography, ecology, and environmental quality. A wide range of domestic and foreign investigations have been selected to demonstrate practical applications of this data for detecting, mapping, measuring, and assessing earth resources and environmental conditions. Photographic and computer processing of the data is required prior to making the data available to the users.

The capability of ERTS-B will be increased over that of ERTS-1. This increased capability will allow measurement of the heat radiated from land and

water surfaces, both day and night. The measurements of temperature differences between objects as well as temperature changes with time provide a means to observe important phenomena not otherwise possible to observe from space. The ERTS-B images will be used to locate, map, and measure pollution of large lakes, bays, and estuaries indicated by temperature changes, and to provide information about the qualities of soils and nature of geological structures. Investigations of processes relating to ocean shoreline changes and ocean currents affecting coastal land and water uses will also be conducted.

In FY 1974, we will continue to receive, process, and distribute ERTS-1 data to the investigators. We also will initiate the development of the temperature sensing instrumentation on ERTS-B. ERTS-B subsystems now in assembly will be completed and stored until they are required for flight in 1976. Maintenance and periodic test will be performed to ensure flight worthiness.

Earth Observations Aircraft Program

	1972	1973	1974
Earth observations aircraft program.....	$12,350,000	$13,000,000	$16,000,000
Total.....	$12,350,000	$13,000,000	$16,000,000

Since its inception in 1965, the Earth Observations Aircraft program (EOAP) has served essentially as a test bed for evolving remote sensing techniques and sensor development. In this role NASA remote sensing aircraft provided the major source of data for university, in-house and other government agency investigators who were exploring the remote sensing techniques in forestry, agriculture, geology, geography, oceanography, ecology, and environmental quality. The launch of ERTS-1 and the forthcoming launch of Skylab have produced a marked shift in emphasis in the EOAP toward the support of investigations associated with data acquired by earth observations spacecraft.

In its new role, the aircraft is considered to be a vital element of a remote sensing system utilizing space, airborne and surface observations in achieving research objectives associated with the above earth sciences disciplines.

Approximately 85% of the existing aircraft program capability is being devoted to support of ERTS-1 investigations with the remainder associated with supporting research and technology, sensor development and demonstration flights, and disaster survey flights for which NASA's unique capabilities are needed. This trend will continue in FY 1974, although the number of flights required to support the total program will increase sharply since the aircraft survey requirements for ERTS and Skylab run concurrently during that period.

To meet these increased requirements, we will (1) increase the utilization of the existing aircraft fleet, (2) modify and operate a second RB-57B aircraft, and (3) accelerate data outputs. Aircraft capability will be improved by the addition of positional navigation systems in the two high altitude aircraft and by procurement of additional sensors required to support ERTS and Skylab.

The impact of ERTS and Skylab is such that regional studies in cooperation with State and local agencies can no longer be supported by Manned Spacecraft Center (MSC) and Ames Research Center (ARC) aircraft. For this reason, we will use available and surplus government aircraft on a regionally dedicated basis.

Because of the aircraft's extensive flight hours, the NASA NP-3A aircraft may need to be replaced or modified. This aircraft represents one-third of the capability at MSC and the only aircraft instrumented primarily for oceanographic survey work.

Design and Development of Advanced Experimental Instruments

	1972	1973	1974
Design and development of advanced experimental instruments.....	$427,000	$1,550,000	$1,600,000
Total.....	$427,000	$1,550,000	$1,600,000

A number of instruments are now being developed to meet user requirements in the earth resources disciplines. It is presently planned that these experiments be utilized in the mid and late 1970's missions of NIMBUS G, EOS, and the Shuttle. These experiments will allow measurements of such parameters as sea state, sea surface temperature, sea surface color, effluents in estuaries and streams, and the characteristics of surface materials. The experiments are at various stages of development with two having already been tested from aircraft: the radiometer-scatterometer, to determine sea state and sea surface windfields; and a passive microwave radiometer, to accurately measure water temperatures from aircraft flights.

In FY 1974, we will continue development of these instruments and initiate development of: (1) instruments for measuring soil moisture, an important factor in agriculture, geological and meteorological investigations; and (2) advanced microwave instrumentation to improve all weather and day/night observation.

Data Processing and Interpretation, and Sensor Definition

	1972	1973	1974
Data processing and interpretation, and sensor definition.....	$9,889,000	$9,750,000	$12,600,000
Total.....	$9,889,000	$9,750,000	$12,600,000

The objectives of these activities are to provide the users needed advances in remotely sensed data processing and interpretation techniques and definition of future sensors.

Emphasis of research in FY 1973 has centered on fostering the direct involvement of agencies responsible for resources management at the regional level, supporting centers of excellence activities which promote the advancement of sensor and data processing state-of-the-art, and conducting research to explore the potentialities of and to prepare for future Earth Resources Survey systems.

Activities in FY 1974 will include continuation of these fundamental research investigations with emphasis placed on developing models and application demonstrations.

For remote sensing technology to be useful, it must be adaptable into an appropriate earth science model (e.g., hydrology) and an appropriate resource management model (e.g., river and flood control). An immediate objective of the ERS program is the development of models which will provide a capability to test the results of contemplated actions and alternatives. Information derived from such models will assist in the design of information systems which in turn will lead to improved models. The development of useful models will be emphasized in FY 1974.

A difficult task in research and development is the transfer and acceptance of new technology. Demonstration projects such as the Southern Corn Leaf Blight Experiment serve as cogent and practical means of moving research from the laboratory to the ultimate user. Potential demonstration projects have been identified for FY 1974 which will portray the practical usefulness of remote sensing technology.

Earth and Ocean Physics

	1972	1973	1974
Earth and ocean dynamics monitoring satellite (GEOS-C).....	$1,675,000	$4,400,000	$3,400,000

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	1972	1973	1974
Terrestrial measurement referencing satellite (LAGEOS).....	---	---	$1,500,000
Experiment data analysis.....	---	---	2,700,000
Design and development of advanced experimental instruments.....	$261,000	$300,000	400,000
Measurement systems and forecasting techniques.....	1,102,000	1,500,000	2,700,000
Geodetic satellites (GEOS 1&2)...	1,125,000	1,300,000	---
Total.....	$4,163,000	$7,500,000	$10,700,000

The Earth and Ocean Physics Applications program (EOPAP) is designed to merge the discipline of geophysics and oceanography with space techniques to provide significant contributions to the prediction of ocean surface conditions on a global basis and earthquake hazard assessment toward the ultimate goal of prediction and alleviation.

The Ocean Dynamics Monitoring Satellite (GEOS-C) program will demonstrate new systems and techniques to be used in EOPAP. The objectives are to provide (1) an accurate geometric description of the earth's surface, (2) a more precise mathematical description of the earth's gravitational field, and (3) determine the variations in the geometry of the ocean surface, the solid earth, the gravity field and other geophysical areas. This more accurate data is essential to the accomplishment of the EOPAP objectives.

The LAGEOS program includes a very dense (high mass to area ratio) satellite which will provide a permanent reference point in a very stable orbit. It will permit very accurate range measurements and will be the first satellite compatible with the extreme precision earth motion measurements required for crustal motion and earthquake studies.

Experiment Data Analysis provides for analysis of all data obtained in the Earth and Ocean Physics Applications program, including data obtained in earth-based experiments and satellite experiments, for application to such problems as monitoring sea state, mapping ocean currents and global circulation patterns, monitoring a wide range of dynamic disturbances of the oceans, interaction between ocean and atmosphere, and a variety of earth motion factors relating to earthquakes.

Measurement Systems and Forecasting Techniques activities involves the establishment of a base of analytical and experimental techniques and feasibility demonstrations which are required for the orderly development and implementation of the Earth and Ocean Physics Applications program.

Earth and Ocean Dynamics Monitoring Satellite (GEOS-C)
(Formerly Geodetic Satellites)

	1972	1973	1974
Spacecraft	$1,232,000	$2,400,000	$2,400,000
Sensors	443,000	1,800,000	700,000
Ground operations	---	200,000	300,000
Total	$1,675,000	$4,400,000	$3,400,000
Delta (Launch Vehicle Procurement program)	(1,000,000)	(2,700,000)	(---)
Total (including launch vehicles)	($2,675,000)	($7,100,000)	($3,400,000)

The GEOS-C program will demonstrate new systems and techniques to be used in EOPAP. The objectives are to: (1) demonstrate the feasibility of mapping the topography of the ocean surface with a satellite-borne radar altimeter, (2) provide a more precise mathematical description of the earth's gravitational field, and (3) investigate solid-earth dynamic phenomena such as polar-motion and earth-rotation variations, earth tides, and continental drift theory with precision laser ranging.

Experiments include: (1) a precision radar altimeter to measure the ocean surface topography and sea state (wave height), (2) satellite-to-satellite tracking utilizing ATS-F in synchronous orbit to demonstrate the direct measurement of the earth's gravity field, (3) precision laser tracking determination of precise locations on the earth's surface, and (4) intercomparisons of new and established techniques. The major FY 1974 efforts include the integration of instruments and spacecraft and acceptance test prior to shipment to the Western Test Range for launch in 1974.

Terrestrial Measurement Referencing Satellite (LAGEOS)
(Laser Geodetic Satellite)

	1972	1973	1974
Spacecraft	---	---	$1,200,000
Experiments	---	---	300,000
Total	---	---	$1,500,000

The LAGEOS program will include a very dense laser reflector satellite which will provide a permanent reference point in a very stable orbit for precision earth-motion measurements; e.g., crustal motions, fault motions, polar motion and earth-rotation variations, solid earth tides and other factors associated with earthquakes.

The satellite is a .6 meter (2 feet) diameter ball weighing 680 kilograms (1500 pounds), covered with approximately 500 laser corner reflectors. The spherical shape of this very dense satellite, coupled with its relatively high circular polar orbit, will minimize orbital uncertainty and at the same time meet measurement goals on a global scale. The satellite will have an expected usable lifetime of at least 50 years.

The LAGEOS program will ultimately permit very accurate measurements to determine positions of points on the earth. It will be the first spacecraft dedicated exclusively to high-precision laser ranging and will provide the first opportunity to acquire laser-ranging data that is not degraded by errors originating in the target satellite. These high-accuracy range measurements from this permanent orbiting reference point will be used to accomplish many of the extreme-precision earth-motion measurements required for the understanding of earthquakes.

A considerable amount of program planning and design specifications have been completed. Detailed optical, mechanical, and thermal analyses have been performed, together with comprehensive studies of the influence of spacecraft design to the range measurements. However, additional tasks, including the determination of the most economical method of fabricating laser corner reflectors to meet the design specifications, are yet to be performed.

In FY 1974, we will initiate design and development of the spacecraft and laser reflectors to be launched in 1976.

Experiment Data Analysis

	1972	1973	1974
Experiment data analysis.....	---	---	$2,700,000
Total.....	---	---	$2,700,000

Experiment Data Analysis has the following objectives: to analyze all data obtained in the Earth and Ocean Physics Applications program, including data obtained from earth-based experiments and earth/satellite experiments, and to apply these data to particular end objectives, such as earthquake hazard assessment and alleviation, mapping ocean currents, monitoring sea state and other ocean dynamics effects, ocean circulation and the interactions between ocean and atmosphere.

In FY 1974, data from experiments, both earth-based and satellite, will be analyzed to determine applicability, feasibility, and limitations in providing solutions to these problems. Data from experiments will be analyzed to establish the relative merits of competing techniques and the applications of acquired data to the development of analytical models for earthquake hazard assessment and for understanding ocean dynamic conditions such as ocean current transport and circulation. Also included are the analysis and synthesis of the large quantities of the data obtained from prior and planned flight missions to derive essential information for the development of methodology, systems, and analytical techniques for future systems.

Design and Development of Advanced Experimental Instruments

	1972	1973	1974
Design and development of advanced experimental instruments.....	$261,000	$300,000	$400,000
Total.....	$261,000	$300,000	$400,000

In FY 1974, we will complete ongoing and initiate new instruments required for future Earth and Ocean Physics Applications missions. For example, advances in pulse-compression radar for high precision sea state measurement that meet the user needs will be made.

Measurement Systems and Forecasting Techniques

	1972	1973	1974
Measurement systems and forecasting techniques.....	$1,102,000	$1,500,000	$2,700,000
Total.....	$1,102,000	$1,500,000	$2,700,000

The objectives of Measurement Systems and Forecasting Techniques are to establish a base of analytical and experimental techniques and feasibility demonstrations which are required for the orderly development and implementation of the Earth and Ocean Physics Applications program.

This portion of the Earth and Ocean Physics Applications program will perform a series of interconnected tasks including total systems studies for the Earth and Ocean Physics Applications program and design studies of satellite/ground systems and experiments. The funding will support the establishment of measurement requirements as they relate to the design of new sensors and subsystems. Also, studies will be conducted to develop methodologies for assembling earthquake hazard assessment and ocean dynamics models. To support the validation of satellite data, ground truth and forecasting techniques will be further developed.

Space Processing

	1972	1973	1974
Advanced experiment definition and development.....	---	($3,100,000)*	$3,100,000
Total.....	---	($3,100,000)	$3,100,000

*Funded under Space Flight Operations

The ultimate objective of this program is to exploit the unique characteristics of space flight to prepare and process materials in ways that are not possible or economically practical on earth. The eventual benefits of the program are expected to include new knowledge of materials and improvements directly applicable to industrial processes on the ground as well as unique products produced in space for use on earth.

The space processing activity will involve a continuing evolution of research experiment definition, experiment development, earth-based and space-based experimentation leading to flight demonstration of various physical and procedural aspects of space processing techniques. Following these demonstrations, it is envisioned that industry will proceed with operational exploitation of this new space frontier.

The FY 1974 effort will build on the experience gained in Apollo and Skylab and will include engineering development and research support in the areas of metals and composite materials, biological materials, glass and ceramics, and crystal growth. These activities will be primarily directed toward research and definition and development of future space processing experiments and equipment. In addition, the program will focus interest within user groups on the potential benefits to be derived from the application of space flight to work in materials science and technology. Further, it will include the definition of future space missions involving space processing including Shuttle missions.

Communications

	1972	1973	1974
Multi-user communication experimental satellite (ATS-F).....	$47,712,000	$52,100,000	$16,000,000
Canadian cooperative satellite (CAS-C).....	2,500,000	3,200,000	3,100,000
Experiments coordination and operation support.....	---	---	3,000,000

	1972	1973	1974
Applications technology satellite (ATS 1-5).....	$1,450,000	$1,200,000	---
Cooperative applications satellite (CAS-A).....	100,000	100,000	---
Design and development of advanced experimental instruments.....	909,000	650,000	---
Radio interference and propagation.....	1,600,000	---	---
Systems technology and techniques	5,500,000	1,000,000	---
Traffic management studies.....	---	200,000	---
Total.....	$59,771,000	$58,450,000	$22,100,000

With the objectives that have guided NASA's Communications program for over a decade nearly achieved, fiscal and manpower resources dedicated to this program will be phased out over the next few years and efforts focused on other NASA programs where the research and development requirements for meeting national needs are more pressing and demanding. The Communications program has been characterized by the conduct of a broad-based program of research and applications technology development and demonstrations which has fulfilled NASA's responsibilities under the Communications Satellite Act of 1962. In implementing this program, NASA has cooperated with other government agencies in applying space-derived technology to meet their requirements for communications and data transmission, and with other countries in the advancement and utilization of space-related technology.

As the redirection of effort from Communications to other agency objectives begins to take place, the FY 1974 Communications program will continue to be dynamic and to produce vital technology for this nation. During the next fiscal year, the Applications Technology Satellite-F mission will enter final development stages leading up to its launch in the spring of 1974. This satellite is designed to test advanced techniques incorporating new hardware features such as a large space erectable antenna with high pointing accuracy in order to conduct applications experiments in community braodcasting in such areas as health and education. Also during the coming fiscal year, NASA will continue to work with Canada in preparing and building the Canadian Applications Satellite-C, designed to test communications experiments demonstrating high power broadcast technology and scheduled for launch in 1975. The FY 1974 program will also be characterized by the continuation of support of user agency experiments.

Multi-User Communications Experiments Satellite (ATS-F)
(Formerly Applications Technology Satellite)

	1972	1973	1974
Spacecraft	$26,443,000	$35,846,000	$12,500,000
Instrumentation	18,543,000	13,512,000	3,000,000
Ground station procurements and modifications	2,726,000	2,742,000	500,000
Total	$47,712,000	$52,100,000	$16,000,000
Titan III-C (Launch Vehicle Procurement program)	(9,000,000)	(5,500,000)	(---)
Total (including launch vehicles)	($56,712,000)	($57,600,000)	($16,000,000)

The objectives of the ATS-F program are to test advanced technologies and conduct specific applications and science experiments for maximizing the communications use of the synchronous orbit. As a part of the ATS-F mission, space technology will be applied to meet unique educational and public services informational needs in individual disciplines such as health and education and to determine the utility of satellite systems to meet the aircraft and ship navigation and traffic control needs. Also to be accomplished are demonstration experiments involving the tracking and acquiring of data from another satellite, GEOS-C.

The ATS-F spacecraft development will make contributions to advanced technologies having to do with large space erectable antennas possessing high pointing accuracy and high gain narrow beams. In addition, studies of interferometry techniques, methods for precision station keeping, solar array deployment, and laser satellite communications are included. With respect to experimentation, the health/education experiment of the Department of Health, Education, and Welfare and the Corporation for Public Broadcasting will be supported. In this experiment, ground-based actvities involving the development of programmatic material and the analysis of resultant data will be funded by Health, Education, and Welfare and the Corporation for Public Broadcasting.

The Position Location and Aircraft Communications Experiment (PLACE) to be conducted in coordination with the Department of Transportation necessitates that the development of unique aircraft and ground equipment be completed. During FY 1974, the PLACE transponder will be integrated with the ATS-F spacecraft. In addition, FY 1974 funding will provide for flight systems tests of the ATS-F spacecraft including experiments and flight acceptance level environmental tests. The integration, installation, and checkout of all experiments for the ATS-F mission will be achieved. Funding will also support preparation of the ATS-F spacecraft for launch in 1974. The initial postlaunch operations of the ATS-F experiments will be supported along with the reduction and analysis of the first data returned by the spacecraft.

Canadian Cooperative Satellite (CAS-C)

	1972	1973	1974
Spacecraft studies.....	$100,000	$500,000	$500,000
Experiments.....	2,400,000	2,275,000	1,950,000
Ground systems studies.....	---	425,000	650,000
Total.....	$2,500,000	$3,200,000	$3,100,000
Delta (Launch Vehicle Procurement program).....	(---)	(2,800,000)	(1,600,000)
Total (including launch vehicles).....	($2,500,000)	($6,000,000)	($4,700,000)

The Canadian Department of Communications (DoC) and NASA entered into a Memorandum of Understanding in April 1971 to launch a Canadian Cooperative Satellite (CAS-C) in 1975 to flight test certain advanced communications technologies. The overall objective of the project is to advance the state-of-the-art in spacecraft and related ground-based technologies relevant to future communications and other satellite applications systems. Canada will provide funding support for the spacecraft development. NASA's prime responsibility is for development of the high power transmitter tube and associated equipment and for the launch of the spacecraft. Canada and the United States will share equally in the communications experiment time available.

After the satellite is placed in geostationary orbit, NASA and DoC will conduct communications experiments utilizing a high power 12 GHz spacecraft transponder. In view of further crowding the spectrum below 10 GHz by domestic satellites, the investigation of the use of frequencies above 10 GHz is considered urgent by the Federal Communications Commission (FCC), Office of Telecommunications Policy (OTP), Department of Defense (DoD), Department of State (DoS), and NASA.

The spacecraft is designed for experimental communications with small terminals at the 12/14 GHz frequency bands allocated for space broadcast and satellite communications services at the World Administrative Radio Conference in 1971. NASA funding includes the support of spacecraft studies, advisory services to Canada, review and evaluation of spacecraft design, and the conduct of flight tests. The spacecraft will conduct flight tests of technology experiments including more efficient power tubes and versatile solar power panel arrays.

Fiscal Year 1973 funds are required to continue high power tube development including the design, fabrication, and test of the engineering model of the

Transmitter Experiment Package (TEP). Fiscal Year 1974 funds will be required to fabricate and test the flight configuration engineering test model of the TEP, fabricate and test the prototype TEP, and initiate fabrication of the flight model TEP.

Fiscal Year 1974 effort will include planning and procurement of the ground station system and providing for required modification and procurement of spare parts.

Experiments Coordination and Operations Support

	1972	1973	1974
Experiments coordination and operations support.....	---	---	$3,000,000
Total.....	---	---	$3,000,000

The objective of this effort is to continue study, research, and evaluation activities necessary for accomplishing the ATS-F and CAS-C mission objectives. Efforts will continue in providing a proper technical interface with investigations in such areas as satellite teleconferencing systems, educational telecommunications systems, small terminal technology, improved on-board signal data processing techniques, radio frequency interference and communications systems analysis and data collection in order to assure the utilization of the unique capabilities of ATS-F and CAS-C in a highly effective way.

In 1969, NASA made a public offer to the user community to use the capabilities of the Applications Technology Satellites (ATS) 1, 3, and 5 spacecraft in orbit after the NASA experiments are completed. Under the procedures established, the experimenter must bear the ground expenses. This offer has received substantial response.

Experiments conducted by non-NASA groups include feasibility experiments in the use of satellite communications to assist in remote medical diagnoses and consultation, computer and fingerprint data exchange, distribution of instructional television and Computer Aided Instruction (CAI), and position determination of vehicles.

Availability of spacecraft with greatly increased capability, such as the Multi-User Communications Experiment Satellite (ATS-F) and the Canadian Cooperative Satellite (CAS-C), will result in additional responses

to utilize the experiment opportunities represented. To effectively use these resources, users require information from NASA on developing experiment requirements, determining which experimental spacecraft are suitable, identifying critical milestones and resource requirements, developing experiment plans and procedures, and developing operating procedures and evaluation techniques. Fiscal Year 1974 funds are required to continue the development of information for effective user experiments programs related to ATS-F and CAS-C after the NASA experiments are completed.

Multidisciplinary Earth Observing Satellite (EOS) Definition

	1972	1973	1974
EOS definition studies.....	$1,000,000	$1,000,000	$3,000,000
Total.....	$1,000,000	$1,000,000	$3,000,000

The Multidisciplinary Earth Observing Satellite which is being studied will incorporate major advances in instrumentation which will yield many practical benefits to mankind. Current plans envision several groups of sensors being flown together so that simultaneous measurements can be made in 1977 and following time period. Of these groups, the thematic mapper and the multispectral microwave imaging radiometer are identified as having particular promise. Both require more earth viewing area and power than is available on present earth observing spacecraft.

A thematic mapper is needed to identify and describe the characteristics of surface features in greater detail and variety than present technology allows. The multispectral scanner, a similar flight-tested instrument, uses four bands of the spectrum to identify types of vegetation, soil, minerals, water, and constructions. The thematic mapper advances the capability of its predecessor by scanning the earth in seven spectral bands to obtain better definition of surface features and their more precise identification and classification.

The multispectral microwave imaging radiometer (MMIR) will function in the presence of cloud cover, aerosols, and water vapor absorption, which are serious handicaps to observation of surface features. Certain phenomena such as sea ice, sea state, ocean brightness, temperature, salinity, and soil moisture are potentially directly measurable using multispectral microwave methods. Like the use of the visible and infrared portions of the spectra, microwave must be used in several frequencies to separate the various effects that are observed at the receiver. The MMIR will employ five bands as that number appears to offer the greatest promise for space experiments.

Multispectral visible, infrared, and microwave instrumentation with these capabilities requires more power and earth viewing area than has been available

on previous polar orbiting earth observation satellites. In addition, supporting sensors, of the same type needed for atmospheric quality research, are needed to determine characteristics of the atmosphere, so essential to interpretation of the detailed data from the other sensors. This sophisticated sensor instrumentation requires the development of an observatory-class satellite to accomplish mission objectives.

Several EOS missions to support the basic disciplines of Earth Resources, Meteorology, Oceanography, and Pollution Monitoring are anticipated. Results from these experiments would be incorporated into operational programs as appropriate. The EOS spacecraft will be compatible with Shuttle and conventional launch vehicles.

Shuttle Experiment Definition

	1972	1973	1974
Shuttle experiment definition...	---	---	$4,500,000
Total.....	---	---	$4,500,000

The advent of the Space Shuttle in the late 1970's will introduce a new era in the economy and flexibility of Space Applications endeavors. These features are intrinsic in the easy access to space in the large volume and weight-carrying capabilities of the shuttle, and particularly in the ability to return payloads to earth. Of particular utility to many Applications activities will be the utilization of the shuttle in a sortie mode where modules accommodating investigations in a particular discipline can be ferried to orbit along with man to extract the most data from brief investigations and then returned to earth for updating and for injecting current results into future mission planning. The sortie mode would provide the same kind of flexibility and cost-effective platform for experiments in orbit that our research aircraft have provided at altitudes within the atmosphere. Studies have been made in relation to many Applications disciplines which show the potential efficiency with which many investigations can be accommodated. It is, however, necessary to define more explicitly the specific equipment to be integrated into the sortie module as a general purpose laboratory in a discipline and then to define the interfaces and the detailed operating techniques to be involved in the shuttle accommodation. Work needs to be initiated now in all of the potential uses for Space Applications in order to assure compatibility as the shuttle and the sortie modules are developed and to thereby provide availability of this highly promising investigative technique early in the shuttle time period.

Applications Studies

	1972	1973	1974
Applications studies.....	---	---	$2,000,000
Total.....	---	---	$2,000,000

Future occasions for applying space-derived technology and know-how for the benefit of mankind are very much dependent upon communicating effectively with users, constructing systems for providing usable data on a timely basis, and clearly defining new opportunities. Consequently, these Applications Studies will enable NASA to identify users and their needs and requirements and, in response, to analyze and evaluate other promising applications. In addition, this effort will allow NASA to identify and define new concepts that fall within NASA's area of expertise and to initiate investigations of new approaches as well as alternate applications of new systems and technologies.

More specifically, in recognition of the importance of ensuring that space applications research and development activities respond to the user and in particular the State, regional, and local communities, studies will be initiated to determine and evaluate various methods for identifying users, user spokesman, and user needs and problems.

Also, in view of the need and the importance of providing to the user as expeditiously as possible the benefits that are available to him as a result of the space applications program activity, studies will be undertaken to investigate techniques for data interpretation and information handling that will better execute and facilitate the transfer of benefits obtainable from space-derived data.

Finally, studies will be conducted that will determine the feasibility of developing systems having to do with energy conservation techniques, unconventional energy sources, urban transportation systems and modes, and waste disposal and energy recovery for municipal systems.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1974 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR

AERONAUTICS AND SPACE TECHNOLOGY PROGRAMS

(Thousands of Dollars)

Programs	Budget Plan FY 1972	Budget Plan FY 1973	Budget Plan FY 1974	FY 1973 Funds Applied to FY 1974 Program	FY 1974 Budget Authority Requested
Aeronautical research and technology.....	109,340	150,640	171,000	25,000	146,000
Space research and technology.....	74,365	64,760	65,000	---	65,000
Nuclear power and propulsion.....	29,806	17,100	4,000	4,000	---
Total.....	213,511	232,500	240,000	29,000	211,000

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1974 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

AERONAUTICAL RESEARCH AND TECHNOLOGY PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1972	1973	1974
Research and technology base.....	$69,440,000	$75,559,000	$79,001,000
Systems and design studies.....	5,700,000	7,444,000	5,473,000
Systems and experimental programs...	34,200,000	67,637,000	86,526,000
Total.....	$109,340,000	$150,640,000	$171,000,000
FY 1973 funds applied to FY 1974 program.....			-25,000,000
Budget authority requested.....			$146,000,000

Distribution of Program Amount by Installation:

Manned Spacecraft Center.....	---	$205,000	$199,000
Marshall Space Flight Center....	$1,115,000	880,000	900,000
Jet Propulsion Laboratory.....	1,449,000	1,172,000	850,000
Wallops Station.....	60,000	91,000	50,000
Ames Research Center.....	31,914,000	32,479,000	40,216,000
Flight Research Center.....	9,977,000	11,665,000	13,853,000
Langley Research Center.....	31,666,000	46,788,000	60,290,000
Lewis Research Center.....	29,166,000	54,493,000	53,241,000
Headquarters.....	3,993,000	2,867,000	1,401,000
Total.....	$109,340,000	$150,640,000	$171,000,000

HIGHLIGHTS OF BUDGET PLAN

Research and Technology Base

Materials - Basic research and development studies on metals, ceramics, polymers and composites of those materials that will lead to improved high temperature properties and reliability.....	$5,800,000	$5,414,000	$6,595,000

	1972	1973	1974
Structures - Advancement of technology for future short and long haul transportation systems and air defense systems in areas of high temperature structures, composite structures, analysis and design, and structural dynamics.....	$3,800,000	$5,500,000	$6,357,000
Avionics - Application of advanced theory to avionic systems design; develop technology for Vertical Take-Off and Landing (VTOL) automated flight, pilot warning, control and display for improving general aviation aircraft safety; application of active control technology to advanced transport aircraft design.....	2,600,000	3,000,000	3,154,000
Propulsion - Efforts supporting engine, engine components, and nacelle improvements aimed at improved performance, pollution and noise reduction, and weight and cost reduction.....	19,340,000	26,557,000	26,348,000
Aerodynamics - Programs to increase understanding and predictability of complicated aerodynamic and flight dynamic phenomena to provide improved vehicle design criteria.....	12,900,000	8,800,000	8,864,000
Configurations - Vehicle configuration programs to provide technology base for general aviation aircraft with improved safety and flight characteristics; for Short Take-Off and Landing (STOL), VTOL, and rotorcraft vehicles with improved capability for short haul applications; for long haul transports; and for military fighter, bomber, and missile systems.....	19,800,000	19,800,000	20,463,000

	1972	1973	1974
Life Sciences - Research and technology relative to the relationship between man and advanced aeronautical systems.....	$3,100,000	$3,100,000	$3,766,000
Aircraft Operations - Development of refined knowledge of the atmosphere (low level winds, high altitudes, turbulence) for improved vehicle design and operating procedures and develop solutions to problems spawned by current aircraft operations (slippery runways, lightning effects, turbulence detection, fire, crash) in the flight and runway environments.....	2,100,000	3,388,000	3,454,000
Total, Research and Technology Base.....	$69,440,000	$75,559,000	$79,001,000
Systems and Design Studies			
Systems Studies - Examination and analysis of new ideas for aeronautical missions and systems. Included in FY 1974 are low density short haul air transportation service, and short haul STOL systems..	$1,600,000	$2,903,000	$3,586,000
Design Studies - Efforts focused on lift-fan research aircraft to define near term research airplane program, and advanced technology transport to determine technology requirements that require additional in-depth study.....	4,100,000	4,541,000	1,887,000
Total, Systems and Design Studies	$5,700,000	$7,444,000	$5,473,000
Systems and Experimental Programs			
Experimental Engine Programs			
Experimental Quiet Engine for Conventional Take-Off and Landing Aircraft - Test program of this engine completed in FY 1973.....	$5,000,000	$949,000	

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	1972	1973	1974
Quiet, Clean Short-Haul Experimental Engine (QCSEE) - Five year effort to develop and demonstrate noise levels of 95 EPNdB at 500 feet.....	---	$1,868,000	$4,000,000
Engine Refan Program - To investigate and demonstrate noise reduction modifications that are retrofittable to current jet aircraft.....	---	21,000,000	18,000,000
Subtotal, Experimental Engine Programs.....	$5,000,000	$23,817,000	$22,000,000
Flight Experiments Programs			
C-8 Augmentor Wing Research Aircraft - Proof-of-concept flight tests of augmentor wing powered-lift concept to provide technology base; develop design and certification criteria, and operational procedures for turbofan STOL transports.....	$2,200,000	$1,350,000	$529,000
F-8 Transport Technology Flight Experiment - Flight verification of high-speed supercritical wing completed in FY 1973. Follow-on effort terminated in FY 1973.....	1,000,000	2,729,000	---
YF-12 Flight Experiments Program - A joint USAF/NASA flight test program to investigate prediction techniques and problems of civil and military long range aircraft in regimes of structures, propulsion systems, and aerodynamics, with emphasis on the latter two in FY 1974.....	2,900,000	5,542,000	5,499,000
Transonic Aircraft Technology (TACT) Flight Experiment - A joint NASA/USAF program to determine the applicability of the supercritical wing concept to a swept wing aircraft. The aircraft will be first flown in its normal Air Force mode for baseline information and again after being retrofitted with a supercritical wing.....	100,000	734,000	1,122,000

	1972	1973	1974
Fly-By-Wire Experimental Program - Development and experimental flight test of reliable cost-effective digital electronic flight control systems for advanced aircraft.....	$1,000,000	$2,124,000	$1,180,000
Composite Structures Flight Experiment - Will provide actual flight service experience concerning fatigue behavior, maintenance requirements, and inspectibility of selective composite reinforcement of metal aircraft structures using the USAF C-130 airplane and the Army CH-54 helicopter.....	2,000,000	2,029,000	1,000,000
Subtotal, Flight Experiments Programs.....	$9,200,000	$14,508,000	$9,330,000
Research/Experimental Vehicle Program			
Rotor Systems Research Aircraft - Definition, detailed design, initiate procurement of research aircraft, (a joint Army/NASA program). Acquisition of the new type aircraft will allow flight tests to demonstrate the flight applicability of advanced rotor concepts from hovering to fast conventional flight.....	700,000	1,614,000	5,266,000
Tilt Rotor Research Aircraft - Define vehicle based on research data. Design and fabricate research vehicle (Joint Army/NASA program). To conduct proof of concept evaluation and flight research in tilt rotor technology.....	400,000	1,637,000	5,345,000
Quiet Experimental STOL Transport Research Airplane (QUESTOL) - NASA's QUESTOL program has been cancelled in FY 1973. A research and technology			

	1972	1973	1974
effort is continuing under the quiet propulsive-lift technology program in FY 1974 which is applicable to STOL aircraft.....	$14,600,000	$3,339,000	---
Subtotal, Research/Experimental Vehicle Program.....	$15,700,000	$6,590,000	$10,611,000
Operating Systems Experiments Programs			
Noise Reduction Flight Procedures Experiments - Technology for and demonstration of noise abatement flight paths for existing jet transports and for advanced aircraft operating in an upgraded air traffic control system.....	300,000	2,924,000	4,118,000
Terminal Configured Vehicle Operations Experiments - Demonstrate technology of aeronautical aspects of an advanced air traffic control system. Designing into future aircraft a new terminal capability to be compatible with the potential of the new Federal Aviation Administration (FAA) air traffic control ground automation.....	400,000	4,753,000	5,000,000
Vertical Take-Off and Landing (VTOL) Operating Systems Experiments -Develop avionics technology and operating data peculiar to VTOL aircraft operating in an advanced air traffic control system with emphasis on automatic landing systems.....	300,000	643,000	800,000
Short Take-Off and Landing (STOL) Operating Systems Experiments - A joint DoT/NASA program to develop and conduct flight experiments with advanced navigation, guidance, and control concepts for all-weather STOL operations.....	$3,300,000	$2,702,000	$4,667,000
Subtotal, Operating Systems Experiments Programs.....	$4,300,000	$11,022,000	$14,585,000

	1972	1973	1974
System Technology Programs			
Advanced Supersonic Technology - To provide an expanded supersonic technology base in the technical areas critical to any future considerations for an environmentally acceptable and economically viable supersonic transport.....	---	$11,700,000	$28,000,000
Quiet Propulsive-Lift Technology - Generate a foundation of quiet propulsive lift technology in support of civil and military transport development having improved approach, landing, take-off, climbout and airport area low-speed maneuvering capabilities.....	---	---	2,000,000
Subtotal, Systems Technology Program.....	---	$11,700,000	$30,000,000
Total, Systems and Experimental Programs.....	$34,200,000	$67,637,000	$86,526,000

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

AERONAUTICAL RESEARCH AND TECHNOLOGY PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The FY 1974 Aeronautics program is directed to maintaining our international technological superiority in civil and military aviation. Within this context, the principal objectives of the FY 1974 program are: (a) to reduce the environmental pollution attributed to aircraft through the development of quiet, pollution-free engines and propulsive-lift systems, and refinement of aircraft operational procedures around terminal areas; (b) decrease air traffic congestion and delay time with increased safety through technology for improved airports, air traffic control systems and terminal configured vehicle concepts; (c) proceed with the investigation and demonstration of noise reducing design modifications applicable to existing propulsion systems on narrow-body civil jet transport aircraft; (d) provide an expanded supersonic technology base in those technical areas critical to the potential future development of an environmentally acceptable and economically viable supersonic transport, thus providing the knowledge and maintaining the options for an informed future decision; (e) continue test programs on rotor vehicles, advanced helicopters, and associated technology for the Vertical Take-Off and Landing (VTOL) and Short Take-Off and Landing (STOL) aircraft of the 1980's; (f) provide assistance to the military through research and technology and proof-of-concept activities aimed at removing technological obstacles from current developments and at providing future options. Joint and/or coordinated programs with other agencies such as Department of Defense and Federal Aviation Administration/Department of Transportation will continue.

The FY 1974 Aeronautics program will be conducted within the context of three major program activities initiated in FY 1973, namely: Research and Technology Base, Systems and Design Studies, Systems and Experimental Programs. In consonance with the major technology objectives under the Research and Technology Base, NASA will maintain a vigorous activity in its fundamental role of conducting basic research and developing the technology for new capabilities and missions which are not presently amenable to more precise definition. Emphasis will remain in building a solid technology base embracing such disciplines as materials, structures, avionics, airbreathing propulsion, aerodynamics, vehicle configuration, aeronautical life sciences, and aircraft operating systems, from which whole vehicle/operating systems/pilot-passenger-environment interacting concepts may emanate and be analyzed. These total concepts will, in turn, be tested and proven as either a single or a series of systems or experimental programs.

Among specific experimental programs continuing in FY 1974 will be: (1) a five year effort to develop and demonstrate a quiet, clean short-haul experimental engine with maximum noise levels of 95 EPNdB at 500 feet; (2) an engine fan program to investigate and demonstrate noise reduction modifications that are retrofittable to current jet engines such as the JT8D; (3) advanced supersonic technology program designed to yield the desired answers to the numerous problems affecting any future consideration for a U.S. supersonic transport; (4) a joint USAF/NASA YF-12 flight experiment program to investigate prediction techniques and problems of civil and military long-range aircraft in the supersonic speed regimes; (5) two joint Army/NASA research aircraft programs (Rotor Systems Research Aircraft and Tilt Rotor Research Aircraft programs) investigating rotors and rotor aircraft for vertical lift concepts; (6) a fly-by-wire experimental flight test program investigating reliable cost-effective digital electronic flight control systems for advanced aircraft; (7) a series of operating systems experiments programs designed to flight-test and demonstrate the technology for advanced avionics systems in aircraft, to reduce noise through (optimized) flight path procedures around terminal areas, and to give aircraft the necessary compatibility with an advanced, fully automated air traffic control system. The QUESTOL project, begun in FY 1973 to develop an experimental aircraft for the purpose of investigating propulsive-lift technology applicable to short-haul transports intended for civilian use is being cancelled. Instead, a quiet propulsive-lift technology program applicable to conventional, as well short or reduced take-off and landing vehicles will be continued as a systems technology program.

BASIS OF FUND REQUIREMENTS:

Research and Technology Base

	1972	1973	1974
Materials research and technology...	$5,800,000	$5,414,000	$6,595,000
Structures research and technology..	3,800,000	5,500,000	6,357,000
Avionics research and technology....	2,600,000	3,000,000	3,154,000
Propulsion research and technology..	19,340,000	26,557,000	26,348,000
Aerodynamics research and technology	12,900,000	8,800,000	8,864,000
Configurations research and technology.....	19,800,000	19,800,000	20,463,000
Life sciences research and technology.....	3,100,000	3,100,000	3,766,000
Aircraft operations research and technology.....	2,100,000	3,388,000	3,454,000
Total.....	$69,440,000	$75,559,000	$79,001,000

Materials Research and Technology

The aeronautical materials research and technology program involves the study and improvement of materials with the objectives of reducing the structural weight of aircraft, improving their performance, increasing their longevity and reliability, and improving economy of operation. The elements of the program include basic research, discipline research and technology, and systems research and technology.

One aspect of this work in FY 1974 will focus on building up the store of basic knowledge of materials. It will involve examining the atomic-scale behavior of alloys, coatings and refractory compounds, and its relationship to their mechanical, structural and electronic properties.

Procedures will also be developed and verified for predicting the useful life of materials. New techniques will be developed in fracture mechanics, the application of life-prediction parameters and the study of the effects of aggressive environments such as those containing hydrogen.

High performance polymers will be developed and characterized for service as adhesives and coatings. Studies of composite materials will include investigations of advanced filaments, high temperature polymeric and metal matrices, and adhesives for composite joining and attachment. Fabrication methods, evaluation of mechanical and chemical performance, and nondestructive evaluation to detect internal flaws and debonding between metals and composites will also be emphasized.

Heat-resistant nickel-, cobalt-, iron-, and titanium-base alloys will be investigated for use in airbreathing power plants. Advanced techniques such as dispersion strengthening, pre-alloyed powder processing, unidirectional solidification and eutectic solidification will be used to obtain property improvements. Protective coatings will be developed to minimize high temperature reaction with the environment. Refractory ceramic compounds will also be studied for application in vanes and other hot-end components.

Structures Research and Technology

The aeronautical structures research and technology program is directed toward the development of superior short-haul and long-haul transportation systems that are economical and accident free, and toward the maintenance of pre-eminence in air defense systems. The elements of the program encompass basic research, discipline research and technology, and systems research and technology. The structures activity includes the analysis of complex shell structures, the development of novel structural concepts for withstanding the high temperatures encountered in hypersonic flight, structural analysis and design, structural dynamics, structural integrity, and the development and demonstration of composites in structural applications.

Studies indicate that significant payoffs in "return on investment" may be possible by the introduction of composites in the airframes and engines of large commercial transport aircraft.

The emphasis on composite structures in FY 1974 will continue to build confidence in the reliability of such structures through investigations of the behavior of composites, laboratory testing, and service demonstrations. Various types of filament and matrix combinations will be investigated to establish strength characteristics, fatigue and fracture behavior, and effects of long time service exposure.

Analysis and laboratory experiments will be conducted to investigate the effects on structural integrity and enhance prediction of useful life of vehicle structures where stress concentrations, varied load histories, and extreme environmental conditions exist.

During FY 1974 investigations will be conducted both in-house and under contract to identify actively cooled systems that can cope with the severe thermal environment to be experienced by the airframe and propulsion system of a hypersonic vehicle.

In the area of analysis and design, the technology for automating preliminary and detailed design processes will continue to be developed. Two high priority thrusts will be toward the inclusion of fatigue, fracture and flutter considerations in automated design systems. Maintenance and improvements to NASTRAN will continue.

Avionics Research and Technology

Avionics perform all aircraft guidance, control, and sensing functions and serve as the interface with external commununication and navigation systems. The primary objectives of the avionics research and technology program are to increase aircraft performance potential, provide greater aircraft operational flexibility, and to improve aircraft reliability through development and validation of a design base for advanced digital avionics systems. These systems will permit new aircraft configurations and capabilities that can maintain U.S. leadership in long-haul transportation, will allow reliable automated operation for complex aircraft such as VTOL, and will enable general aviation aircraft to safely participate in the air traffic environment.

In FY 1974, preliminary design studies of actively-controlled, reduced-weight aircraft configurations will be initiated and active control system design guidelines will be formulated and investigated through continuation of associated computer/hardware simulations. The application of optimal guidance and control theory to four-dimensional guidance and automated landing will be evaluated for the C-8 Buffalo research aircraft. Related

efforts on automated VTOL avionics will cover design of a fail-operational, low-cost inertial navigation system; will initiate development of breadboard interface equipment for low-altitude navigation; and will evaluate new flight display approaches for automated systems monitoring and management. The joint university research effort on general aviation avionics will focus on guidance and control techniques which increase general aviation safety under instrument flight conditions. Development of a low-cost stability augmentation system and a flight director, which can significantly reduce pilot workload, will be continued. Innovative approaches to the design of an airborne atomic clock which offers new capabilities in communication and navigation, and the analytical definition of scattering phenomena to improve the measurement of visibility in fog and rain will be undertaken. Close liaison will be maintained with other organizations and agencies.

Propulsion Research and Technology

Propulsion research and technology in FY 1974 will emphasize noise and pollution reduction as well as the improvement of the performance of all propulsion system components and the study of component interactions. Advanced propulsion systems for the 1980's and 1990's will also be considered.

The noise research will be in three areas; noise generation sources, noise propagation, and noise suppression devices. The goal of the program is to evolve the technology and determine the economic and performance penalties for achieving aircraft noise levels 10 to 20 PNdB below current FAR 36 levels. Acoustic performance will be measured on a series of low pressure ratio fans for powered lift propulsion systems. Surface/jet interaction noise mechanisms will be studied in greater depth. A computer program will be started to predict noise from a complete propulsion system, including duct propagation and radiation of noise. Work on sonic inlets will continue and designs will be tested on the NASA quiet CTOL engine and on a 30-inch high pressure ratio fan rig. NASA will work with and support the Department of Transportation and other Government agencies on efforts supporting jet noise reduction.

The aircraft pollution problem is two-fold, the prediction and reduction of engine emissions, and the distribution and chemistry of pollutant emissions after they leave the engine. Basic studies of pollutant formation chemistry in combustion processes will be conducted. Mechanisms and techniques for the control and reduction of nitric oxide, carbon monoxide, hydrocarbon and smoke emissions will be investigated. The clean combustor program, started in FY 1973, will complete its first phase of screening concepts for lower emission of oxides of nitrogen and other pollutants. This program will culminate in engine tests of a low-pollution combustor in FY 1976. A prototype installation will be made in FY 1974 of an instrument package on a Boeing 747 aircraft that will automatically measure and record minor atmospheric constituents during regular commercial flights. The 747 flights are part

of a global air sampling program started in FY 1972 and which will be conducted over a period of several years, eventually involving 10 to 15 aircraft installations. Also, in FY 1974, NASA will provide the Climatic Impact Assessment program of the Department of Transportation with a prediction of emission levels out to 1990, based on cycle predictions and technology extrapolation.

Work on propulsion system components will continue to be a major part of the propulsion research and technology effort. In FY 1974, the component program will include high temperature turbine life prediction, high pressure ratio compressor stages with increased stall margin, stoichiometric combustors, mixed compression inlets, low-noise exhaust nozzles, high speed gears, shafts, and bearings, high temperature lubricants and high performance components for small military and civil aircraft gas turbine engines. Concepts for improving component performance will be tested in small-scale and full-scale rigs, wind tunnels and flight. Available analytical techniques for predicting component performance will also be improved.

Research will be continued for providing the technology needed for combining high performance components into complete systems with optimized operating characteristics. Work will continue to establish a general base of low-cost engine technology for application to turbojet and turbofan engines in the 500 to 1,000 pound thrust class. Building on the low-cost component technology established to date, an experimental ordnance engine has been fabricated for the Navy. Upon completion of altitude chamber performance tests at Lewis Research Center, the engine will be flight tested by the Navy at the Naval Weapons Center, China Lake. Performance tests of the hypersonic research engine will also be completed this year. Further research will be conducted in FY 1974 leading toward a hydrogen-fueled, regeneratively-cooled engine design, with no variable geometry, utilizing swept leading edges and fuel injector struts to reduce cooling requirements.

Studies will continue on the assessment of mission requirements, propulsion technology needs, and engine component and system characteristics that will be needed for advanced missions.

Aerodynamics Research and Technology

The development of safer and more efficient advanced aircraft systems requires a continuing program of basic aerodynamic research. In order to reduce cost and time in ground and flight tests, intensive research will continue on the development of numerical methods and computer programs which can be used accurately and efficiently for the study of aerodynamic problems, both two- and three-dimensional, throughout the range of flight speeds. Turbulent boundary layer modeling experiments will be pursued to provide empirical inputs to enable the computer programs to account for significant viscosity effects.

The introduction of very large aircraft into the nation's transportation system has aggravated the wake turbulence problem. Emphasis in the research will be given to seeking ways of alleviating the hazards of wake turbulence through the control of trailing vortices at their source.

Research aimed at producing improved airfoils, high lift devices and other aircraft components that may improve the performance of aircraft at all flight speed regimes will continue.

The mixed flow transonic speed range continues to pose serious aerodynamic problems to all but low speed aircraft flight systems. Of particular concern is the problem of correctly simulating aerodynamic flow in the transonic speed range in wind tunnels. Research will be conducted to improve test techniques and correlation between viscosity-dependent data obtained from scale model tests in wind tunnels with flight data at full-scale Reynolds numbers. These studies will include the effects of model support interferences, tunnel wall constraints, flow quality, as well as design techniques to minimize such effects.

Means will be sought to minimize the noise generated by sources on aircraft other than its propulsion system in order to obtain the full benefits of engine quieting procedures.

Research will be directed to improve the capabilities of inflight simulation using the General Purpose Airborne Simulator and ground-based simulation for handling qualities research to improve the ease and safety of flying. Analytical and experimental efforts will be directed to improving dynamic response characteristics of aircraft at angles of attack at and beyond the stall.

Configurations Research and Technology

The aerodynamic characteristics, including performance, stability and control, handling qualities, stall and spin, and crashworthiness of different representative general aviation aircraft will be documented and analyzed; advanced configurations incorporating innovative propulsion and control systems will be evaluated.

Static rig, acoustic chamber, and two-dimensional wind tunnel tests of the elements of advanced powered lift Short Take-Off and Landing (STOL) and Reduced Take-Off and Landing (RTOL) concepts will be carried out in-house and under contract by Ames and Langley Research Centers. The most promising optimumly-integrated versions will be studied using complete wind tunnel models representative of transport configurations. Flight dynamics studies of representative STOL transports will continue utilizing ground-based simulators and include a joint program with the FAA to define STOL certification criteria. Similar studies will be carried out on promising lift-fan VTOL transport and jet-lift military applications. Flight research in this area will include handling qualities studies using the X-14 and X-22 variable stability aircraft.

In a joint program with the Army, contracted and in-house basic studies will be continued to enable prediction of rotor airloads, performance, and noise in hover and forward flight. Wind tunnel and whirl tower tests will be made at Langley and Ames Research Centers of advanced rotor concepts using both small- and large-scale models. Ames in-house and contracted studies to derive tilt prop-rotor systems having improved performance and dynamic characteristics will be continued; related ground-based simulator studies will aid in defining flight control and stabilization systems, and handling quality requirements for tilt rotor aircraft.

Investigations of advanced Conventional Take-Off and Landing (CTOL) transports will concentrate on wind tunnel tests and analysis to evaluate aerodynamic performance, stability and control of fixed-wing concepts incorporating supercritical aerodynamics for efficient operation in the M=0.90 to 0.98 regime, and of an oblique (variable yaw) wing concept which has promise for a cruise Mach number of about 1.4 together with excellent terminal area flight characteristics (quiet, efficient, modest runway requirements). Some of the generalized investigations of aerodynamic controls and related components for gust and maneuvering load control, as well as for control configured systems, will have application to a broad speed regime up to M=4 or 5.

Heating, stability, control and performance analytical and experimental studies will be continued to provide a configuration technology base pursuant to the aerodynamic design of efficient hypersonic aircraft. Emphasis will be on tests to determine engine-airframe interactions including jet exhaust effects.

Studies at Langley Research Center to advance the technology for military aircraft and missiles will provide a background of aerodynamic data for use in performance evaluations and in making various trade-off analysis of differing systems with emphasis on improvement of performance, stability and control characteristics, especially at high angles of attack. The joint United Kingdom/NASA Vectoring in Forward Flight program will continue into Phase II in which the operating envelope of a Harrier aircraft will be extended by use of aerodynamically balanced nozzles. Thrust vectoring and its effectiveness in combat maneuvers will be evaluated in the Differential Maneuvering Simulator at Langley Research Center. Flight tests of a supersonic Remote Piloted Research Vehicle will be conducted at Flight Research Center for high angle of attack investigations. The missile configuration studies will investigate such important variables as body shape, and wing and tail planform and location which will enable more effective missile control. Apart from the above generalized configuration studies, NASA will continue to provide substantial assistance at the request of the military services in solving problems of military aircraft, missiles and weapon systems in all the aeronautical disciplines using NASA's wind tunnels, simulators, computational capability and research personnel expertise.

Life Sciences Research and Technology

The aeronautical life sciences program is concerned with providing a research and technology base for solutions to human problems blocking or impeding the growth of air transportation. One major focus of the program is to develop criteria to assure the acceptance of aircraft noise exposure and operations by the public. Another major focus is to develop automated flight management cockpit technology to guarantee the safety, economy, and effectiveness of new air transportation systems.

The public acceptance, or psychoacoustics program, is conducted at the Langley Research Center. Langley personnel have taken the lead over the last ten years in developing noise exposure criteria and in defining community attitudes about aircraft operations. The major thrust of the program is to (1) refine aircraft noise measurement units to account for aircraft employing propulsive-lift techniques, (2) determine the subjective benefit of various noise reduction techniques, (3) determine acceptable sonic boom exposure levels, and (4) characterize the influence of fear of aircraft crashes, background noise, and number of operation effects on shaping community attitudes about aircraft noise and operations.

Programs to remove the growth constraints of civil air transportation require the introduction of new control and display systems to a complex, high workload, cockpit environment. Unless the complete cockpit is completely defined, the benefits of the new system may not be realized. A technology base in computer and graphics systems is nearly in hand to permit required cockpit reconfiguration. By applying the techniques and methodology of human factors engineering, it will be possible to demonstrate the safety, economy, and effectiveness of computer-based cockpit systems for the generation of aircraft of the 1980's. Ames Research Center has the lead in defining automated flight management cockpit technology.

Aircraft Operations Research and Technology

The objectives of this continuing program are to provide for the development of techniques and procedures which will yield information of a scientific and technical nature by which improvements can be effected in aviation safety, in flight test instrumentation, and in understanding airport pollution and airfield traffic mechanisms. Collectively, these efforts should yield results of significance to continuing the increase in operational safety and efficiency levels in civil and military aircraft through increased understanding of hazard avoidance design and operations.

Aircraft operations research and technology activity embraces both basic research and systems technology efforts. In the basic research area, programs will be continued in FY 1974 to obtain data on the intensity, extent, and

frequency of occurrence of atmospheric perturbations with a view towards the establishment of boundaries of safe, economical flight and realistic design criteria. These FY 1974 efforts continue previous studies of fog, low level winds and high altitude turbulence. In the system technology area, programs will build on FY 1973 progress and be continued in studies of: (1) airport pollution as influenced both by aircraft operations, and local meteorological factors; (2) improved control of aircraft on the runway in order to increase the rate of airport operations; (3) minimization of runway occupancy time, in order to reduce terminal congestion; (4) avoidance or reduction of hazards associated with flight operations, such as: structural/mechanical failures, aircraft wake and atmospheric turbulence encounters, in-flight icing, lightning strikes, in-flight and postcrash fires, rotating machinery component failures, and high energy solar flare particles (radiation) in order to directly improve safety; and development of new concepts and techniques for aircraft flight test instrumentation required for research purposes.

Systems and Design Studies

	1972	1973	1974
System studies.....	$1,600,000	$2,903,000	$3,586,000
Design studies.....	4,100,000	4,541,000	1,887,000
Total.....	$5,700,000	$7,444,000	$5,473,000

System Studies

Aeronautical System Studies promote the successful transfer of technology produced in the Research and Technology (R&T) Base into total systems for future experimental programs. Elements of this analytical capability exist throughout all technical disciplines. These investigations provide guidance for program direction and balance, focus aeronautical program relevance on perceived national needs, incorporate effective means for evaluating options prior to commitment of major funding and support an adequate design base for future programs. Such studies also provide feedback to the ongoing R&T Base program. They also identify attractive options and "high payoff" areas and suggest future design studies. They help assure that NASA is working on the "right" problems. Although this activity is predominantly in-house, it is supported by some specific contractual activities that include in FY 1974:

(a) Air Transportation Systems Study focusing on the problem of providing short haul air transportation to lightly populated or remote areas of the U.S., by studying the short haul market plus candidate system and vehicle concepts offering safe, comfortable and economical service. This study responds to Civil Aviation Research and Development (CARD) Policy Study recommendations.

(b) Low-Density Short Haul Total System Synthesis Study which in conjunction with the above effort, investigates the feasibility and economics of providing enroute and terminal navigation systems for remote areas of the U.S. This study responds to the recommendations made by the CARD Policy Study.

(c) Short Take-Off and Landing System Study which in FY 1974 will continue follow-on investigations of select areas of concern identified in the FY 1973 effort with emphasis on defining redirection of technology development effort consistent with study results. In FY 1974, STOL system studies, for example, will consider several levels of noise constraints unique to various airports and their communities around the nation. These airports will be categorized into several groups depending on permissable noise footprints. Various classes of candidate STOL aircraft will be examined in terms of compatibility with a number of realistic noise constraint levels with the aim of identifying a "common denominator" type of aircraft which will meet, optimally, local and regional noise constraints, satisfy airport requirements, and yet be amenable to quantity production necessary for economic viability.

Design Studies

Advanced Transport Technology System Studies. Initial system studies addressed long-haul transports having conventional take-off and landing characteristics emphasizing cruise performance and identified critical technology needs required to achieve significant economic benefits. Additional studies are required.

A study of design concepts using technology advances proven to be practical and cost-effective to respond to future terminal area requirements without unduly penalizing cruise performance is under way.

A second study has been undertaken, directed toward the feasibility of using liquid hydrogen as fuel. The incentive for this effort is a serious national concern about the steadily rising cost and eventual depletion of petroleum-based fuels.

Lift-Fan Aircraft Design Studies. Conceptual design studies will be continued under contract by the Ames Research Center to assess the effects of major design parameters on promising advanced civil VTOL transports which could be developed by the mid-1980's, to examine potential military VTOL aircraft concepts utilizing lift-fan and lift/cruise-fan propulsion, and to assess possibilities of a lift-fan research aircraft program which could have high intrinsic value for both civil and military advanced aircraft developments. The studies will be closely allied with wind tunnel and simulator investigations of VTOL aircraft in the Configuration Research and Technology program.

Systems and Experimental Programs

	1972	1973	1974
Experimental Engine Programs.....	$5,000,000	$23,817,000	$22,000,000
Quiet, clean short-haul experimental engine (QCSEE).....	---	1,868,000	4,000,000
Engine refan program.....	---	21,000,000	18,000,000
CTOL experimental quiet engine.....	5,000,000	949,000	---
Flight Experiments Program.....	9,200,000	14,508,000	9,330,000
C-8 augmentor wing research aircraft.....	2,200,000	1,350,000	529,000
YF-12 flight experiments program...	2,900,000	5,542,000	5,499,000
TACT (transonic aircraft technology) flight experiment....	100,000	734,000	1,122,000
Fly-by-wire experimental program...	1,000,000	2,124,000	1,180,000
Composite structures flight experiment.....	2,000,000	2,029,000	1,000,000
F-8 transport technology flight experiment.....	1,000,000	2,729,000	---
Research/Experiment Vehicle Program.	15,700,000	6,590,000	10,611,000
Rotor systems research aircraft....	700,000	1,614,000	5,266,000
Tilt rotor research aircraft.....	400,000	1,637,000	5,345,000
Quiet experimental STOL aircraft (QUESTOL).....	14,600,000	3,339,000	---
Operating Systems Experiments Program	4,300,000	11,022,000	14,585,000
Noise reduction flight procedures experiment.....	300,000	2,924,000	4,118,000
Terminal configured vehicle operations experiments.....	400,000	4,753,000	5,000,000
VTOL operating systems experiments.	300,000	643,000	800,000
STOL operating system experiments..	3,300,000	2,702,000	4,667,000
System Technology Programs.....	---	11,700,000	30,000,000
Advanced supersonic technology.....	---	11,700,000	28,000,000
Quiet propulsive lift technology...	---	---	2,000,000
Total.....	$34,200,000	$67,637,000	$86,526,000

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Experimental Engine Programs

Quiet, Clean Short-Haul Experimental Engine (QCSEE)

Powered lift propulsion system technology for future high performance commercial jet transports, constitutes a major objective of the NASA propulsion research and technology efforts. One of the most significant pacing elements of a technically and economically feasible powered lift aircraft is a quiet, clean and highly efficient propulsion system. The propulsion system is the key technology element for which less can be predicted with certainty than for any other technology element of powered lift aircraft.

During FY 1972 and FY 1973, various propulsion systems for Externally Blown Flap, and Augmentor Wing powered lift aircraft were examined through studies supported by experimental research on low noise engine components and systems to determine which powered lift propulsion system concept would provide the most needed and fruitful areas for engine research and technology. As a result of the studies and experimental research, it became clear that the principal technology questions and uncertainties in the Augmentor Wing propulsion system lie primarily in the unique installation characteristics (high pressure ducting, valving, thrust reversing and augmentor flap) rather than in the engine itself. However, the technology status for the very quiet, very high bypass ratio engines for externally blown flap propulsive-lift applications is a source of major uncertainty particularly with reference to the true impact of the extremely low noise requirement on the design of the propulsion system and on installed weight and performance. Therefore, the QCSEE program has been structured to integrate and demonstrate the technology required for very high bypass ratio engines, since this addresses the greatest need and provides the most fruitful opportunity for powered lift engine technology advancement. The definitive establishment of the technology base for the QCSEE program will require a complete experimental propulsion system demonstration and verification using credible, full scale high performance hardware.

The QCSEE experimental engine design will incorporate the advanced noise and pollution reduction techniques needed to meet the stringent noise and pollution levels expected for future powered lift aircraft.

The QCSEE program is not directed towards the development of an engine for flight and the experimental engine resulting from QCSEE will not be flown. The QCSEE program provides for close cooperation and coordination with the Air Force in their development of the Advanced Turbofan Engine demonstrator, to insure that every reasonable opportunity for design commonality and mutual cost savings can be taken.

Engine Refan Program

The objective of this program is to apply NASA noise reduction technology to the existing propulsion systems on narrow-body civil jet transport aircraft.

This program will demonstrate the noise reduction possible by modifying the existing propulsion systems on narrow-body two- and three-engine aircraft. The modification consists of replacing the existing two-stage fans of the JT8D engine with larger-diameter single-stage fans and installing these modified engines in acoustically treated nacelles. These modifications will result in small performance changes. The noise reductions possible with this approach are significantly greater than those achievable by the use of nacelle acoustic treatment alone.

This experimental demonstration program is closely keyed to future FAA rulemaking actions directed at noise reduction. Program objectives and schedules are coordinated to provide maximum support to FAA. Technical information has been and will continue to be provided to Environmental Protection Agency.

Modifications of the JT8D engine are being developed by Pratt and Whitney. Propulsion system installations for the 727, 737, and DC-9 are being designed by Boeing and McDonnell Douglas. Ground tests of the modified JT8D engine in one or more acoustically treated nacelles will be conducted early in calendar year 1974. Design consultation is being provided by American and United Airlines. The program is managed by the Lewis Research Center.

Flight Experiments Program

C-8 Augmentor Wing Research Aircraft

Flight tests initiated in FY 1973 at the Ames Research Center will be completed in FY 1974 with the modified C-8 research aircraft to verify that the aerodynamic lift increase found in previous wind tunnel tests of the augmentor wing concept is obtainable in flight and can be translated into better take-off and landing performance; to document climbout, descent, and noise characteristics; and to define the safe operational boundaries and procedures for the aircraft. A 50-hour flight investigation will also be conducted to study in detail jet STOL handling qualities during IFR landings, including examination of curved, decelerating approaches, and means of integrating the flight controls to simplify the pilot control task and reduce his work load during such operation. The vehicle will then be ready as a facility for further handling qualities research and for general STOL operating systems experiments to be supported jointly with DOT in a separate program. The overall program is a continuation of a joint NASA-Canadian/ Department of Industry, Trade and Commerce effort to examine the characteristics of the jet augmentor wing concept specifically and powered-lift STOL concepts

in general. The results will aid in the development of design and certification criteria, and in the establishment of terminal area operation procedures for powered-lift transport aircraft.

YF-12 Flight Experiments Program

The joint USAF/NASA flight experiments program using YF-12 aircraft will be continued to evaluate current analytical techniques, provide the basis for improved design prediction techniques, and provide solutions for unknown problems uncovered in flight. Correlation and evaluations of flight loads measurements, loads prediction including aeroelasticity and thermal effects, and structural analysis for flexible hot-structure aircraft will be conducted at the Ames and Flight Research Centers. At the Flight Research Center, inlet dynamic measurements such as pressures, flow fluctuations, and flow distortions, will be obtained in flight at both transonic and supersonic speeds and will be compared to wind tunnel scale model results at Ames Research Center and full-scale tests of a complete inlet system in the wind tunnel at Lewis Research Center. Mutual interactions of the YF-12 propulsion system and aircraft will be evaluated at Flight Research Center. At Langley Research Center, precise laboratory measurements on a test body will be performed at supersonic speeds of a variety of parameters in boundary layer development. These data will be analyzed and correlated with those of flight tests made at Flight Research Center on the identical test body to provide a better analytical representation of the physics of the supersonic boundary layer process.

The unique capabilities of the YF-12 aircraft will also be used for research oriented to the advanced supersonic technology program in the areas of structures and propulsion. Preparations will be made to incorporate in the YF-12 aircraft titanium and composite panels, a complete loads alleviation and modal suppression control system, an inlet shock stabilization system, and an integrated airframe/propulsion control system. In the advanced supersonic technology experiments area, the YF-12 funds support only the operational expenses associated with the aircraft.

Transonic Aircraft Technology (TACT) Flight Experiment

This joint Air Force/NASA program is creating the data base for swing-wing aircraft utilizing the supercritical wing concept. The program encompasses mathematical studies, wind tunnel tests, and flight experiments. Most of the wind tunnel studies have been conducted and flight tests of the basic (unmodified) F-111A test aircraft have been completed. With the baseline flight tests completed, the aircraft will be modified with a supercritical wing-set and subsequently flight tested in FY 1974. The supercritical wing installation will be accomplished by the Flight Research Center.
This is being done in consonance with the Air Force which is procuring the supercritical wing-set and will perform wind static load testing, dynamic analyses, and general engineering support. Later in the program, the Air

Force will supply fuel, chase planes, and a test pilot. The flight test spectrum of testing will explore high angles of attack, high roll angles, and especially the combination of each. These tests will be accomplished from ground level to maximum altitude at subsonic, transonic, and supersonic speeds. Management of the program will transfer from the Air Force to NASA with the delivery of the supercritical wing to the Flight Research Center. Flight tests will be conducted jointly with Air Force and NASA pilots. Correlations between the baseline and TACT flight test results and wind-tunnel test results will be made.

This program will provide the data base for the application of supercritical technology to future military combat aircraft and future civil aircraft that may utilize variable sweep.

Fly-By-Wire Experimental Program

The objective of this program is to provide the component and subsystem design and test experience required for civilian and military implementation of advanced reliable Digital Fly-By-Wire (DFBW) flight control systems which will permit greater operational capability and significantly increased performance of future aircraft. Digital fly-by-wire flight control, which replaces present mechanical/hydraulic control systems by electrical wires and digital processors, offers the minimization of aircraft loads and reduction in drag, thus, providing the cornerstone for development of associated reduced weight aircraft designs with major economic and performance advantages. In addition, DFBW systems, once developed and demonstrated, can be applied to new aircraft designs through software changes and minor modifications, yielding large development cost and time savings.

Phase IA comprises tests of a single-channel Apollo-derived DFBW system installed in a F-8C aircraft with an analog fly-by-wire backup system to obtain early DFBW data. Phase IB will replace the Apollo hardware with aircraft-compatible, cost-effective digital components and will evaluate the resultant system performance in flight to establish a design base for DFBW component and subsystem hardware. The initiation of a follow-on Phase II program in the future would then use these design data for the development and flight verification of a fully redundant, cost competitive DFBW system compatible with commercial aircraft applications. Primary focus of the program is on leadership in long-haul subsonic transports with applicability to supersonic transports, superior V/STOL and advanced fighters and bombers. During FY 1974, feasibility tests of the first all-FBW system in any aircraft will be completed under the Phase IA effort. The Phase IB prototype DFBW aircraft hardware, based on the criteria derived from the Phase IA tests will be developed and installed in the F-8C. Initial flights of this system are planned for early FY 1975.

Composite Structures Flight Experiment

The objective is to gain flight service operational experience by means of installing primary and secondary composite structures in representative types of aircraft. The components installed are redesigned and substituted for metal structure to achieve superior structural performance such as weight saving and improved aeroelastic characteristics obtainable from composites. Currently, an Army CH-54B helicopter with composite reinforced fuselage is in flight evaluation phase and a center wing box is being designed for installation on two Air Force C-130 airplanes. During FY 1974, fabrication of the C-130 wing boxes will be completed. Laboratory structural tests and pre-delivery flight tests will be completed in FY 1975. Following completion of testing, the aircraft will enter routine service operation, and the performance of the wing boxes will be monitored for several years. The results of this experience will provide valuable data for future application of composite structures in civil as well as military aircraft.

Research/Experimental Vehicle Program

Rotor Systems Research Aircraft

The expanding role of the helicopter in both civilian and military applications has generated requirements which exceed the current state-of-the-art of rotary wing technology. Flight tests of promising advanced concepts have been conducted by building a new aircraft or modifying an existing aircraft for each concept, but this is costly in time and money and often gives less than adequate results.

NASA and the Army have been investigating alternate approaches for obtaining adequate and timely test results of advanced concepts in flight without the excessive time, cost, or data limitations of the "one at a time" approach. Both agencies have concluded that a specially designed research aircraft is needed with adequate instrumentation to operate over a wide range of test conditions to test a variety of advanced rotor concepts in the real environment of flight. The Rotor Systems Research Aircraft will fulfill this need.

NASA/Army in-house and contractor predesign studies were conducted to establish the feasibility of an advanced research vehicle and to define the characteristics of and requirements for the flight vehicle, the flight test control system, and the research instrumentation systems. Request for Proposals (RFP) will be issued in March 1973 for the design and fabrication of two research aircraft. Contract award will be in the second quarter FY 1974 with design and component fabrication being carried out throughout FY 1974. First flight is scheduled for early 1976.

The Rotor Systems Research Aircraft project is jointly funded. The Project Office is located at Langley Research Center and is jointly staffed with NASA and Army personnel.

Tilt Rotor Research Aircraft

The Army, Air Force, NASA and industry have been pursuing tilt rotor technology for many years. The tilt rotor concept offers the best opportunity for extending the proven performance capability of the helicopter. Conceptually, the tilt rotor possesses the best characteristics of both the helicopter and the fixed-wing aircraft.

The objective of a jointly funded and managed NASA/Army program is to design and fabricate two tilt rotor aircraft to conduct a proof of concept evaluation and to conduct research in flight to provide the technology needed for commercial and military applications.

Two contractors have been selected for a preliminary design competition which will lead to the award of a single contract for the design and fabrication of two tilt rotor aircraft in late FY 1973. Engineering design, material procurement, tooling, and manufacturing will be carried out through FY 1974, with aircraft rollout and first flight scheduled for the second and fourth quarters of FY 1976, respectively.

Operating Systems Experiments Program

Noise Reduction Flight Procedures Experiment

The objectives are (1) development of operational avionics systems, refinement of operational procedures, and demonstrations of operational feasibility of the two-segment noise abatement flight paths which are acceptable by the airlines and pilots for routine scheduled operations and (2) analysis, simulation, and flight tests in order to reduce to practice other techniques. Although noise reduction flight procedures have shown the potential for significant noise reduction and the procedures are well within the performance capability of current jet transports, these procedures impose new requirements on pilot duties and workload, on pilot displays, on the guidance and navigation systems, and on the aircraft control system. A substantial effort is required before suitable avionics can be equipped and sufficient experience gained so that they are accepted by the airlines, the pilots, and FAA for routine operations in instrument weather as well as clear weather. In FY 1973, the program included the development and start of flight evaluation of two-segment avionics using Instrument Landing System (ILS) co-located Distance Measuring Equipment (DME) and barometric altitude for vertical guidance in a B-727 aircraft. In FY 1974, development and flight evaluation of two-segment avionics using three-dimensional area navigation for guidance will be conducted in a DC-8 long-haul narrow-bodied jet transport. Evaluation of B-727 two-segment avionics in

scheduled service will be made by several air carriers. Studies will be made to determine the applicability of a two-segment approach over the entire fleet of jet transports. Development and flight evaluations will start on other techniques such as decelerating approaches and use of the capabilities of the microwave landing system being developed by Federal Aviation Administration.

Terminal Configured Vehicle Operations Experiments

In a companion program to the Federal Aviation Administration air traffic control automation program, NASA will define and demonstrate the technology for aircraft and avionics performance needed for efficient terminal area operation with advanced air traffic management concepts. The requirements to operate safely and with regularity, independent of weather, is increasingly important in overall economics of civil aviation operations. At the same time, however, the jet aircraft must be converted into a vehicle which is a better neighbor, more efficient in the terminal area phase of flight, and capable of high accuracy in four-dimensional terminal area trajectories. The combinations of steep and curved descents and landings in adverse weather conditions with sufficient precision for safe traffic separation and maximum runway capacity utilization require a definite advance in the state-of-the-art in airborne navigation, guidance and control, and a closer integration of the avionics with the propulsion, aerodynamics, and structures subsystems of the aircraft. This program will develop airborne systems technologies (navigation, guidance, control, and displays) for advanced aircraft to reduce time of flight, establish schedule reliability, assure compatibility with the future air traffic environment and control facilities, and assure acceptance by airline pilots. In FY 1973, aerodynamics and flight control simulations are being conducted to evaluate aircraft performance limitations. Parametric sensitivity and trade-off studies between aircraft performance characteristics and ground and airborne electronic system capabilities will be made. Flight experiments will be started in FY 1974 to place realistic bounds on the new concepts, evaluate critical systems and procedures, demonstrate systems operations, and to gather data on actual all-weather operations in Category III operational conditions (zero foot decision height, 150 foot runway visual range). In order to provide authenticity to these evaluations and demonstrations, a B-737 aircraft will be uniquely modified and equipped to investigate present and future airport environments, automatic systems, displays, digital techniques, reliability, and piloting techniques and procedures. The Wallops-Langley CTOL Aircraft Flight Research Facility will be established in FY 1974, using the facilities of both Langley Research Center and Wallops Station, which will contain appropriate system elements in a framework so that the relative effects of change in various system elements on precision control, pilot workload, and available margins of safety can be measured.

VTOL Operating Systems Experiments

This program involves the development of advanced, flexible navigation, guidance, and control avionics which will be used in simulation and flight experiments to investigate operational procedures and system concepts which can improve the operational efficiency, public acceptance, safety and reliability of VTOL vehicle short-haul transportation. Major emphasis will be placed on providing the avionics for automatic take-off and landing of VTOL vehicles. The first fully automatic landings by a full-scale, manned helicopter at a predetermined spot was made by Langley Research Center, in February 1972. Although this accomplishment was performed using laboratory type equipment, it is considered a major milestone in a continuing research program aimed at permitting helicopters and future VTOL vehicles to fly routine missions under poor visibility in an advanced air traffic control environment. The advanced, flexible navigation, guidance, and control avionics system will be installed in a helicopter which will be used in FY 1974 to develop, by flight experiments in the terminal area, a data base for use by industry and Government in establishing system concepts, design criteria and operating procedures for VTOL aircraft, VTOL ports, VTOL landing guidance systems, airborne avionics, flight control systems, and air traffic control.

STOL Operating Systems Experiments

The objectives of this program are being carried out jointly with the FAA/DOT under a program known as the Joint DOT/NASA STOL Operating Experiments program, which reflects common interests in the development and investigation of aircraft and electronic technologies, operational procedures, and system concepts which can improve the operational efficiency, public acceptance, safety, and reliability of STOL vehicle short-haul transportation. An advanced integrated avionics and display system (STOLAND) was developed in FY 1972 and FY 1973 to perform navigation, guidance, and control in flight and ground simulations. Unique flexibility has been obtained by the use of a single, general purpose digital computer for all navigation, guidance, control and display computation. The development has required special approaches to hardware and software in order to provide all of the desired advanced capabilities. The first STOLAND equipment will be installed in a C-8A Buffalo during the last quarter of FY 1973, and flight experiments, which have been defined jointly by FAA and NASA, will start. In FY 1974, the second STOLAND system will be installed in a C-8A Buffalo modified into an augmentor wing jet STOL research aircraft. The flight experiments in these aircraft and simulation will investigate such things as accuracy with which specified profiles can be flown, the aircraft response characteristics in flying the profiles, landing flare and touchdown performance, pilot workload, systems functioning and reliability, the effect of STOL aircraft on the air traffic control system, and information which can be used to develop design criteria and operational procedures for STOL operations.

Systems Technology Programs

Advanced Supersonic Technology

The objective of the advanced supersonic technology program, initiated in FY 1973, is to provide an expanded supersonic technology base in the technical areas critical to the future development of an environmentally acceptable and economically viable supersonic transport so that if it is determined to be in the national interest to consider such a development program, the information upon which to base a decision will be available. The advanced supersonic technology program addresses environmental concerns by research on noise minimization and air pollution, and the economic viability aspects by airframe system studies and advances in the technical disciplines of propulsion, structures and materials, aerodynamics, and stability and controls.

An advanced supersonic transport propulsion system must satisfy many different operational requirements such as high thrust and low noise at take-off, high efficiency during subsonic hold and cruise, and high efficiency during supersonic cruise. In FY 1973, broad parametric studies are underway of candidate conventional and variable-cycle engine concepts. Engine definition studies and a preliminary design phase of the most promising concepts will be initiated in FY 1974. Noise suppression nozzles, currently being investigated under the Department of Transportation-Federal Aviation Administration/Supersonic Transport Follow-on program in ground-based facilities, will be evaluated by the Lewis Research Center in flight tests of a modified F-106B aircraft in FY 1974. The advanced supersonic pollution reduction technology program complements the DoT Climatic Impact Assessment Program (CIAP) and in FY 1974 the efforts will be expanded to include combustor pollutant studies at supersonic cruise conditions and combustors designed to minimize the production of oxides of nitrogen at high altitudes. The stratospheric jet wake experiment program which combines laboratory tests, theory, and flight tests will be continued in FY 1974 to provide data which can be used to assess the environmental impoact of jet emissions on the stratosphere.

The design of an economically viable supersonic transport requires reduced structural weight fractions attainable though the application of advanced concepts, design tools, and relatively new materials. In-depth studies will be continued in FY 1974 to determine the best structural approaches to the highly aerodynamic efficient arrow-wing configurations and configurations identified in the airframe systems study with emphasis on thermal stress, static aero-elasticity, and flutter. Automated design techniques which would significantly reduce the manpower and flow time required to carry out vehicle design iterations initially started in FY 1973 with the development of an automated flutter and fracture module will be continued. These design modules will be incorporated in an advanced supersonic technology version of IPAD (Integrated Program for Aerospace Vehicle Design). Titanium technology must be advanced beyond the present

state-of-the-art to minimize structural weight. Fabrication methods applicable to titanium alloy structures were initiated in FY 1973. Fabrication of structural panels will continue in FY 1974 and the panels will be subjected to accelerated and real time tests of strength, fatigue and fracture, and cyclic heating under supersonic flight conditions. A high temperature composite materials program similar to the titanium components program will also be conducted. The materials will include both boron and graphite fibers in both epoxy and polymide resins and boron-aluminum composite materials. Present fuel tank sealants do not provide the service life required for the temperatures to be encountered in the Mach number range of interest for an advanced supersonic transport. The Ames Research Center program on fuel tank sealants will continue to synthesize, characterize, and vulcanize sealant elastomers and then select the optimum sealants for ground tests in FY 1974 and flight tests in FY 1975.

The highly swept arrow-wing configuration concept is currently being studied at the Langley Research Center to increase its aerodynamic efficiency at supersonic cruise and improve the configuration's low speed characteristics. In FY 1974, extensive wind tunnel tests will be conducted to support follow-on arrow-wing concepts. Also, improved theoretical methods at both subsonic and supersonic speeds, particularly at critical off-design flight conditions, will be developed and validated and used in the design and analysis of advanced supersonic configurations. The technology effort started in FY 1973 to develop design methods for use in defining practical minimum boom configuration concepts will continue in FY 1974. In addition, Langley Research Center will conduct a program to establish criteria describing sonic boom exposure levels which are acceptable to communities. Subjective response data will be obtained and correlated with sonic boom signature characteristics and occurrence effects beginning in FY 1974.

The stability and controls technology programs at the Ames Research Center will concentrate on pilot-in-the-loop simulations of proposed control-configured vehicle concepts to define acceptable levels of handling qualities for safe operation in all flight modes. Piloted motion simulator studies will also be conducted to investigate the acceptability of candidate redundant control system concepts in terms of the control system stability and responses in normal operation and the ability of the pilot to detect and react to failure in the systems.

The advanced supersonic technology airframe systems studies will define, assess, and promote the development of advances in supersonic technologies most likely to result in a quiet, clean, and economically viable supersonic transport. Following the FY 1973 definition of technologies, a cycle beginning in FY 1974 of increasingly detailed "preliminary" design studies will exercise the technological inputs from all other advanced supersonic technology program elements with principal emphasis on propulsion/airframe

integration. The unique capabilities of the YF-12 aircraft will be used in FY 1974 for flight research oriented to the advanced supersonic technology program in the areas of structures and propulsion. Preparations will be made in FY 1974 to flight test titanium and composite panels and to demonstrate the feasibility of an inlet shock stabilization system in flight. During FY 1974 programs involving the design, fabrication, and YF-12 flight tests of an integrated airframe/propulsion control system and a complete loads alleviation and modal suppression control system, will be conducted.

Quiet Propulsive-Lift Technology

The objective of this program is to generate a foundation of quiet propulsive-lift technology to support development of civil and military transports with the advantages of improved approach, landing, takeoff, climbout, and airport area low-speed maneuvering capabilities. This technology is applicable to conventional-, reduced-, and short-takeoff and landing (CTOL, RTOL, and STOL) systems. It offers the potential of efficient, quiet, and safe operation in steep and highly maneuverable approach and climbout flight paths, and represents an essential key to community noise reduction, terminal air congestion relief, and the creation of an improved, environmentally acceptable, short-haul air transport system.

Analytical and wind tunnel investigations of the aerodynamic and propulsion system aspects of alternative turbofan propulsive-lift concepts will be continued in FY 1974, together with definition of potential low-cost flight research vehicle approaches to fulfillment of the quiet propulsive-lift research objectives which require flight testing. This effort will include preparation for participation in flight testing of the Air Force Advanced Medium STOL Transport prototypes as one means of obtaining necessary propulsive-lift flight data.

The effort involves activity at all of the Aeronautics and Space Technology Centers, with Ames Research Center serving in the lead capacity.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1974 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

SPACE RESEARCH AND TECHNOLOGY PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1972	1973	1974
Research and technology base.....	$64,565,000	$49,425,000	$54,675,000
Systems and design studies.....	700,000	1,230,000	1,300,000
Systems and experimental programs..	9,100,000	14,105,000	9,025,000
Total.....	$74,365,000	$64,760,000	$65,000,000
Distribution of Program Amount by Installation:			
Manned Spacecraft Center.....	$2,202,000	$300,000	$690,000
Marshall Space Flight Center...	8,140,000	5,465,000	3,340,000
Goddard Space Flight Center....	3,935,000	3,555,000	4,035,000
Jet Propulsion Laboratory.....	16,268,000	13,389,000	11,672,000
Ames Research Center.....	7,173,000	6,699,000	7,739,000
Flight Research Center.....	1,215,000	1,382,000	1,050,000
Langley Research Center.....	16,255,000	13,835,000	15,018,000
Lewis Research Center.....	16,654,000	18,817,000	20,838,000
NASA Headquarters.....	2,523,000	1,318,000	618,000
Total.....	$74,365,000	$64,760,000	$65,000,000

HIGHLIGHTS OF BUDGET PLAN

Materials - Basic and applied research studies aimed at increasing the long life performance and reliability of materials in the space environment.....	$8,700,000	$6,360,000	$6,530,000
Structures - Development of advanced structural concepts and structural dynamics technology, including thermal protection system and deployable space structures.....	9,000,000	5,275,000	5,721,000

	1972	1973	1974
Guidance, Control and Information Systems - Development and evaluation effort in the areas of precise guidance and control of space vehicles and experiments; storage and processing of data; high data rate information transfer; imaging and measuring; and reliable, long-life electronic components and systems.....	$14,065,000	$12,330,000	$13,816,000
Propulsion - Chemical and electric propulsion technology advancements.	15,300,000	9,380,000	12,859,000
Power - Advancements in solar array, battery, fuel cell and power processing technology.....	7,500,000	6,898,000	6,448,000
Entry - Aerothermodynamic and thermal protection system effort for solution to the problems of high-speed entry and flight of spacecraft in atmospheres of earth and other planets.....	8,300,000	8,532,000	9,301,000
Safety - Safety research in aeronautics and space is continued under the space propulsion program in the R&T base in FY 1974. The safety data bank is supported under the FY 1974 applications technology.....	1,700,000	650,000	---
Total, Research and Technology Base.....	$64,565,000	$49,425,000	$54,675,000
Systems and Design Studies - Analysis and study to identify technology requirements for focusing technology programs and identification of new areas of opportunity	$700,000	$1,230,000	$1,300,000
Total, Systems and Design Studies	$700,000	$1,230,000	$1,300,000

	1972	1973	1974
System Technology Programs.....	---	$467,000	$1,500,000
High Energy Laser Technology Program - Research on high energy laser systems and laser transmission of power in space.....	---	467,000	1,500,000
Flight Experiment Programs.....	$1,500,000	4,815,000	1,225,000
Synchronous Laser Communications Experiment - Discontinued in FY 1974 due to cancellation of the ATS-G spacecraft.....	800,000	3,000,000	---
Atmospheric Flight Experiments - Flight tests of X-24B entry vehicle to assess performance, handling qualities, operational factors, and control characteristics in the low supersonic to subsonic speed regimes.....	700,000	1,068,000	1,050,000
(SPHINX) Space Plasma High Voltage Interacting Experiment - Final assembly and qualification for flight test in FY 1974.....	---	593,000	74,000
Meteoroid Technology Satellite - Data reduction and analysis of satellite data.....	---	154,000	101,000
Spacecraft/Payload Programs.....	3,200,000	2,920,000	3,100,000
Low Cost Payloads Program - Focuses on reducing costs of future payloads through use of shuttle capabilities and standardization of subsystems.....	---	---	3,100,000
Electric Auxiliary Propulsion - Ion thrusters and pulsed plasma thrusters, funded under the space propulsion program starting in FY 1974.....	1,400,000	690,000	---

	1972	1973	1974
Space Storable Propulsion - Space storable propulsion technology program funded under the space propulsion program starting in FY 1974.....	$1,800,000	$2,230,000	---
Transportation Programs.....	2,400,000	2,653,000	---
Solid Rocket Motors - Solid rocket motor technology program funded under the space propulsion program starting in FY 1974.....	1,300,000	1,081,000	---
Solar Electric Propulsion - Solar array-powered ion engine system funded under the space propulsion program starting in FY 1974.....	1,100,000	1,572,000	---
Applications Technology.....	2,000,000	3,250,000	3,200,000
Civil Applications - Uses NASA capability to assist in the solution of public sector problems....	2,000,000	1,987,000	1,700,000
Applications Data Systems Support - Provides support for the Aerospace Safety Data Bank and the data management for the earth resources survey program.....	---	1,263,000	1,500,000
Total, Systems and Experimental Programs.....	$9,100,000	$14,105,000	$9,025,000

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

SPACE RESEARCH AND TECHNOLOGY PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The goals of this program are designed to build a technology base which will adequately support current and future space activities. The FY 1974 program is expressed in terms of three coherent output activities: Research and Technology Base; Systems and Design Studies; and Systems and Experimental Programs. The fundamental work of the Space Research and Technology program is concentrated in the R&T Base and is aimed at providing an understanding of physical phenomena pertinent to space programs. It includes research concerned with material properties and behavior, lasers and other optical phenomena, materials and techniques for improved electronic devices; gas dynamics and aerothermodynamics phenomena associated with planetary atmospheric entry; combustion processes, fluid dynamics, plasma characteristics, ion optics, and discharge characteristics associated with chemical and electric propulsion; and basic understanding and improvements in the theory and technology of chemical power producing machines and solar power conversion materials. The Research and Technology Base also includes applied research programs which utilize the fundamental technology developed by the basic research in the development of: improved materials and structures; the analytical and numerical techniques for designing complex structures; guidance, control and information systems; thermal protection systems; propulsion and power for earth applications, space science and future planetary programs.

A low cost payloads technology program has been included as a new activity under Systems and Experimental Programs. This effort will be aimed at reducing the costs associated with space flight experiments. Of special concern will be the standardization of instrument packages or subsystems and elimination or reduction on the number of redundant and backup systems through increased reliability. Another activity, a high energy laser technology program, previously incorporated under the R&T Base, is being explicitly identified this year as a systems technology program. A number of programs have been terminated, reduced or redirected due to changing emphasis and time schedules in NASA's overall space program, and to permit the inclusion of higher priority efforts. In the area of propulsion, the space storable program is being terminated because its application to the planetary program has moved downstream significantly. The solid rocket motor, electric auxiliary propulsion, and solar electric propulsion efforts are being moved back to the R&T Base at reduced levels for similar reasons, while the synchronous laser communication program, previously included in the FY 1973 program, has been terminated due to the cancellation of the ATS-G satellite on which it was scheduled to fly.

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The FY 1974 program will also continue efforts to define specific public sector problems to which space technology can be applied, to develop conceptual solutions, and to demonstrate the feasibility of selected concepts. This activity is funded under the applications technology (civil applications) program item.

In summary, the Space Research and Technology program shows an overall reduction in the Systems and Experimental Programs category and a corresponding increase in the R&T Base. This is the result of the several migrations to the R&T Base indicated previously plus some offsetting terminations and new additions to the list of experimental programs. The net effect is the same level of effort for the remainder of the R&D Base in FY 1974 that was programmed in FY 1973. The proper balance will continue to be sought between the amount of effort devoted to the fundamental technology encompassed by the R&T Base and the nearer term objectives of the Systems and Experimental Programs.

BASIS OF FUND REQUIREMENTS:

Research and Technology Base

	1972	1973	1974
Materials research and technology.	$8,700,000	$6,360,000	$6,530,000
Structures research and technology	9,000,000	5,275,000	5,721,000
Guidance, control and information. systems research and technology.	14,065,000	12,330,000	13,816,000
Propulsion research and technology	15,300,000	9,380,000	12,859,000
Power research and technology.....	7,500,000	6,898,000	6,448,000
Entry research and technology.....	8,300,000	8,532,000	9,301,000
Safety research and technology....	1,700,000	650,000	---
Total.....	$64,565,000	$49,425,000	$54,675,000

Materials Research and Technology

The materials program for space combines basic research, discipline research and technology, and systems research and technology into an integrated effort which is focused toward fulfillment of NASA's needs for present and future space missions. The more basic research is directed toward solution of materials problems to enhance the capability for both advanced disciplinary and systems research and technology. Although a primary goal is research and technology in preparation for future missions, a large portion of the program is in support of current space efforts. Direct support is given, for example, to the shuttle and related experimental programs by work on shuttle materials and the effects of environmental hazards on materials. The unmanned programs receive support from programs concerned with materials behavior in earth orbital systems technology.

During FY 1974 basic materials research will continue to seek increased understanding of the electronic, molecular, and atomic structures of solids and surfaces and relating this understanding to material properties. Such research will aid in the development of materials and devices for both manned and unmanned spacecraft.

Development of materials capable of withstanding the hazards of the space environment will be continued. Improvements in heat pipes and thermal control surfaces will be investigated. The meteoroid environment will also continue to be measured. High temperature materials will be investigated for the reentry thermal protection systems of advanced spacecraft. High temperature bearings, seals, and lubricants will also be studied for application to rotating machinery and aerodynamic control systems. Composite materials will also be designed and fabricated to reduce the weight of spacecraft and their payloads.

Structures Research and Technology

The space structures R&T program primary objectives involve development of new structures concepts, advanced analytical methods, and experimental techniques needed for future space systems. Application of these technology advances is explored in preliminary design and experimental investigations to demonstrate performance and provide solutions to potential problems. The results of some of these activities are applicable to current and near-term space systems and others to advanced systems requiring new approaches to achieve feasibility or enhance capability.

A major portion of the recent effort has been devoted to space shuttle structural design and dynamics technology. In FY 1974, the magnitude of shuttle activities in this program will be decreased; those remaining will be concentrated on verification of integrated thermal protection systems and structure by experiments in unique NASA facilities and on critical dynamic factors related to shuttle development.

In structural dynamics, emphasis will be given to reducing the cost of spacecraft through improvements in loads prediction and response techniques and through more rational qualification test procedures. The control of liquid-structure interactions and high temperature effects on vibration will also be investigated. The development of the Integrated Program for Aerospace Vehicle Design (IPAD) program will begin, and the maintenance and improvement program for NASA Structural Analysis (NASTRAN) will continue, including three dimensional hydroelastic capability in support of the shuttle vehicle.

Significantly increased emphasis is needed in such areas as structural concepts for large space-erectables, shuttle payloads, and composite structures unique to space systems. Fabrication of larger models of furlable antennas for planetary missions will be undertaken to permit laboratory experiments which will confirm the technology readiness for full-scale design of large antenna structures.

Efforts will be expanded on development and testing of pressure vessels and other space system structures using advanced composites. (In structural dynamics, additional emphasis will be given to vibration environments, control and isolation of vibration, high-temperature effects, and control of liquid-structure interactions, automated design methods, and finite element analysis techniques.) These problem areas will be critical for design and operation of many shuttle payloads as well as others to be launched prior to shuttle operational availability.

Guidance, Control and Information Systems Research and Technology

Electronic devices and systems provide the interfaces between man and machine which permit inanimate vehicles and mechanical systems to perform as extensions of man's intellect in alien or hostile environments. Research and development activities in the guidance, control and information systems program are directed toward attaining reduced cost, increased reliability, improved performance and new capabilities for the electronic systems used in space exploration and application programs. Program emphasis centers on the development of technology to enhance the detection, transfer and translation of data into useful information, guidance and control systems for long-lived earth orbital and planetary spacecraft, and the electronic components and techniques used to create functional systems.

During FY 1974, development of new electronic devices for sensing, storing and displaying information will continue with emphasis on solid state displays and materials for optical mass memories. Advances in robotics and artificial intelligence will be applied to an autonomous roving vehicle to evaluate problems and demonstrate potential utility. Development of low cost guidance, control and stabilization systems will continue with emphasis on standardized, modular components for earth orbital and planetary spacecraft. Research on optical memory systems and processors to provide storage and handling capabilities for the large masses of data to be encountered in operational earth observation satellites will continue. Development of components and techniques for improving the gain, bandwidth and transmitter power of microwave communication systems will continue with particular emphasis on higher frequency systems to conserve bandwidth and provide expanded capability for operational systems. Research on lasers and development of optical components to provide very wide band, high data rate optical communication links between earth orbital satellites, data relay satellites and ground stations will be pursued. A program to automate the fabrication and testing of large scale integrated circuit arrays to reduce costs and provide long-life, reliable

electronic components and subsystems will be initiated. Development of high resolution sensors for planetary imaging and remote measurement of environmental characteristics of the earth will continue with emphasis on the application of solid state, tunable lasers and charge-coupled-devices technology. Techniques, sensors and systems to improve the accuracy and flexibility of deep space guidance and navigation systems will be developed to permit exploration of the outer planets. A program to improve reliability and lower costs of on-board data storage systems will be initiated with emphasis on the definition of system characteristics and the application of magnetic "bubble" memory technology as a solid state replacement for mechanical tape recorders. Coordination of these research and development activities will be effected through formal and informal interchanges with other Government agencies and joint support of interagency advisory groups where appropriate.

Propulsion Research and Technology

The broad objectives of the chemical and electric propulsion research and technology program are: (1) to discover and explore very advanced concepts leading to major increases in space vehicle performance; (2) to advance the key component technologies; and, (3) to evaluate and demonstrate the feasibility of selected advanced systems. Particular emphasis is being placed on factors such as reusability and standardization that will lead to reduced future mission costs.

In FY 1974 the advanced concepts program will focus on atomic and metallic hydrogen, laser heating of propellants, and activated species of helium and oxygen in a search for chemical rocket performance in the specific impulse range of 500-2000 seconds. Experimental hardware designed in FY 1973 for producing several of the activated species in very small quantities will be built and tested.

Work will continue on the pacing technologies for chemical rockets, ranging from research on combustion, fluid dynamics and polymer chemistry, to the technology of long-life components and materials, zero-g propellant transfer, and very high mass fraction solid motors.

The electric propulsion research and technology program is aimed at increasing performance through a better understanding of ion and plasma acceleration, thruster loss mechanisms and durability limits. Basic studies of ion optics, magnetic field effects, etc., will be continued in FY 1974. In addition, the technology of long-life, vectorable thrusters to operate at more than double present thrust densities will be developed. Tests exploring effects of engine clustering will be completed in FY 1974 and the use of alternate propellants will be investigated. Special emphasis will continue to be given to vehicle/solar electric propulsion subsystem characterization and operational support software requirements associated with low thrust missions.

The system evaluation and feasibility program will continue toward the ultimate goal of demonstrating: (1) reusable oxygen-hydrogen technology leading to 470-second specific impulse and high mass fractions for applications such as a Space Tug; (2) a modular electric primary propulsion system capable of performing difficult future missions such as cometary rendezvous, direct flybys to the outer planets in any year, or geosynchronous missions that are not practical with existing launch vehicles or a single launch Shuttle; and (3) electric auxiliary (station-keeping/altitude control) propulsion, including life testing of north-south station-keeping ion engine experiments to be flown on the ATS-F spacecraft. In addition, ground testing and evaluation of small pulsed and hydrazine resistojet attitude control thrusters will be carried out.

Included in the propulsion program is a safety research effort to obtain a better understanding of the hazards, and to improve the safety of NASA and contractor operations associated with cryogenic propellants and related systems.

Power Research and Technology

The objectives of the solar and chemical power technology program in the next six years are to: (1) reduce system costs by 50%; (2) reduce system weight by 50%; (3) increase system efficiency 100%; and (4) increase system life by 100%. The results of these activities will be to reduce the costs of spacecraft power systems both directly and indirectly. Improved uniformity, reproducibility and reliability of devices will reduce the need for testing and evaluation, activities whose costs far exceed those of the devices being tested. Longer shelf life and cycle life, higher radiation resistance, and reduced weight, all necessary for deep space exploration in any case, will benefit orbital missions, also, by reducing the need for redundancy and for repair and replacement of parts or even total spacecraft.

The principal goal in the solar area is to cut costs by at least 50%, while also doubling radiation resistance and obtaining 50% more power density. Emphasis at Lewis Research Center is on new cell types, wrap-around contacts, and plastic covers. Jet Propulsion Laboratory is stressing the 50 watt/lb array, standard module design, and coordinating standardization efforts on a nation-wide basis. Work on fuel cells aims at cutting costs/kw by 90% while increasing stack life to 10,000 hours. Lewis Research Center is working on improved components, such as catalysts and matrices, while identifying present life-limiting factors and searching for ways to eliminate them.

Battery efforts are directed towards doubling energy density and life; and towards developing a capability for reliable life prediction. This last goal is pursued at Goddard Space Flight Center by improvements in quality control and devising new test methods. Lewis Research Center is developing the lighter weight batteries and tougher separators needed for the first two goals. Jet Propulsion Laboratory is working on non-gassing cells as well as plastic seals, both aimed at very long stand and operating lives for deep space missions.

Comprehensive analyses have shown that significant benefits, particularly in reliability, and increased power capacity, as well as reduced overall power system cost and weight, are realizable through use of a higher voltage d.c. electric power processing and distribution subsystem. Power processing research and development will focus on the technology for voltage transformation and regulation, and continued development of needed control and protection devices for multi-kw, higher voltage d.c. electric power systems.

Entry Research and Technology

The objectives of the entry technology program are directed toward an understanding and timely solution of aerothermodynamic and heat protection problems relating to design and operation of planetary probe spacecraft and earth-orbital vehicles. The program is composed of three elements: basic research which is directed toward attaining a better understanding of the behavior and properties of high energy fluid flows associated with spacecraft flight; discipline research and technology, which deals with the development of new aerodynamic and heat protection system technology required for earth-orbital, planetary spacecraft, and launch vehicle design and operation; and entry system technology, which is aimed at generating aerothermodynamic technology support for major NASA flight programs and missions such as the Space Shuttle and planetary exploration probes.

Using various aerothermodynamic research facilities and high-speed advanced computers, some of the major tasks in basic research to be carried out by the Ames and Langley Research Centers and the Jet Propulsion Laboratory will deal with study and analysis of equilibrium and nonequilibrium flow fields, high temperature gas transport, and shock layer convective and radiative heat transfer. These Centers will also conduct experimental and analytical investigations to determine aerodynamic stability, control, and performance of planetary probes and advanced earth-orbital vehicles with emphasis on the design of ablative heat shields for protection against very high radiative heating during planetary entry. Extensive wind tunnel testing will be carried out in support of the Space Shuttle to evaluate vehicle aerodynamic heating, stability, performance and control, and trajectory parameters. The Ames and Langley Research Centers will also carry out a coordinated program to evaluate and test reusable surface insulation Shuttle heat shields. As the required support for the Shuttle becomes less demanding, research efforts will shift to development of technology for advanced earth-orbital vehicle design.

Systems and Design Studies

	1972	1973	1974
Systems and Design Studies.....	$700,000	$1,230,000	$1,300,000
Total.....	$700,000	$1,230,000	$1,300,000

Systems and Design Studies

The advanced concepts and missions studies help promote the successful transfer of technology produced in the R&T Base into total systems for future experimental programs. Such analyses examine new technologies, vehicles and missions, their technical requirements as well as anticipated national needs, and serve to assess promising options including constraints such as time and funding along with external factors. Such studies also provide feedback to the ongoing R&T Base program.

The results of the space systems studies aid in the screening and selection of promising approaches to important problems and their solutions from a vast array of alternatives. Such studies help define objectives and priorities. They provide analytical measures of expected outcomes of candidate programs before costly investment is made in hardware and testing. They identify attractive options and "high payoff" areas and suggest future design studies.

In FY 1974 considerable effort will be applied to the study of user interactive systems and system concepts to achieve improved performance at lower costs. The development of new system analysis tools will continue, in order to meet the needs for developing better methods for mission analysis and computerized systems engineering techniques.

New and innovative concepts will continue to receive attention. Special emphasis will be placed on the utilization of space in terms of removing technical and economic constraints by identifying the benefits and payoffs possible in the future through new space technology.

Systems and Experimental Programs

	1972	1973	1974
System Technology Programs.....	---	$467,000	$1,500,000
High energy laser technology...	---	467,000	1,500,000
Flight Experiment Programs.....	$1,500,000	4,815,000	1,225,000
Atmospheric flight experiment..	700,000	1,068,000	1,050,000
(SPHINX) Space plasma high voltage interaction experiment.....	---	593,000	74,000
Meteoroid technology satellite.	---	154,000	101,000
Synchronous laser communications experiment.....	800,000	3,000,000	---
Spacecraft/Payload Programs.....	3,200,000	2,920,000	3,100,000
Low cost payloads.....	---	---	3,100,000
Electric auxiliary propulsion..	1,400,000	690,000	---
Space storable propulsion.....	1,800,000	2,230,000	---
Transportation Programs.....	2,400,000	2,653,000	---
Solid rocket motors.....	1,300,000	1,081,000	---
Solar electric propulsion.....	1,100,000	1,572,000	---
Applications Technology.....	2,000,000	3,250,000	3,200,000
Civil applications.....	2,000,000	1,987,000	1,700,000
Applications data systems support.....	---	1,263,000	1,500,000
Total.....	$9,100,000	$14,105,000	$9,025,000

System Technology Programs

High Energy Laser Technology

The relatively new field of high energy lasers has expanded rapidly and has given promise of a wide range of applications. The ability of lasers to transmit intense beams of energy over great distances opens interesting possibilities for space missions. Satellites may receive power from a laser beam transmitted from a central power source. Orbit-to-orbit shuttles and other spacecraft may be propelled by laser powered rocket motors.

To investigate the applicability of high energy lasers to missions in space, NASA is conducting a laser technology program with emphasis given to transmission of power by high energy lasers in space. Major emphasis will be on the technology required to provide long-lived laser systems to operate in

the space environment, and research on high-energy (short-wavelength) laser concepts and receiver/converter concepts to transform laser beams to electrical energy or thrust. Studies will also be conducted of large size optical systems to determine the distance limits for transmitting lasers beams of several different wavelengths. This technology effort is allied with the research on lasers conducted in the electrophysics research program and will make full use of laser technologies being established throughout the Nation under laser programs in other agencies.

Flight Experiment Programs

Atmospheric Flight Experiments

Following completion of the M2-F3 Lifting-Body flight research program in mid-FY 1973, a new vehicle design will be evaluated in a series of flight tests at the Flight Research Center. Flight tests and supporting work will be conducted under a new program designated the entry technology configuration program. The vehicle is designated the X-24B and is based on extensive work carried out by the Air Force Flight Dynamics Laboratory. Information is needed on terminal area performance (low supersonic speeds to landing) of configurations potentially applicable to advanced spacecraft and high performance fighter aircraft.

The low supersonic and subsonic aerodynamic characteristics of the X-24B will be evaluated in a joint program between NASA and the Air Force. The program will be carried out by the Flight Research Center and will span approximately two years from the first scheduled flight in late FY 1973. The X-24B vehicle was fabricated by modification of the X-24A previously used in the lifting-body flight research program. The vehicle has a lift over drag ratio (L/D) of approximately 2.5. A launch mode similar to that used in previous lifting-body flight tests will be used. Objectives of the flight test program are to: assess performance, handling qualities, and operational factors; to determine control characteristics and assess requirements for future vehicles; and to determine and assess any unpredicted problems.

(SPHINX) Space Plasma High Voltage Interaction Experiment

The objective of the SPHINX project is to obtain engineering and flight data necessary to design high voltage systems that can be exposed directly to the space environment such as for communication satellites. In addition, it is expected that the flight data will serve as a reference set for future ground testing.

The SPHINX project consists of planning, developing, qualifying, and flying a small (165 lb.) self-contained, auxiliary satellite using the Titan/Centaur proof flight as the launch vehicle in 1974. It will carry experiments to investigate the interaction between high voltage (up to $\pm$ 16KV) surfaces and the space plasma. Project management is at the Lewis Research Center.

During FY 1973, testing of the dynamic model of the spacecraft, and of the flight configured experimental system package (ESP) and spacecraft bus were completed. In FY 1974, final assembly of the ESP with the spacecraft bus and their qualification as a complete spacecraft will be completed with delivery to the Eastern Test Range (ETR) scheduled for the end of FY 1973.

Meteoroid Technology Satellite

At 11:10 a.m. EDT on August 13, 1972 the Meteoroid Technology Satellite (MTS) was launched from Wallops Island by a four-stage Scout D launch vehicle into an elliptical orbit with a perigee of 495.8 km (268 nm) and an apogee of 814.5 km (440 nm). The orbit inclination is a nominal 38 degrees and the orbital period approximately 98 minutes. The spacecraft is expected to have a minimum lifetime of one year. The primary objective of the MTS is to evaluate the effectiveness of a typical bumper-protected multi-sheet spacecraft structure for meteoroid protection. This is the first inflight test of the bumper concept. Although operational anomalies have developed with the spacecraft, it is expected that the primary objective will be accomplished.

This project supports the objective of investigating space environmental hazards by flight testing protective concepts. The focus is on space experiments aimed at developing meteoroid protection in long-lived space labs and stations. Funds beyond FY 1973 are for data reduction and analysis.

Spacecraft/Payload Programs

Low Cost Payloads

The NASA space evaluation program is a new effort with the purpose of extending the useful work of the space program within the limits of its available budget.

Historically, the costs of space systems have been relatively high. Among the reasons for the high cost are the constraints of weight and volume limitations, the high degree of automaticity and reliability required, and the inability to repair or refurbish space equipment once launched. These constraints necessitated tailormade equipment to fit the requirements of approved missions.

The advent of the shuttle launch system will relieve or eliminate many of these constraints. Relief of weight and volume, for example, will permit a designer to select from proven conservatively designed equipment when configuring a new spacecraft or payload, even when the equipment exceeds his specific requirements or capacities.

Accordingly, NASA has initiated a program of identifying a series of "standardized" subsystems that will fulfill a majority of our future requirements. These standard subsystems include power, communications, data processing, stabilization and attitude control propulsion. Significant economies will result in developing spacecraft and payloads because the costs of design,

development, qualification testing, and documentation can be amortized against several users of these subsystems.

In addition, the ability of the shuttle to refurbish spacecraft promises the economies of extended useful life of our space systems, with attendant cost savings in the shuttle era. NASA is engaged in studies to modularize future space systems and subsystems to facilitate such refurbishment.

In FY 1974, after defining appropriate ranges of subsystem capabilities, engineering models of the selected lines of standard subsystems will be designed and built. In subsequent years, this work will lead to development and qualification of families of standard subsystems or subsystem modules, which will be used whenever possible on all future spacecraft and payloads. This significant change in our approach to spacecraft development will result in substantial savings in the cost of future space systems.

Applications Technology

Civil Applications

The Office of Aeronautics and Space Technology, Applications Technology Office uses NASA capability to help solve public sector problems. It is primarily a systematic effort to translate broad statements of public problems into workable definitions. Probable solutions are evaluated jointly with the appropriate "user" to determine the worth of the solution in the actual environment. Actual solutions must be implemented by the user organization.

Applications technology effort is now focused in three specific areas: public safety/service, environmental engineering, and energy management.

Principal FY 1974 efforts will involve the development of computer tools to aid student counseling, environmental programs directed toward urban air pollution monitoring and reduction, water conservation and waste processing in homesites and recreational sites, and solid waste upgrading to obtain useful products. Energy management programs will involve the development of conversion techniques for getting more useful work from the same quantity of heat energy and conservation techniques which would minimize the amount of energy required to perform certain functions.

Applications Data Systems Support

This program continues support for the Aerospace Safety Data Bank and the data management for the Earth Resources Survey program. Development of advanced information management systems to exploit and demonstrate the wider capabilities of the software developed for the Safety Data Bank for assisting in the application of technology to public needs will be continued.

The computer software (NASA Aerospace Safety Information Systems (NASIS)) developed in support of the Aerospace Safety Data Bank is a generalized information management system with an inherent capability to support a variety of other needs. Widespread interest has developed both within NASA and the technical community. At the present time, NASIS is being utilized in support of the Safety Data Bank, the ERSP program, the Carnegie-Mellon Institute and is being applied by the Food and Drug Administration (FDA) in a nationwide information handling system.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1974 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

NUCLEAR POWER AND PROPULSION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1972	1973	1974
Nuclear power.....	$9,306,000	$7,361,000	$1,000,000
Nuclear propulsion.....	17,100,000	6,455,000	---
Electrophysics.....	3,400,000	3,284,000	3,000,000
Total.....	$29,806,000	$17,100,000	$4,000,000
FY 1973 funds applied to FY 1974 Program			-4,000,000
Budget authority requested			---

Distribution of Program Amount by Installation:

Marshall Space Flight Center	$513,000	$325,000	---
Goddard Space Flight Center.	60,000	50,000	---
Jet Propulsion Laboratory...	3,445,000	2,675,000	$850,000
Ames Research Center.....	648,000	581,000	540,000
Langley Research Center.....	442,000	417,000	341,000
Lewis Research Center.....	24,276,000	12,874,000	1,924,000
NASA Headquarters.....	422,000	178,000	345,000
Total.....	$29,806,000	$17,100,000	$4,000,000

HIGHLIGHTS OF BUDGET PLAN

Research and Technology Base

Nuclear Power - Isotope Brayton technology to extend capability of radioisotopic power modules to a range from several hundred watts to a few kilowatts. Zirconium hydride reactor, thermionic reactor, and radioisotope generator programs are terminated in FY 1973.....	$9,306,000	$7,361,000	$1,000,000

	1972	1973	1974
Nuclear Propulsion - Nuclear propulsion program terminated in FY 1973 as a result of further stretchouts in NASA programs.....	$5,000,000	$6,455,000	---
Electrophysics - Plasmadynamics research applicable to both propulsion and power production, research aimed at generation, conversion, and transmission of energy at various wavelengths through space and planetary atmospheres; superconductors to achieve higher transition temperatures with resulting size, weight, and cost reductions in generation and transmission of power; and nuclear physics to bring theory closer to experiment ultimately leading to calculations of nuclear interactions.....	3,400,000	3,284,000	3,000,000
Total, Research and Technology Base.....	$17,706,000	$17,100,000	$4,000,000
Systems and Experimental Programs			
NERVA - NERVA engine development terminated in FY 1972.....	$12,100,000	---	---
Total, Systems and Experimental Programs.....	$12,100,000	---	---

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

NUCLEAR POWER AND PROPULSION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Nuclear Power program in FY 1974 will concentrate on low power dynamic conversion system technology for application to both space and terrestrial programs. Electrophysics effort will continue in FY 1974 to cover the conduct of fundamental research in the general area of molecular energy and energy conversion and transmission.

The present program planning environment emphasizes technology programs which are applicable to planned NASA missions. The continuing reappraisal of agency priorities dictates the curtailment or termination of programs which have long range potential to missions in the distant future, but are not required for missions now planned. Accordingly, the Nuclear Propulsion program and most of the Nuclear Power program will be terminated in FY 1973. This includes Nuclear Propulsion programs in solid core reactor technology and advanced nuclear propulsion concepts, such as gas core reactor propulsion and laser-ignited fusion propulsion. In the Nuclear Power area, work on systems for intermediate power levels using the zirconium hydride reactor and on higher power levels using the thermionic reactor concept have been terminated.

BASIS OF FUND REQUIREMENTS:

Research and Technology Base

	1972	1973	1974
Power research and technology.....	$9,306,000	$7,361,000	$1,000,000
Propulsion research and technology.....	5,000,000	6,455,000	---
Electrophysics research and technology.....	3,400,000	3,284,000	3,000,000
Total.....	$17,706,000	$17,100,000	$4,000,000

Power Research and Technology

The FY 1974 Nuclear Power program will consist of isotope Brayton technology. This technology development effort is directed toward extending

the basic capability provided by radioisotopic power modules to a range of from several hundred watts to a few kilowatts. The objective is a conversion system which combines a five- to ten-year life with a high conversion efficiency of 25 to 30 percent. Brayton is the only ongoing element of our technology program which has the potential to achieve such high performance. The system will use the multi-hundred watt (MHW) isotope heat source being developed by the AEC and will provide roughly four times the MHW power for about the same costs.

The current isotope Brayton program is an outgrowth of the previous Brayton cycle development effort. This effort laid the sound technological base for significant improvement in conversion system life and reliability. The FY 1974 program will continue with the design and procurement of critical experimental components for subsequent development testing.

Electrophysics Research and Technology

The electrophysics program consists of research on the physics of generation, conversion, and transmission of energy, and emphasizes fundamental ideas and novel approaches. This research has relevance to innovations in space power and propulsion to long-range transmission of power in space, to communications, and to generation and utilization of energy for terrestrial needs.

A major component of this research program is plasmadynamics which is concerned with understanding the interactions of high temperature plasmas with electric and magnetic fields. Included is research on the cause and control of instabilities and the effects of boundary layers in magneto-plasma-dynamic power generation schemes. Studies of non-equilibrium ionization are also conducted. Since intense magnetic fields are required in certain plasmadynamic apparatus, attention is given to research related to superconducting magnets, including the construction of magnets for research purposes.

Another component of electrophysics research is quantum electronics which relates to the basic science underlying lasers and the propagation of light beams through matter. New laser concepts are explored covering a wide spectrum of wave lengths. High-resolution spectrographic measurements of the atmosphere are performed, and measurements are made to determine fundamental data on reaction rates, state lifetimes and cross sections for ions, molecules, and atoms. These data are basic and universally applicable to the development and use of lasers and other devices which depend on the emission or the absorption of radiation. Research is also conducted on the interactions of high energy particles with matter.

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RESEARCH AND DEVELOPMENT

FISCAL YEAR 1974 ESTIMATES

BUDGET SUMMARY

OFFICE OF TRACKING AND DATA ACQUISITION

TRACKING AND DATA ACQUISITION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1972	1973	1974
Operations	$201,800,000	$195,700,000	$198,200,000
Equipment	50,700,000	44,131,000	42,700,000
Supporting research and technology	11,500,000	8,500,000	9,100,000
Total	$264,000,000	$248,331,000	$250,000,000

Distribution of Program Amount by Installation:

Marshall Space Flight Center	$300,000	---	---
Goddard Space Flight Center	185,530,000	$183,750,000	$182,300,000
Wallops Station	6,458,000	6,500,000	6,500,000
Jet Propulsion Laboratory	57,181,000	43,781,000	46,100,000
Flight Research Center	2,614,000	1,650,000	1,650,000
Langley Research Center	1,065,000	700,000	600,000
NASA Headquarters	10,852,000	11,950,000	12,850,000
Total	$264,000,000	$248,331,000	$250,000,000

HIGHLIGHTS OF BUDGET PLAN

Operations

Spaceflight Tracking and Data Network - Skylab, ASTP, and unmanned mission support. FY 1974 support load will average 40 satellites. Satellite Network and Manned Space Flight Network to be consolidated over several years	$111,472,000	$108,700,000	$108,200,000
Deep Space Network - Planetary and interplanetary mission support. FY 1974 workload includes Pionner 6-9, MVM'73, Pioneer 10 & G	38,798,000	32,000,000	33,700,000

	1972	1973	1974
Aeronautics and Sounding Rocket Support - Support for WS sounding rocket programs and FRC and LRC flight research programs. Covers rockets, aircraft, and lifting bodies.....	$5,343,000	$5,500,000	$5,300,000
Communications - NASA's global communications network (NASCOM) supporting all NASA and NASA-supported projects. Skylab and MVM'73 are major additions to FY 1974 requirements.....	30,768,000	32,000,000	33,000,000
Data Processing - Information processing for both real time control and analysis. Major new image data processing facility to support ERTS being operated in FY 1973 and FY 1974.....	15,419,000	17,500,000	18,000,000
Total, Operations.....	$201,800,000	$195,700,000	$198,200,000
Equipment:			
Spaceflight Tracking and Data Network - Procurement for consolidated Spaceflight Tracking and Data Network (STDN) in support of ongoing and new project requirements.....	$29,152,000	$21,000,000	$19,900,000
Deep Space Network - Procurement for network support of planetary missions; includes equipment for dual Viking s/c support in both S- and X-band mode.....	13,335,000	10,800,000	12,500,000
Aeronautics and Sounding Rocket Support - Procurement of instrumentation for sounding rocket and aeronautics program support.....	4,536,000	3,100,000	3,200,000

	1972	1973	1974
Communications - Upgrading NASCOM wideband circuit switching capability for real time control of spacecraft.....	$2,434,000	$2,431,000	$2,300,000
Data Processing - Continuing procurement of Telemetry On-Line Processing System (TELOPS) to handle increased real time data processing requirements.....	1,243,000	6,800,000	4,800,000
Total, Equipment.....	$50,700,000	$44,131,000	$42,700,000
Supporting Research and Technology			
Tracking, Orbit Determination, and Ground-Based Navigation - Improved techniques for ground-based navigation of planetary orbiters, landers, swing-by, and earth orbiter missions.....	$3,063,000	$2,150,000	$2,400,000
Spacecraft-to-Ground Communications, Telemetry, and Command-Tracking and Data Relay Satellite System (TDRSS) studies emphasizing data management and data flow integration problems. Study extension of capabilities to handle multiple spacecraft support and increasing data rates.....	4,583,000	2,940,000	3,000,000
Network Operations and Control Technology - Study automation techniques for improving real-time control techniques, and use of minicomputers for Deep Space Network.....	2,269,000	1,840,000	1,750,000
Data Handling and Processing - Definition of improved format standards. Development of processing systems for imaging data from earth resources technology satellites. Work on high data rate satellite problems.....	1,585,000	1,570,000	1,950,000
Total, SR&T.....	$11,500,000	$8,500,000	$9,100,000

OFFICE OF TRACKING AND DATA ACQUISITION

TRACKING AND DATA ACQUISITION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The purpose of this program is to provide responsive and efficient tracking and data acquisition support to meet the requirements of all NASA flight projects. The Tracking and Data Acquisition program is a direct and vital counterpart to the total flight program of NASA through which the conduct of all space flight missions is carried out. In addition to NASA flight projects, support is provided, as mutually agreed, for projects of the Department of Defense, other government agencies, and other countries and international organizations engaged in space research endeavors.

Support is provided for manned and unmanned flights; for spacecraft, sounding rockets, and research aircraft; for earth orbital and suborbital missions; for lunar and planetary missions; and for space probes.

Types of support provided include: (a) tracking to determine the position and trajectory of vehicles in space, (b) acquisition of scientific data from onboard experiments, (c) acquisition of engineering data on the performance of spacecraft and launch vehicle systems, (d) transmission of commands from ground stations to spacecraft, (e) communication with astronauts and acquisition of biomedical data on their physical condition, (f) communication of information between the various ground facilities and central control centers, and (g) processing of data acquired from the space vehicles. Such support is essential for achieving the scientific objectives of all flight missions, for executing the critical decisions which must be made to assure the success of these flight missions, and, in the case of manned missions, to insure the safety of the astronauts.

Tracking and data acquisition support is provided by a worldwide network of NASA ground stations and an instrumentation ship, supplemented by appropriate instrumented aircraft. These facilities are interconnected by a network of ground communications lines, undersea cables, high frequency radio links, and communication satellite circuits which are leased from domestic and foreign carriers and which provide the capability for instantaneous transmission of data and critical commands between spacecraft and the control centers in the United States from which the flights are directed. Facilities

also are provided to process into meaningful form the large amounts of scientific, applications and engineering data which are collected from flight projects. In addition, instrumentation facilities are provided for support of sounding rocket launchings and flight testing of aeronautical research aircraft.

The Research and Development appropriation provides funds for: (a) the operation and maintenance of the worldwide facilities; (b) the procurement of equipment to sustain and modify the systems to support continuing, new, and changing flight project requirements; and (c) the investigation and development of advanced tracking and data acquisition equipment and techniques.

BASIS OF FUND REQUIREMENTS:

The FY 1974 request reflects continuing progress in reducing support costs through a continuing increase in total system efficiency. During FY 1974, the support workload will continue at a high level with Skylab, Earth Resources Technology Satellite, and other unmanned project support constituting a significant ongoing workload. The FY 1974 request also includes funds for continuing the consolidation of the Satellite and Manned Space Flight Networks into a single Spaceflight Tracking and Data Network (STDN). This consolidation effort will take place over the next few years with the planned configuration objectives to be achieved during the period after the end of the Skylab project.

Operations

	1972	1973	1974
Spaceflight tracking and data network	$111,472,000	$108,700,000	$108,200,000
Deep space network	38,798,000	32,000,000	33,700,000
Aeronautics and sounding rocket support	5,343,000	5,500,000	5,300,000
Communications	30,768,000	32,000,000	33,000,000
Data processing	15,419,000	17,500,000	18,000,000
Total	$201,800,000	$195,700,000	$198,200,000

The total operational support workload in FY 1974 will remain relatively heavy with some cost increases for Skylab and planetary support. The operation of the two new overseas 64 meter antenna facilities along with a general increase in staffing in the Deep Space Network to handle the total planetary workload constitute the major operational impacts in FY 1974.

Spaceflight Tracking and Data Network (STDN) Operations

The consolidation of the Manned Space Flight Network (MSFN) and the Satellite Tracking and Data Acquisition Network (STADAN) continued during the past year. Once achieved, the consolidated network (STDN) will have fewer stations and a standardized support capability to support the wide variety of flight missions. The new configuration of stations and support capability is particularly important in accommodating the high data rates and near real time control requirements of upcoming missions. The consolidation is expected to be achieved during the period following the end of the Skylab program.

The STDN presently consists of land stations at nineteen locations, four advanced range instrumentation aircraft (ARIA), and one instrumented ship. The land stations are located at Fairbanks, Alaska; Goldstone, California; Cape Kennedy, Florida; Kokee Park, Hawaii; Rosman, North Carolina; Corpus Christi, Texas; Guam; Ascension Island; Canberra and Carnarvon, Australia; Bermuda; Canary Islands; St. Johns, Newfoundland, Canada; Santiago, Chile; Quito, Ecuador; Winkfield, England; Tananarive, Madagascar; Johannesburg, South Africa; and Madrid, Spain.

The station in Newfoundland is a transportable S-band station which was installed recently to provide Skylab launch support. It formerly was located on Grand Bahama Island.

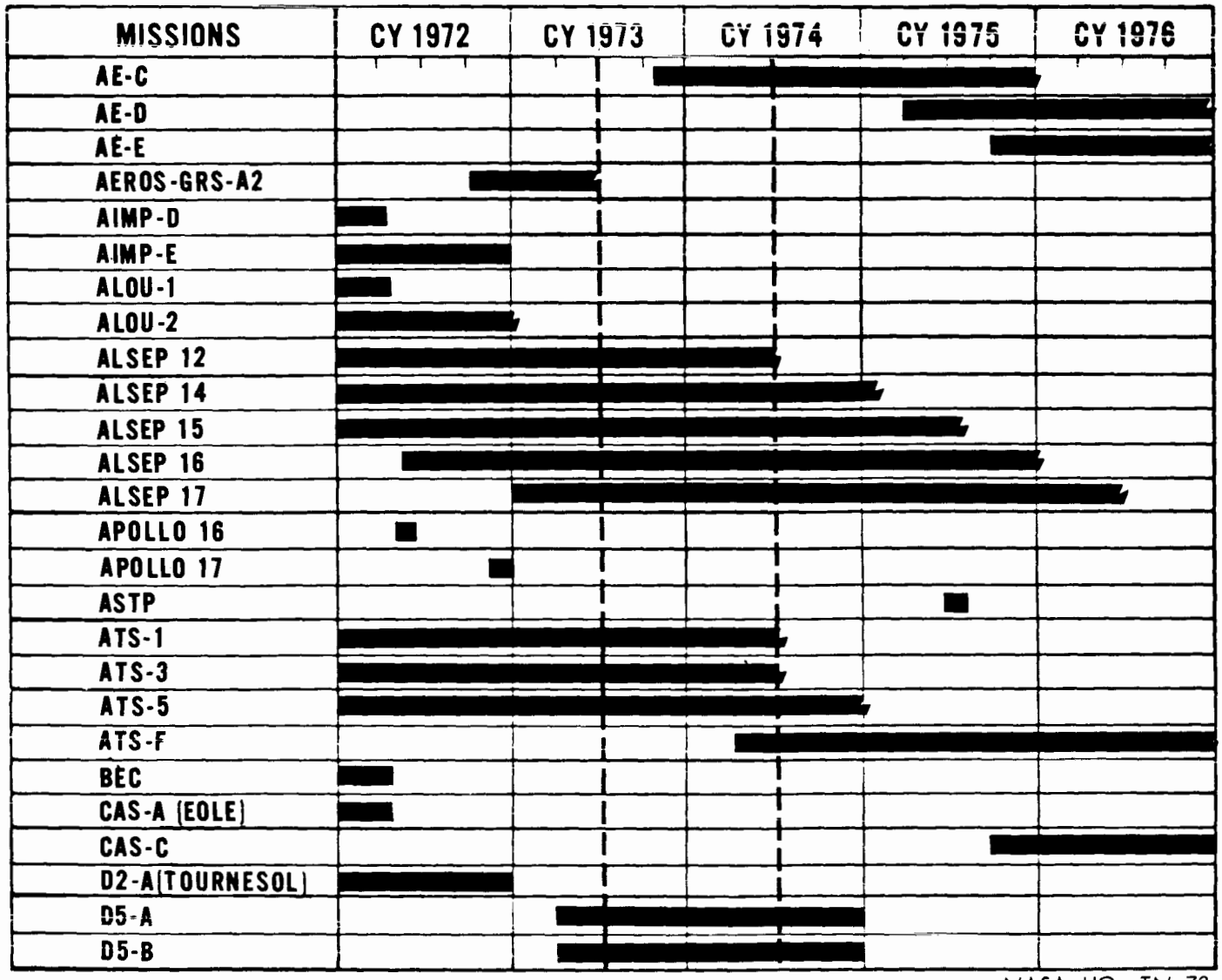
The former STADAN station at Fort Myers, Florida, was closed in June 1972. Part of the Fort Myers equipment was relocated to the former MSFN station at Cape Kennedy to provide a consolidated capability.

A transportable facility is being modified at Goldstone, California, prior to relocation to Europe for Applications Technology Satellite (ATS) F support. This facility formerly was located at Toowoomba, Australia, for support of earlier ATS spacecraft.

The STDN is supplemented by optical tracking stations operated by the Smithsonian Astrophysical Observatory. These stations provide specialized services required for precision orbital tracking.

The STDN is currently supporting the Particles and Fields Satellite left in lunar orbit by Apollo 15 and the Apollo Lunar Surface Experiment Packages (ALSEPs) left on the moon's surface by the Apollo 12, 14, 15, 16, and 17 missions. This workload will be increased substantially with the launch of the Skylab orbital workshop mission in the spring of 1973. During FY 1974, the workload will continue to be heavy with support being provided for all the

SPACEFLIGHT TRACKING AND DATA NETWORK WORKLOAD



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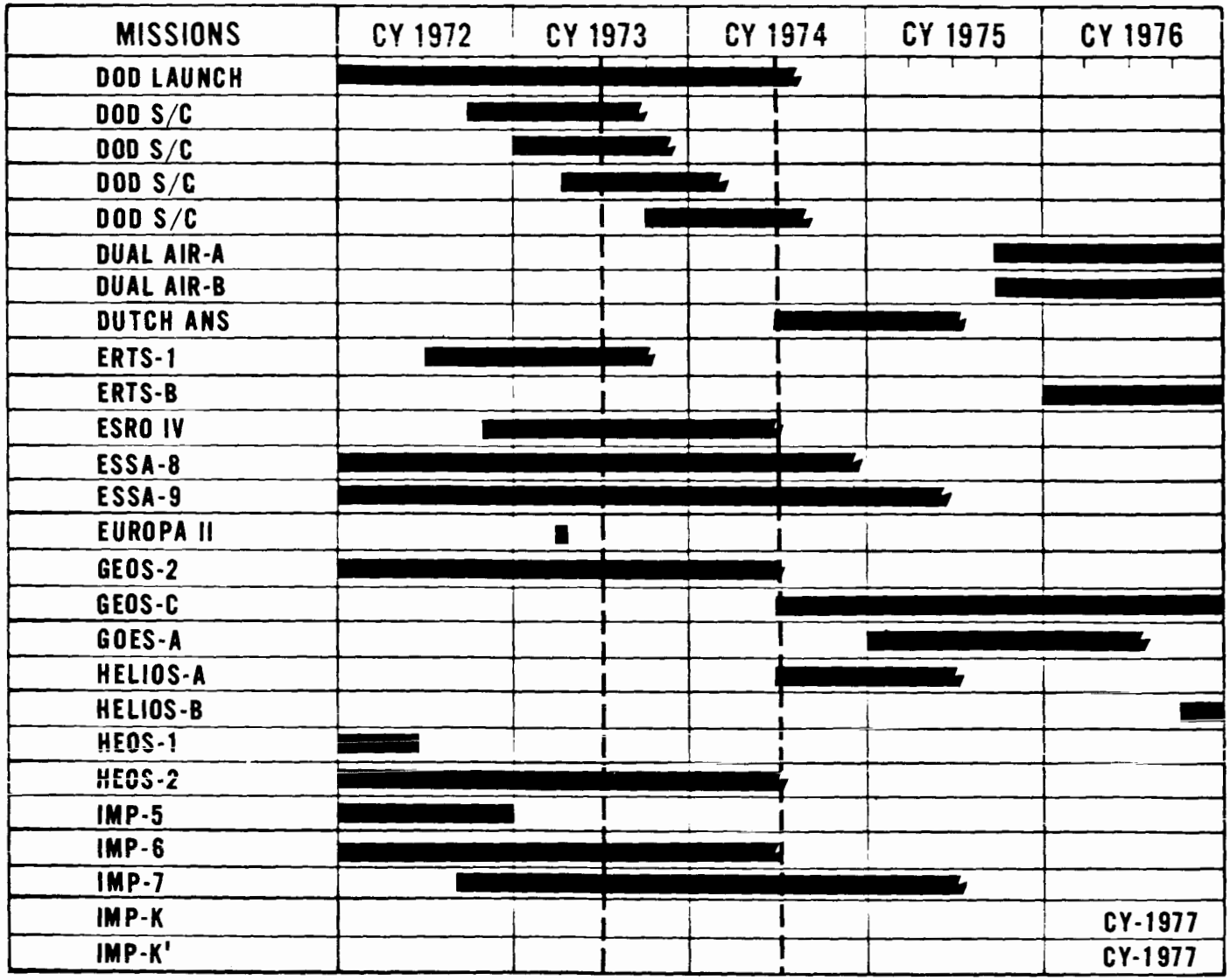
SPACEFLIGHT TRACKING AND DATA NETWORK WORKLOAD



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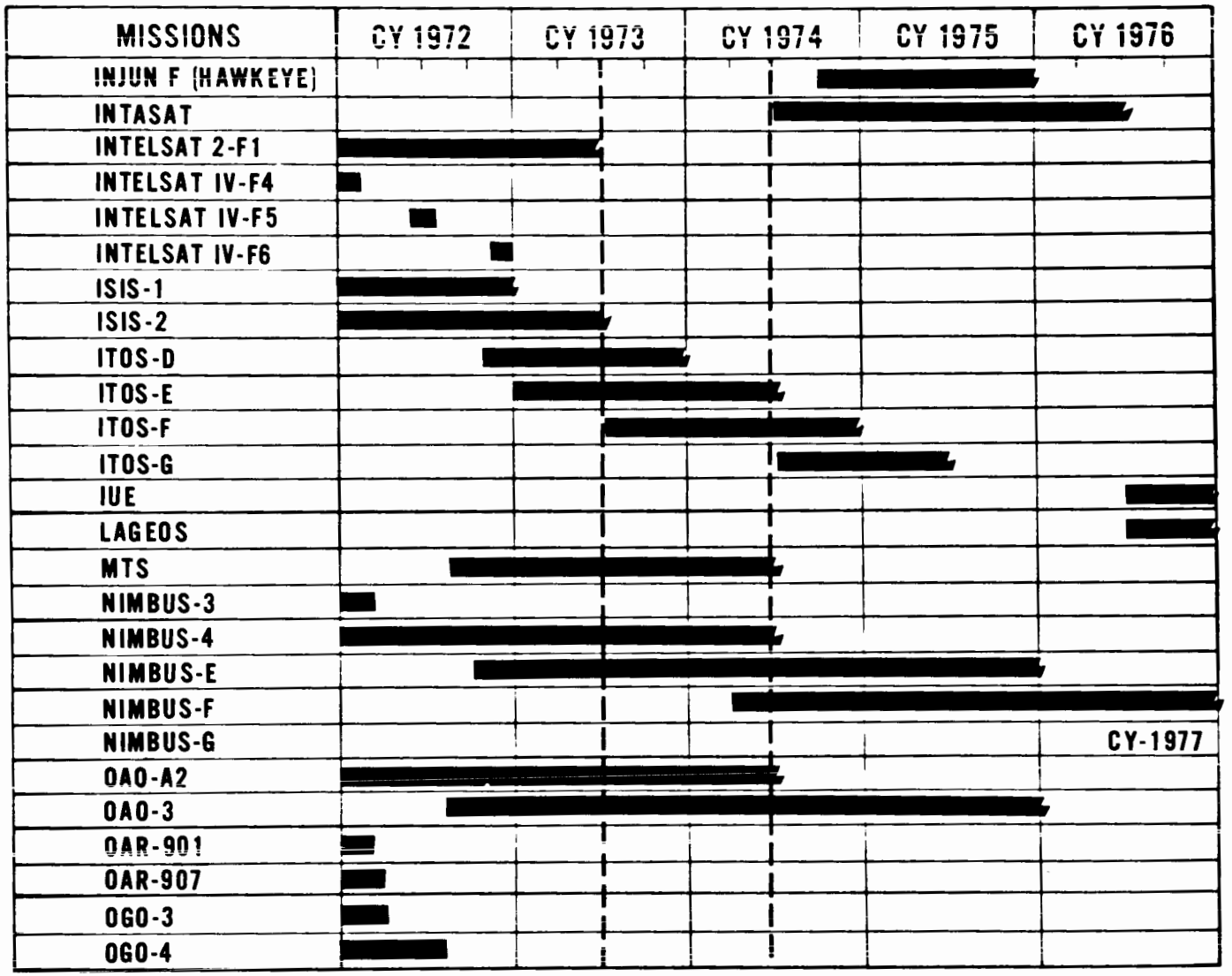

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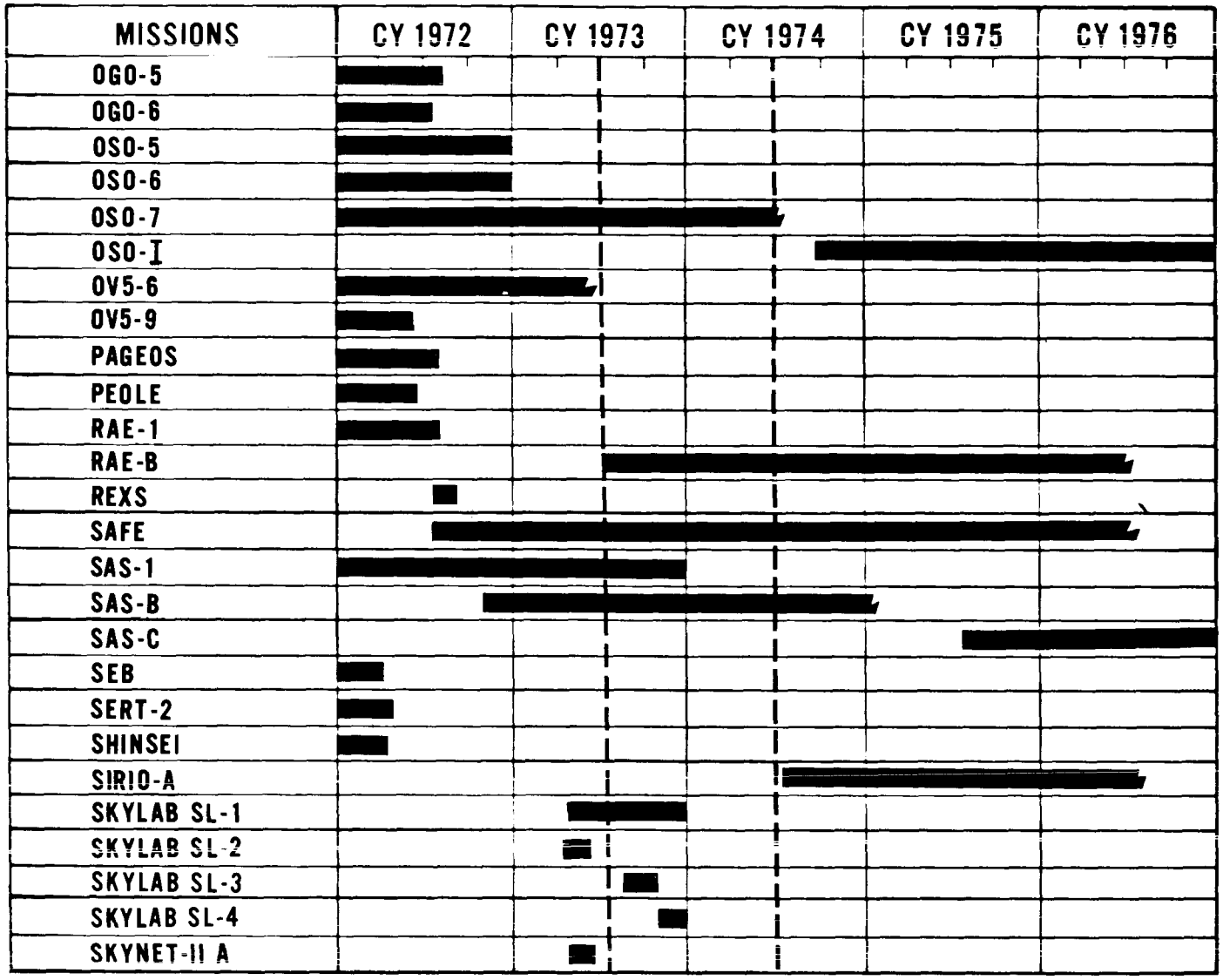

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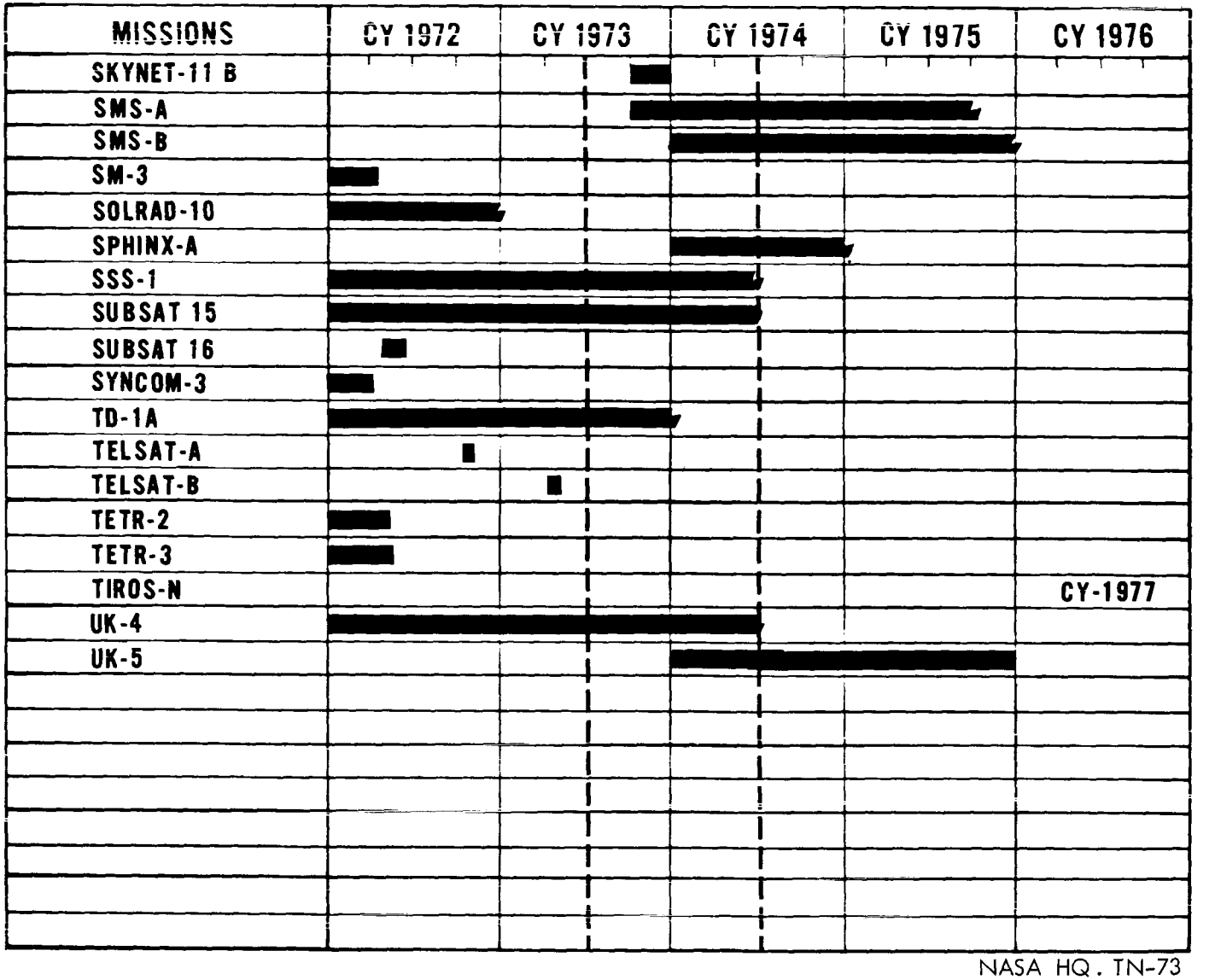

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ALSEPs still producing usable scientific data, the Particles and Fields Satellite left in lunar orbit by Apollo 15, and Skylab.

In the unmanned space flight area, the number of satellites requiring support in FY 1974 is expected to average approximately 40 satellites, and it will be necessary to make continuing adjustments in priorities of all satellites supported to assure adequate coverage within the total STDN capability. Of the new satellites to be launched, the Atmospheric Explorer-C, Radio Astronomy Explorer-B, Nimbus F, and ATS-F missions will impose a substantial workload on the network due to their unique support requirements. The overall workload for the STDN is indicated in the accompanying charts.

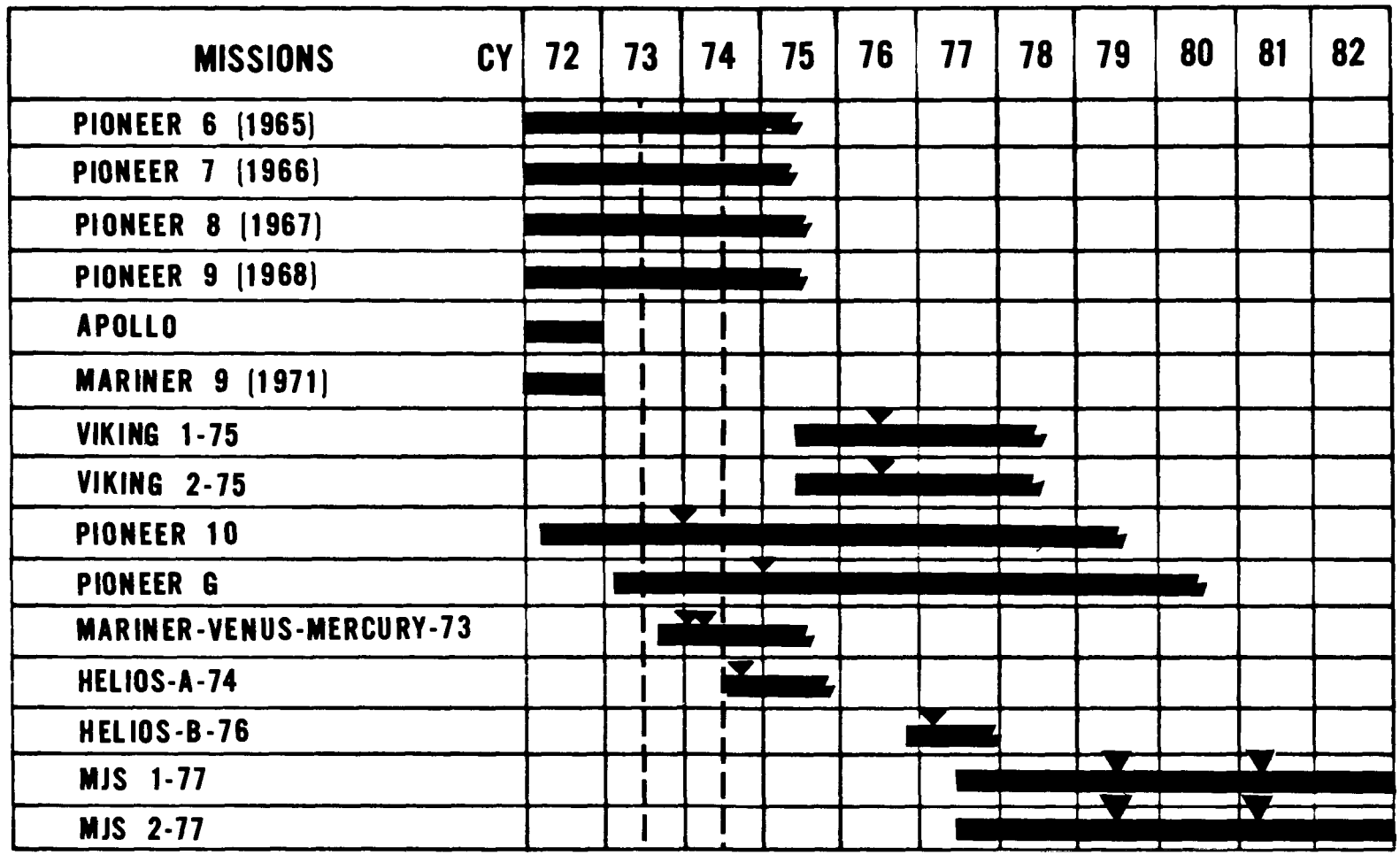
Deep Space Network Operations

The primary function of the Deep Space Network is to support planetary and interplanetary space flight missions. In the past these missions have involved spacecraft traveling to Venus and Mars, distances up to two hundred million miles from the earth. Future missions will travel to Jupiter and beyond, involving distances of six hundred million miles and greater. As a result of these great distances, the facilities in this network which receive the data must be able to perform critical functions using extremely low signal levels. As flight distances continue to increase and the missions become more complex, equipment designs and computer program techniques are required in this network which truly push the state of the art in interplanetary communications.

The Deep Space Network: (a) provides tracking data which are used to determine and make corrections and changes to spacecraft trajectories, (b) acquires engineering telemetry data for determining performance of the spacecraft, (c) transmits commands to the spacecraft, and (d) receives and records the scientific and engineering data which are acquired from the spacecraft. The network stations are located at Goldstone, California; Canberra, Australia; Madrid, Spain; Johannesburg, South Africa; and Cape Kennedy, Florida.

The control center for the Deep Space Network is the Space Flight Operations Facility (SFOF) at the Jet Propulsion Laboratory in Pasadena, California. The two basic types of functions carried out in the SFOF are network control and mission operations. In the past, both types of functions were under the management responsibility of the Office of Tracking and Data Acquisition. Actual experience over several years of supporting lunar and planetary spaceflight missions has indicated that management responsibilities would be clarified by separating the two types of functions. Accordingly, in FY 1973, the mission operations functions were transferred to the Office of Space

DEEP SPACE NETWORK
WORKLOAD



Science. Although FY 1972 funds for the mission operations functions are included in the Deep Space Network operations project, FY 1973 and FY 1974 funds are included within the total for the Lunar and Planetary program.

The two new 64 meter antenna facilities near Canberra, Australia, and Madrid, Spain, are scheduled to become operational at the beginning of FY 1974. The Deep Space Station at Woomera, Australia, was closed in December 1972 and the workload transferred to the Canberra stations.

During FY 1973 the Deep Space Network workload consists of five ongoing Pioneer spacecraft, the Mariner 9 mission, the Apollo 17 mission, and the Pioneer G mission scheduled for launch in the fourth quarter of FY 1973. The major portion of this workload, reflected in the accompanying workload chart, will continue on into FY 1974 along with the Mariner Venus/Mercury 1973 which is scheduled to be launched in the second quarter of FY 1974. For the first time, the Deep Space Network in FY 1974 will be required to support three prime interplanetary missions (Pioneer 10 and G, Mariner Venus/Mercury 1973) with essentially the same view periods and three planetary encounters (Jupiter, Venus, and Mercury). Due to the overlapping view periods of the three interplanetary missions, three separate subnets of antennas will have to be operated in the DSN.

Because of the exceptional receiving system characteristics required to communicate with distant spacecraft, the Deep Space Network facilities also provide unique support to certain ground-based radio science experiments. Support of these experiments will continue on a noninterference basis to the flight missions.

The FY 1974 request includes funds for operation of the Deep Space Network facilities in support of the continuing workload. In addition to the mission support as indicated on the workload chart, network engineering is necessary to maintain the network to meet the requirements of the Mariner Venus/Mercury 1973, Helios, Viking, and Mariner Jupiter/Saturn 1977 missions.

Aeronautics and Sounding Rocket Support Operations

Instrumentation systems are maintained and operated in support of the aeronautics and sounding rocket programs conducted by Wallops Station and the Langley Research Center in Virginia, and the flight research programs of the Flight Research Center, California. General purpose fixed and mobile tracking, telemetry, data handling, recording, timing, plotting, and communications systems are provided as well as special purpose optical equipment.

Specialized mobile telemetry and optical equipments are maintained and operated when required at selected sites along the eastern seaboard and on

Bermuda to support rocket flights from Wallops Station. Some downrange instrumentation is operated by the Langley Research Center, which also provides telemetry stations (two fixed and one mobile) in support of its aeronautical flight programs.

The mobile equipment is van-mounted and is used not only to supplement the fixed equipment at the Centers when the requirements of a particular project (e.g., solar eclipses) exceed the capacity of the installed equipment, but also is deployed to remote sites (domestic, foreign, or shipboard), to meet the geographic requirements of a particular project. In addition, ground support is provided by the Churchill Research Range in Canada on a cost-reimbursable basis.

The Flight Research Center operates the Aerodynamic Test Range, consisting of facilities at the Edwards Air Force Base and the up-range site at Ely, Nevada. These facilities are composed of precision radar tracking, telemetry, and communications equipments which are used to support high performance aircraft research and development programs of both NASA and the Air Force. Programs supported by the Aerodynamic Test Range include various aircraft and lifting body projects, including the F-111, F-104, X-24B, C5-A, YF-12, F-8, and F-15.

Communications Operations

NASA's global communications network (NASCOM) interconnects the NASA tracking and data acquisition facilities in operational support of all NASA projects and projects of other agencies that are supported by NASA. It interconnects by means of leased circuits such facilities as telemetry and command control sites, launch areas, test sites, and mission control centers. The Goddard Space Flight Center operates the network and serves as its major switching point. In the interest of economy, reliability, and full utilization of trunk circuitry, subswitching centers have been established at a number of domestic and overseas locations.

As the NASA flight missions have become more complex in terms of increased data rates and real time or near real time control, substantial advances and innovations have been required in communications technology. The use of communications satellite service and computerized switching of communication circuits are two such examples. Another example is the recently developed technique for increasing the amount of data that can be transmitted over a normal voice circuit. This technique will be used in support of Skylab which has a data transmission rate which is 50% greater than that of Apollo. These innovations have allowed for a significant increase in the communications data handling capacity of the NASCOM with a corresponding decrease in data transmission unit costs.

To maintain the high level of reliability in the NASCOM there is a continuing test program of all circuits in the network. Under this program a specific number of circuits are tested each day; the tests are analyzed and the necessary engineering and alignment are performed as necessary so that each circuit meets an acceptable level of performance. In this manner, the network operating parameters are matched against the predetermined reliability factors to ensure high performance levels.

The FY 1974 budget request provides for meeting the Skylab communications requirements as well as the requirements of all other NASA flight projects. It also includes the necessary funds for the engineering effort for sustaining the high performance levels throughout the network and for operating the various communications facilities in the U.S. and at overseas locations.

Data Processing Operations

Information received in the form of tracking and telemetry data from spacecraft must be processed into a form that is useful both to those performing the real time control of the space vehicle and those responsible for analyzing the scientific and applications data acquired by the spacecraft. Support must be given to a wide variety of programs which vary from the small Explorer satellites to the large and complex Solar and Astronomical Observatories and the Applications and Earth Resources Technology Satellites.

Tracking data are processed to provide orbital elements which are used to prepare predictions of future spacecraft positions necessary for the real time control of a spacecraft, passes of the spacecraft over the stations, and to provide precise position information that can be used by the scientific experimenters to determine where in the trajectory of the spacecraft the scientific measurements were made. Telemetry data must be processed to: (a) separate the information obtained from various scientific experiments aboard the spacecraft, (b) consolidate information from each experiment, (c) determine spacecraft attitude, and (d) correlate these measurements with the position data mentioned above. Processed data are the primary product of the spacecraft missions, and it is through reduction and analyses of these data by the experimenters that a better understanding of earth and space is achieved.

Upcoming projects require extensive premission orbit studies, including spacecraft position and attitude predictions. Studies are also required to work out operational methods and procedures to be used during the actual mission operations of these complex spacecraft.

The FY 1974 budget request is based upon the requirement to process data from previously launched satellites, plus additional satellites that are

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scheduled to be launched during the period. The scientific requirements for the acquisition and processing of data from the older satellites are under continuing review, and support has been terminated or curtailed for a number of these. These support reductions are making possible the support of new satellites, with the exception of the Earth Resources Technology Satellite (ERTS), without major increases in data processing capability.

In FY 1973, a major new image data processing facility to support ERTS was placed in operation. This facility processes the large quantities of image data received from ERTS and provides photographic products to the principal investigators for analysis. The FY 1974 request includes funds for a full year of operation for this facility.

Equipment

	1972	1973	1974
Spaceflight tracking and data network.....	$29,152,000	$21,000,000	$19,900,000
Deep space network.....	13,335,000	10,800,000	12,500,000
Aeronautics and sounding rocket support.....	4,536,000	3,100,000	3,200,000
Communications.....	2,434,000	2,431,000	2,300,000
Data processing.....	1,243,000	6,800,000	4,800,000
Total.....	$50,700,000	$44,131,000	$42,700,000

The tracking and data acquisition support requirements placed on the networks establish needs for equipment which are essential to provide ongoing support to approved programs. Funds for equipment are required to replace obsolete and worn-out items, to modify existing systems to maintain compatibility with changes in flight mission objectives and associated spacecraft instrumentation, to increase the support utilization and efficiency of existing systems, and to complete or provide new systems required to support specific flight missions of approved programs.

In FY 1974, the request includes funds for sustaining the existing capability of networks along with equipment additions to meet the requirements of upcoming planetary programs (Pioneer G, Mariner Venus/Mercury 1973, Helios, and Viking). Also included in the request are funds for the continuing effort to provide a standard network configuration for support of the advanced post-Skylab earth satellite missions such as Nimbus F, International Ultraviolet Explorer, and Atmosphere Explorers D&E. To accommodate the increasing data handling and real time control requirements, funds are included in the FY 1974 request for the phased procurement of a telemetry on-line processing system.

Spaceflight Tracking and Data Network Equipment

The Spaceflight Tracking and Data Network (STDN) equipment program encompasses the procurement of equipment and services necessary: (a) to sustain the network's continuing capability for reliable support to ongoing manned space flight and unmanned scientific and applications satellite missions, (b) to meet new program support requirements for new spacecraft, and (c) to continue to effectively consolidate and standardize the capabilities of the former Satellite and Manned Space Flight Networks to assure efficient tracking, command, and data acquisition support for all earth orbital and synchronous missions in the post-Skylab period.

During FY 1974, the network will continue to support approximately 40 spacecraft on an around-the-clock basis, including many missions with highly complex operational support requirements - Skylab, the Earth Resources Technology Satellite, as well as the new Atmospheric Explorer-C, Radio Astronomy Explorer-B, and Synchronous Meteorological Satellites. To maintain the network's required high level of performance for support of this diverse and demanding workload, a continuing equipment modification effort is required in FY 1974 to maintain the quality and reliability of the network's systems and subsystems. Accordingly, funds are requested for replacement of failure prone systems with more reliable units, for equipment modifications to correct operational deficiencies, and for equipment to be used in operational control of the network. Funds are also requested for provision and modification of test equipment and for minor equipment modifications resulting from changes in support requirements from one mission to the next.

Additions or modifications to network station systems will be completed in FY 1974 to support the Nimbus F and Atmospheric Explorer-C spacecraft. In addition, control center capabilities to support new missions will be augmented, including systems to increase multimission support capability. These augmentations include the expansion of display systems for flight maneuver operations control to meet increased real time attitude and orbit determination for missions including Atmospheric Explorer and the Synchronous Meteorological Satellite for injection into synchronous orbit. In addition, the control center for the Atmospheric Explorer-C spacecraft will be completed. Major pieces of equipment for this center were purchased in FY 1972 and FY 1973. In FY 1974, these pieces of equipment will be installed and checked out to ensure their proper operation for critical real time support of that series of missions.

In FY 1974, it is planned to augment and improve the accuracy of existing laser systems. Very precise tracking systems are a requirement to meet the objectives of the GEOS-C and LAGEOS missions as well as the San Andreas Fault Experiment (SAFE).

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Funds are requested in FY 1974 to continue the standardization and simplification of network systems initiated in FY 1973 as part of a phased plan to combine the most technologically advanced capabilities of the former Manned Space Flight and Satellite Networks. Under this plan, the best features of the tracking, telemetry, command, and data handling systems which have so successfully supported the Apollo program are being combined with the capabilities developed for support of NASA's unmanned scientific satellite projects to assure efficient support for post-Skylab missions such as GEOS-C, Orbiting Solar Observatory-I, the Apollo Soyuz Test Project, the International Ultraviolet Explorer, and other space science and applications programs.

As a part of this plan, effort has been initiated to broaden the transmitting capability of the Apollo unified S-band system and to simplify and standardize its ranging equipment to enable all network stations to support both manned and unmanned missions. This effort will continue in FY 1974. Additionally, work will be initiated in FY 1974 to modify the telemetry and command data processing systems in former Manned Space Flight Network stations for compatibility with unmanned spacecraft. Implementation of these modifications will assure the capability for support of scientific and applications spacecraft at all STDN stations and will provide the flexibility needed to encompass the majority of new project command and telemetry processing requirements with only minor modular additions and modifications.

This plan for consolidation of Manned Space Flight and Satellite Network systems is phased for completion in the post-Skylab period. On completion, the network's equipment configuration should provide the necessary flexibility for earth orbital flight project support and permit economies in network operations, logistics and software costs.

Deep Space Network Equipment

During FY 1974, the Deep Space Network will provide extensive flight and prelaunch support to a large family of planetary and interplanetary missions. Included in this heavy support workload are the still active Pioneer spacecraft launched during and prior to 1968, the Jupiter bound Pioneer 10 spacecraft, as well as the upcoming Pioneer G and Mariner Venus/Mercury missions. Equipment augmentation and network systems support will be continued at the minimum required level to assure uninterrupted tracking and data reception operations to these ongoing missions, and at the same time provide new network system capabilities for approved planetary missions, in particular the multispacecraft Viking 1975 mission. Funds requested in FY 1974 will allow the needed continuity in time-phased equipment procurements initiated in prior years and for other modifications necessary to complete the network configuration required for support of these missions.

Viking mission support will require a number of additional new capabilities to enable simultaneous reception, commanding and data handling of the multiple channels associated with the combined dual Mars orbiters and landers. Increased numbers of receivers at the three 64 meter antenna stations to receive up to three telecommunication downlink signals will be procured. These receivers, of new design, will be capable of receiving simultaneously both the S- and X-band frequencies to be transmitted by the Viking orbiter spacecraft, as well as the separate S-band lander communications link. This new generation design will also provide the Deep Space Network with the needed additional performance to assure support to the more complex and demanding missions planned to go to the outer planets, typified initially by the dual Mariner spacecraft to Jupiter and Saturn in 1977. In order to handle the additional Viking telemetry channels resulting from the increased number of downlink signals, additional telemetry and data systems will be required to handle the much higher frequencies of the improved performance X-band system.

Funds are also requested in FY 1974 to complete augmentation of the microwave and maser subsystems for X-band reception at the overseas 64 meter stations which are presently capable of S-band operations only. High power S-band transmitter modifications initiated in FY 1973 will also be completed to allow dual uplink commanding of the Viking spacecraft. This increased transmission power will be necessary to overcome the increased communication distances associated with the commanding and ranging to outer planet spacecraft.

The FY 1974 funds requested to support the ongoing flight missions are required to maintain the existing network systems reliability and operational integrity. The time-critical demands placed on the network by the various planned and unplanned mission events associated with planetary encounters, and trajectory and attitude maneuvers necessitate that failure-prone and obsolete support equipment modules be replaced.

Additionally, in order to assure that reliable network performance is achieved and that data provided to the flight mission teams is properly validated and available within required periods for inflight decision-making operations, additional network control and data flow equipment will be provided for the network control and monitoring system. FY 1974 funds are requested to provide this additional capability to be operational for the Viking time period.

Aeronautics and Sounding Rocket Support Equipment

A wide variety of fixed and mobile equipment is used to provide instrumentation support of sounding rockets and re-entry vehicles launched from Wallops Station and other locations and for aeronautical flight research projects conducted by the Flight Research Center and Langley Research Center.

To provide instrumentation support compatible with range users' requirements for research tests conducted at Wallops Station and at remote sites using mobile equipment, maintenance and spare parts must be provided, as well as non-recoverable flight hardware, such as onboard antennas, transponders, and power supplies. To meet specific test requirements, augmentation of selected telemetry, communications, command, and data handling systems is required. In addition, mobile radar and telemetry equipment will be refurbished and updated to meet the requirements of the Western Hemisphere Meridional Network Project, a joint Argentine-Brazil-United States effort implementing a US/USSR agreement in the field of meteorology.

Telemetry ground stations are operated by the Langley Research Center to support aeronautical research programs. The aircraft used in these programs are flown from the Wallops and Langley airfields. Funds are requested in FY 1974 to procure specialized checkout and display equipments which are necessary to adapt the ground stations to the requirements of specific flight missions.

The Flight Research Center's Aerodynamic Test Range consists of stations at Edwards, California, and Ely, Nevada, which support various aircraft and lifting body projects, such as the F-111, F-104, X-24B, C5-A, YF-12, F-8, and F-15.

Communications Equipment

The purpose of the NASA Communications Network (NASCOM) is to provide cost-effective and reliable communications between tracking sites, launch areas, and control centers in support of all NASA programs. The FY 1974 request includes the necessary funds for the procurement of equipment to maintain the integrity and reliability of the NASCOM network. It also includes funds for the procurement of equipment to improve the efficiency of the network.

In FY 1974, plans provide for the procurement of a matrix switching capability at Goddard for centralized switching of wideband circuits coming into and within the continental U.S. This will allow for more effective utilization of wideband circuits by allowing for rerouting and sharing of such circuits by users in near real time. Funds are also requested for the associated quality monitoring and control equipment for the matrix switch.

As in previous fiscal years, funds are required to sustain the network in a highly reliable condition through equipment replacement, repairs, and modifications. To ensure a continuing high level of performance, equipment is necessary for circuit quality monitoring and testing, circuit analysis, facility performance, and error detection.

Data Processing Equipment

In FY 1974, funds are requested to complete procurement of the Telemetry On-Line Processing System (TELOPS) which was initiated in FY 1973. The TELOPS is designed to meet the data processing requirements of future spacecraft which are characterized by greater volume and increased need for data in real time (or near real time). Neither of these requirements can be met economically by the expansion of the present data processing facility.

The new system includes an input processor and a mass storage device, both operating with existing large scale computers. The input processor will receive, quality check and store data which has been forwarded from the Station Data Acquisition and Control systems (STADAC) currently being implemented at STDN stations. The mass storage device will contain on-line approximately one year's worth of telemetry data which has been acquired by NASA's scientific and application flight missions. This stored data can be extracted both for real time mission operations purposes as well as for near real time applications, such as scientific analysis.

The TELOPS concept will also result in operational efficiencies by reducing the amount of data which is actually processed and the amount of magnetic tape purchased, along with the associated handling costs.

FY 1974 funds are also requested to maintain the existing data processing systems which are operated 18 hours per day. Obsolete and worn-out equipment must be replaced, and normal sustaining items such as heads for tape decks and cathode ray tubes must be purchased.

Supporting Research and Technology

	1972	1973	1974
Tracking, orbit determination, and ground-based navigation..	$3,063,000	$2,150,000	$2,400,000
Spacecraft/ground communications, telemetry and command.	4,583,000	2,940,000	3,000,000
Network operation and control technology.....	2,269,000	1,840,000	1,750,000
Data handling and processing...	1,585,000	1,570,000	1,950,000
Total.....	$11,500,000	$8,500,000	$9,100,000

The objective of the Supporting Research and Technology (SRT) program is to conduct studies and developments of tracking and data acquisition systems and techniques required to provide new and improved network and data processing capabilities to meet the needs of future missions, and to improve the cost-

effectiveness and reliability of the overall T&DA support for the total mix of NASA flight missions. Program effort is consolidated into four basic areas under which major activities planned for FY 1974 are as follows:

Tracking, Orbit Determination, and Ground-Based Navigation

New tracking instrument capabilities and measurement techniques will continue to be developed to meet the more stringent tracking and ground-based navigation needs of future missions. These needs apply particularly to planetary orbiters and landers, as well as to outer planet gravity-assisted swing-by missions, all of which impose more stringent requirements for extremely accurate tracking and trajectory determination data. The geodesy and earth and ocean physics programs also require significant improvements in tracking accuracies and orbit determination techniques.

Spacecraft-to-Ground Communications, Telemetry, and Command

Studies and developments to extend the capabilities of the space-to-ground telecommunication links will continue in FY 1974. In earth orbital mission support, improved telemetry capabilities are required to handle data rates of 30 to 50 million bits per second, and higher, for high resolution imaging data from earth observation spacecraft. For planetary missions, continuing developments are required to meet the needs of the more complex future missions. For example, special telemetry systems making use of new modulation and signal coding techniques are needed to overcome the communications constraints associated with the planetary atmospheres. Similar developments are needed to extend communications and command capabilities for other types of planetary missions.

Tracking and Data Relay Satellite System (TDRSS) studies will define the systems characteristics, including operational control and data handling requirements for implementation of a TDRSS system using two synchronous satellites. Effort in FY 1974 will also include the development of spacecraft electronics systems and antenna operating techniques to achieve adequate gain and discrimination against interfering signals (RFI). Work will continue on ground station system preliminary design and on user spacecraft communication system design techniques required for multiuser tracking and data acquisition support via TDRSS.

Network Operations and Control Technology

Effort will continue on techniques for centralized control and monitoring of tracking and data acquisition support operations, both at the stations and their respective network control centers. The aim is improved efficiency and effectiveness in the utilization of the overall network system. Features for automated monitoring and control will be examined and developed for those

applications which are determined to be cost-effective and necessary to meet real time operations requirements. For example, the use of stand alone mini-computers for functional control of network subsystems is proving to be an economical way to increase station efficiency and reduce mission-to-mission turn around time. In FY 1974, this effort will be extended to include automation of network control center functions in both the Deep Space Network and the Spaceflight Tracking and Data Network.

Data Handling and Processing

Studies and development will continue relating to data handling and data processing systems and techniques to meet the increasing requirements for real time mission control and user-interactive information systems. These activities will be concerned particularly with the problems of high rate, on-line data handling, storage, and retrieval. Techniques and systems also will be explored for a fully digital approach to handling and processing of imaging data from earth observation satellites.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1974 ESTIMATES

BUDGET SUMMARY

OFFICE OF INDUSTRY AFFAIRS AND TECHNOLOGY UTILIZATION

TECHNOLOGY UTILIZATION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1972	1973	1974
New technology identification, evaluation and publication.....	$950,000	$675,000	$720,000
New technology dissemination.....	1,180,000	1,125,000	1,125,000
Technology applications.....	2,370,000	1,790,000	1,755,000
Program evaluation and benefits....	500,000	410,000	400,000
Total.....	$5,000,000	$4,000,000	$4,000,000
Distribution of Program Amount by Installation:			
NASA Headquarters.....	$5,000,000	$4,000,000	$4,000,000

HIGHLIGHTS OF BUDGET PLAN

	1972	1973	1974
New Technology Identification, Evaluation and Publication Identify and evaluate new technology; publish and distribute Tech Briefs, technical support packages, and other special publications.....	950,000	675,000	720,000
New Technology Dissemination Effect the transfer of aerospace technology results to industrial and public sector users; operation of regional user-oriented transfer services, including an increased emphasis on technology transfer service for State and local government units.....	1,180,000	1,125,000	1,125,000

	1972	1973	1974
Technology Applications Identify public sector problems solvable by aerospace technology; operation of biomedical and technology application teams; application of aerospace technology to public sector needs and increased emphasis on State government oriented problems, including user conferences.....	$2,370,000	$1,790,000	$1,755,000
Program Evaluation and Benefits Analysis, improvement and implementation of technology transfer methods, assess economic benefits of aerospace technology.....	500,000	410,000	400,000

OFFICE OF INDUSTRY AFFAIRS AND TECHNOLOGY UTILIZATION

TECHNOLOGY UTILIZATION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION

The Technology Utilization program transfers the new knowledge and innovative technology resulting from NASA's aeronautical and space research and development program for applications in industry, medicine, and such publicly important areas as transportation, urban development, environmental protection, and safety. Developing multiple uses of the nation's aeronautical and space developed technology via the Technology Utilization program provides an additional return to the public on its investment in NASA's research and development efforts.

The primary objectives of the NASA Technology Utilization program are: (1) to increase the return on the national investment in aerospace research and development by encouraging additional uses of the knowledge gained in those programs; (2) to shorten the time gap between the discovery of new knowledge and its effective widespread use; (3) to move new knowledge across industry, disciplinary, and geographical boundaries; and (4) to develop better means of transferring technology from its points of origin to its points of potential use.

In FY 1974 the emphasis of the Technology Utilization program will be to shorten the time between the development of new technology and its useful application into the market, particularly in those areas of public concern for which technological contributions fulfill a currently unmet need. Efforts will be increased in applying technological solutions to significant public sector needs for demonstration of utility and eventual adaptation in the marketplace.

SUMMARY OF RESOURCES REQUIREMENTS

	1972	1973	1974
New technology identification, evaluation and publication.....	$950,000	$675,000	$720,000
New technology dissemination.....	1,180,000	1,125,000	1,125,000
Technology applications.....	2,370,000	1,790,000	1,755,000
Program evaluation and benefits.....	500,000	410,000	400,000
Total.....	$5,000,000	$4,000,000	$4,000,000

BASIS OF FUND REQUIREMENTS:

New Technology Identification, Evaluation and Publication

In response to the requirements of Section 305(b) of the Space Act, the Technology Utilization officers at all NASA installations identify NASA-sponsored scientific and technical endeavors of potential utility to the nonaerospace sector of the economy. New advances so identified--in such diverse fields as nondestructive testing, cryogenics, laser applications, and human factors engineering--are published in Tech Briefs, Compilations, Handbooks, and Reports.

New Technology Dissemination

Six Regional Dissemination Centers, largely operated by universities, transfer aerospace technology to large and small industrial firms. These centers employ computerized search-and-match techniques resulting in the identification and transfer of aerospace technology directly relevant to the industrial client's technical needs.

During FY 1974, particular emphasis will be placed on location and development of manufacturing, production, and marketing for technical developments resulting from NASA patents and applications engineering projects and related public sector product development activities.

Based on experience in FY 1972 and 1973 in working with economic growth and development programs of other agencies, limited experimental efforts to provide technical information, conferences, and technology transfer services to State and local governments will be undertaken on a cost-sharing basis.

In addition, software for selected computer programs developed in the course of R&D performed for NASA and other government agencies will be made available to industry, government and other interested users through the Computer Software Management and Information Center (COSMIC).

Technology Applications

NASA-sponsored public sector Applications Teams assist groups concerned with medical technology, environmental pollution, urban affairs and public safety in the definition of problems to whose solution NASA aeronautical and space developed capabilities will contribute.

Particular emphasis will be placed on technology applications projects related to State and regional needs. Supporting activities such as user oriented conferences will be provided to insure requirement/solution matches.

Selected projects will be sponsored to perform the necessary applications engineering. Such projects are required to demonstrate the effectiveness and applicability of the technology to specific public sector needs. Encouragement, such as patent licenses and patent waivers where appropriate, will be given to private contractors to further develop technological solutions and public sector markets so that benefits will be widely available throughout the economy.

Program Evaluation and Benefits

The effect of such factors as time lag, technology characteristics and the structure of the industry on the effectiveness of technology transfer will be evaluated. Instances of effective transfer will be documented.

Other studies to analyze and document impacts and benefits of NASA R&D programs will be conducted through close liaison with other NASA program and staff offices. These will include both impacts on technology in current industrial practice, as well as the implications of aerospace technology on increased national capabilities stated in terms of productivity and economic growth and change. Such efforts will include development of exhibit materials, conference coordination, and development of material for use by the communications media.

U. S. GOVERNMENT PRINTING OFFICE : 1973 O - 491-314