National Aeronautics and Space Administration

BUDGET ESTIMATES

FISCAL YEAR 1975

Volume I

AGENCY SUMMARY

RESEARCH AND DEVELOPMENT

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1975 ESTIMATES

AGENCY SUMMARY AND RESEARCH AND DEVELOPMENT

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1975 ESTIMATES

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 $3,247,129,000 are requested for FY 1975 to support the program described in these justifications. The budget plan by appropriation is summarized below.

BUDGET PLAN SUMMARY

	(Thousands of Dollars)		
	1973	1974	1975
Obligational Authority			
Research and development.....	$2,488,475	$2,305,000	$2,346,015
Construction of facilities.....	78,725	101,100	151,490
Research and program management.....	721,783	744,786	749,624
TOTAL, BUDGET PLAN.....	$3,288,983	$3,150,886	$3,247,129
TOTAL, OUTLAYS.....	$3,315,163	$3,179,200	$3,274,900

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

BUDGET SUMMARY

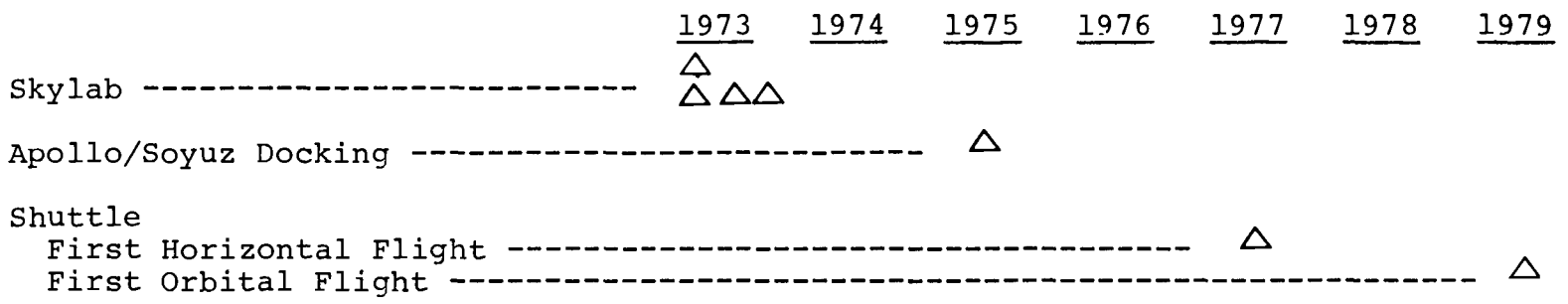
Research and Development	Budget Plan FY 1973	FY 1974	FY 1975
MANNED SPACE FLIGHT.....	1,135,775,000	1,056,500,000	1,124,800,000
Space shuttle.....	198,575,000	475,000,000	800,000,000
Space flight operations..	879,000,000	580,000,000	323,300,000
Advanced missions.....	1,500,000	1,500,000	1,500,000
Apollo.....	56,700,000	---	---
SPACE SCIENCE.....	679,169,000	602,000,000	547,015,000
Physics and astronomy....	126,200,000	94,000,000	140,515,000
Lunar and planetary exploration.....	331,969,000	333,000,000	266,000,000
Launch vehicle procurement.....	221,000,000	175,000,000	140,500,000
APPLICATIONS.....	188,700,000	161,000,000	177,500,000
Space applications.....	188,700,000	161,000,000	177,500,000
AERONAUTICS AND SPACE TECHNOLOGY.....	232,500,000	237,000,000	241,200,000
Aeronautical research and technology.....	150,640,000	168,000,000	166,400,000
Space and nuclear research and technology.....	81,860,000	69,000,000	74,800,000
TRACKING AND DATA ACQUISITION.....	248,331,000	244,000,000	250,000,000
TECHNOLOGY UTILIZATION.....	4,000,000	4,500,000	5,500,000
TOTAL RESEARCH AND DEVELOPMENT.....	2,488,475,000	2,305,000,000	2,346,015,000
Construction of Facilities.	78,725,000	101,100,000	151,490,000
Research and Program Management.....	721,783,000	744,786,000	749,624,000
TOTAL.....	3,288,983,000	3,150,886,000	3,247,129,000
TOTAL OUTLAYS.....	3,315,163,000	3,179,200,000	3,247,900,000

National Aeronautics and Space Administration

MANNED SPACE FLIGHT

- o Interpret and apply scientific and technological data from Skylab:
  - --Solar
  - --Earth Resources
  - --Biomedical
  - --Future Mission Planning
- o Promote international cooperation in space
  - --Apollo/Soyuz Docking Mission with USSR
  - --Spacelab Development by Europe
- o Develop Space Shuttle Transportation System
  - --Routine Access to Space for Man and Machinery
  - --Economical Transportation Costs
  - --Economical Payload Costs

MAJOR FLIGHT ACTIVITY

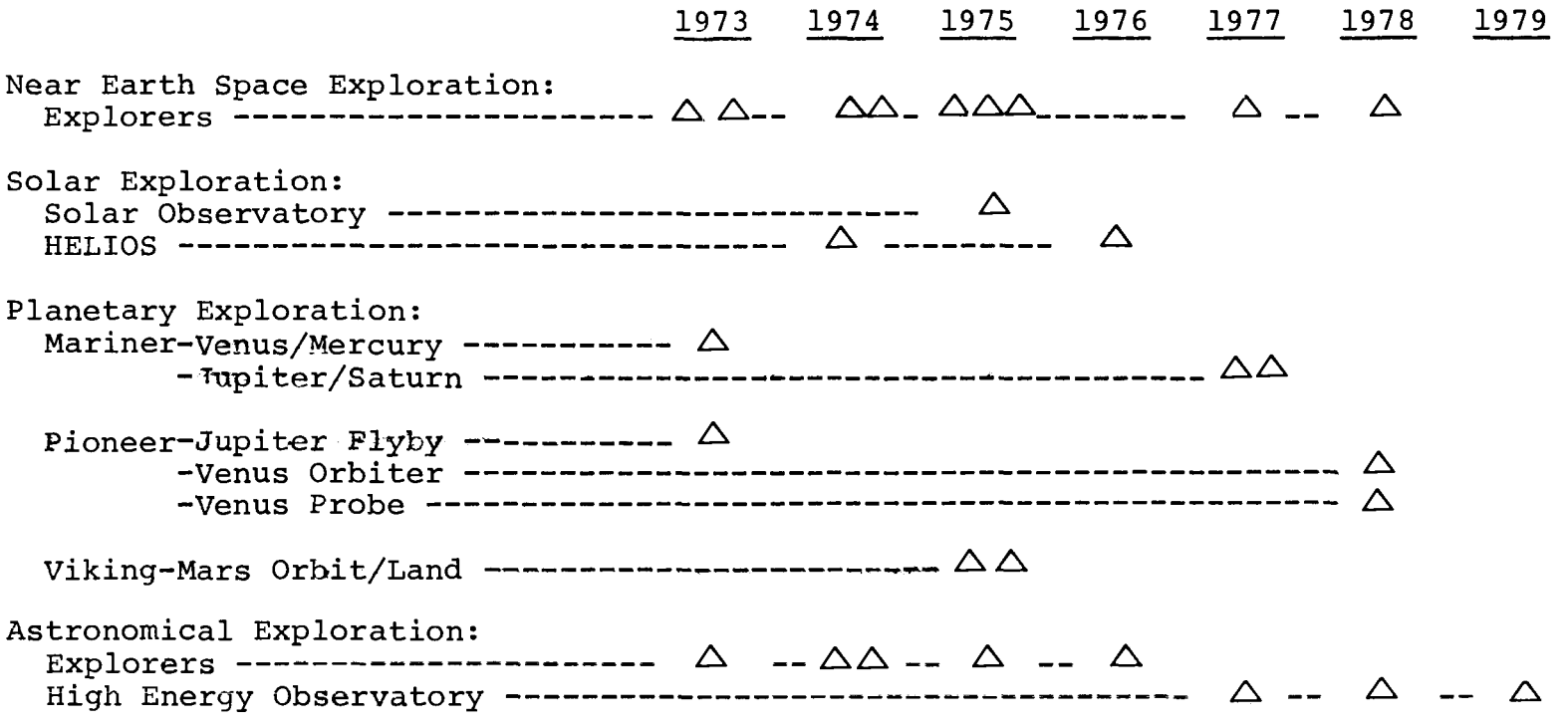


National Aeronautics and Space Administration

SPACE SCIENCE

- o Extend the current state of knowledge in space sciences through a balanced program of new exploratory missions and ground-based investigations
- o Exploit the knowledge gained from current and completed program efforts by thorough analysis and interpretation of the scientific data obtained

MAJOR FLIGHT ACTIVITY



National Aeronautics and Space Administration

SPACE APPLICATIONS

o Develop and demonstrate practical uses of space and space technology.

MAJOR FLIGHT ACTIVITY

	1973	1974	1975	1976	1977	1978	1979
Weather and Climate:							
NIMBUS-F		△					
Synchronous Meteorological		△△					
TIROS					△		
Pollution Monitoring:							
NIMBUS-G						△	
Earth Resources Survey:							
ERTS			△				
Heat Capacity Mapping Mission					△		
Earth and Ocean Physics:							
GEOS		△					
LAGEOS				△			
SEASAT						△	
Communications:							
ATS		△					
CAS			△				

National Aeronautics and Space Administration

AERONAUTICS

- For civil and military aircraft:
  - --Improved Performance
  - --Reduced Energy Requirements
  - --Reduced Environmental Effects

MAJOR PROGRAMS

- --Quiet, Clean, STOL Experimental Engine
- --JT8D Refan
- --Rotor Research Aircraft
- --Quiet Propulsive Lift Technology
- --Supersonic Cruise Technology

National Aeronautics and Space Administration

SPACE AND NUCLEAR TECHNOLOGY

- o Provide a technology base for future space activities
  - --Advanced Spacecraft and Spacecraft Systems Materials and Structures
  - --Improved Chemical and Electric Propulsion
  - --High-Reliability Electronics
  - --Improved Thermal Design for Spacecraft
  - --Efficient Nuclear and Non-Nuclear Power Systems

National Aeronautics and Space Administration

TRACKING AND DATA ACQUISITION

- Worldwide networks of ground stations, an instrumentation ship, and instrumented aircraft interconnected with highly reliable communications to provide support to:
  - --Manned Missions - Apollo/Soyuz Test Project
  - --Automated Earth Orbiting Missions - 35-40 Active Satellites
  - --Planetary Missions
  - --Sounding Rockets
  - --Research Aircraft

TECHNOLOGY UTILIZATION

- Accelerate the dissemination of scientific and technical information generated by the conduct of the Space and Aeronautics programs.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1975 ESTIMATES

SUMMARY OF APPROPRIATIONS

	(Thousands of Dollars)		
	1973	1974	1975
Appropriations	PL 92-383	PL 93-137	Request
Research and Development	$2,600,900	$2,194,000	$2,346,015
Construction of Facilities	77,300	101,100	151,490
Research and Program Management	729,450	744,786	749,624
Basic appropriation	(729,450)	(707,000)	(749,624)
Proposed supplemental for civilian pay raises	---	(37,786)	---
Total	$3,407,650	$3,039,886	$3,247,129

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1975 ESTIMATES

SUMMARY RECONCILIATION OF APPROPRIATIONS TO BUDGET PLANS
(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
Transfers between appropriations	---	-1,425	1,425	---
Total Adjusted Appropriation (Budget Authority)	3,407,635	2,599,475	78,725	729,435
1973 funds applied to 1974 program plan	-111,000	-111,000	---	---
Unobligated balance lapsing	-7,652	---	---	-7,652
Total Budget Plan	$3,288,983	$2,488,475	$78,725	$721,783
Fiscal Year 1974				
Appropriation, PL 93-137	$3,002,100	$2,194,000	$101,100	$707,000
Proposed supplemental for civilian pay raises	37,786	---	---	37,786
Total Adjusted Appropriation (Budget Authority)	3,039,886	2,194,000	101,100	744,786

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1975 ESTIMATES

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

Fiscal Year 1974 (Cont'd)	Total	Research and Development	Construction of Facilities	Research and Program Management
1973 funds applied to 1974 program plan.....	+111,000	+111,000	---	---
Total Budget Plan.....	$3,150,886	$2,305,000	$101,100	$744,786
Fiscal Year 1975				
Appropriation request (Total Budget Plan)...	$3,247,129	$2,346,015	$151,490	$749,624

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1975 ESTIMATES

SUMMARY OF APPROPRIATION BUDGET PLANS BY INSTALLATION

(In millions of dollars)

Installation	Research and Development			Construction of Facilities			Research and Program Management			Total		
	1973	1974	1975	1973	1974	1975	1973	1974	1975	1973	1974	1975
Johnson Space Center	490.0	641.9	812.7	10.1	---	---	91.1	94.5	96.7	591.2	736.4	909.4
John F. Kennedy Space Center, NASA	188.2	109.9	113.4	.6	---	.9	110.6	116.9	118.2	299.4	226.8	232.5
Marshall Space Flight Center	474.8	331.3	295.9	---	---	4.1	137.2	140.3	131.2	612.0	471.6	431.2
Goddard Space Flight Center	484.3	374.2	382.3	.6	1.4	2.1	95.7	98.4	100.6	580.6	474.0	485.0
Wallops Station	15.0	15.7	17.6	.4	1.1	1.4	10.7	11.4	11.7	26.1	28.2	30.7
Jet Propulsion Laboratory	127.1	126.1	159.1	.6	1.3	8.8	---	---	---	127.7	127.4	167.9
Ames Research Center	75.8	84.6	109.0	3.3	---	3.7	42.4	45.9	48.0	121.5	130.5	160.7
Flight Research Center	15.3	15.8	15.9	---	---	---	11.6	12.1	12.5	26.9	27.9	28.4
Langley Research Center	319.9	308.5	194.6	4.3	4.0	3.5	78.6	82.4	85.0	402.8	394.9	283.1
Lewis Research Center	204.1	193.8	140.0	9.7	---	3.2	82.3	79.4	78.4	296.1	273.2	221.6
NASA Headquarters	94.0	103.2	105.5	---	---	---	61.6	63.5	67.3	155.6	166.7	172.8
Various Locations	---	---	---	---	4.0	7.5	---	---	---	---	4.0	7.5
Space Shuttle Facilities	---	---	---	27.9	56.3	86.0	---	---	---	27.9	56.3	86.0
Rehabilitation and Modification	---	---	---	11.5	14.8	14.9	---	---	---	11.5	14.8	14.9
Minor Construction	---	---	---	1.7	4.6	4.5	---	---	---	1.7	4.6	4.5
Facility Planning and Design	---	---	---	8.0	13.6	10.9	---	---	---	8.0	13.6	10.9
Total Budget Plan	2,488.5	2,305.0	2,346.0	78.7	101.1	151.5	721.8	744.8	749.6	3,289.0	3,150.9	3,247.1

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

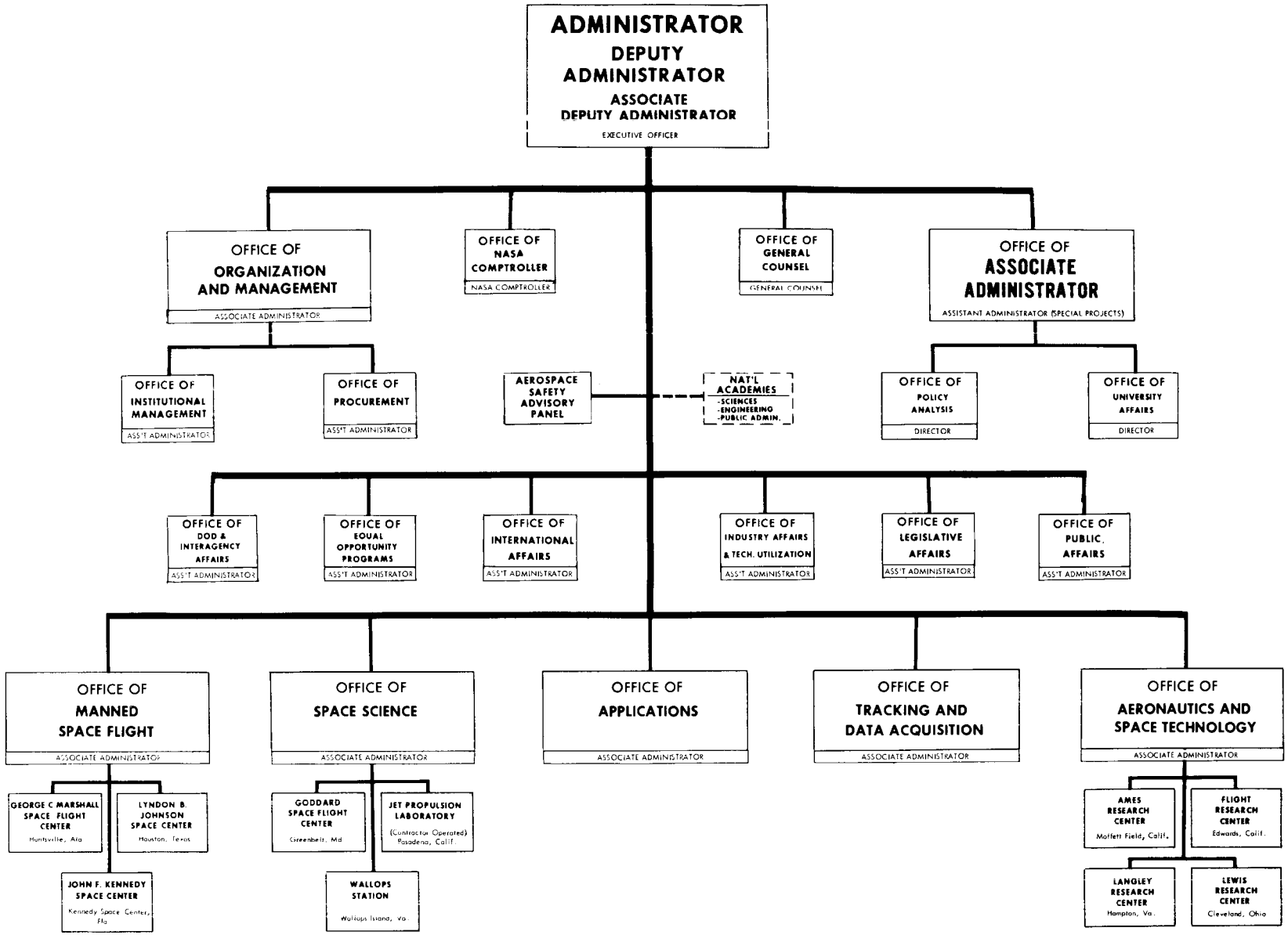
FISCAL YEAR 1975 ESTIMATES

RESEARCH AND PROGRAM MANAGEMENT

SUMMARY OF PERMANENT POSITIONS BY INSTALLATION

INSTITUTIONAL DIRECTOR AND INSTALLATION	FY 1973	FY 1974	FY 1975
MANNED SPACE FLIGHT	11,350	10,525	10,171
Johnson Space Center	3,727	3,652	3,652
John F. Kennedy Space Center, NASA	2,409	2,309	2,309
Marshall Space Flight Center	5,214	4,564	4,210
SPACE SCIENCE	4,403	4,228	4,228
Goddard Space Flight Center	3,966	3,808	3,808
Wallops Station	437	420	420
AERONAUTICS AND SPACE TECHNOLOGY	8,974	8,626	8,626
Ames Research Center	1,730	1,700	1,700
Flight Research Center	483	483	483
Langley Research Center	3,411	3,371	3,371
Lewis Research Center	3,350	3,072	3,072
NASA HEADQUARTERS	1,741	1,591	1,591
Planned unfilled positions	382	---	---
Subtotal	26,850	24,970	24,616
Other than permanent positions	2,349	2,439	2,345
Total, Positions	29,199	27,409	26,961

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION



RESEARCH AND DEVELOPMENT

FISCAL YEAR 1975 ESTIMATES

GENERAL STATEMENT

The National Aeronautics and Space Administration program of research and development is directed toward advancing man's knowledge of earth and its space environment and toward developing and utilizing aeronautics and space technology to accomplish National goals. The program is conducted through the following elements:

MANNED SPACE FLIGHT: A program building on the success of the Apollo and Skylab missions to demonstrate an international cooperative space docking mission and to develop a new space transportation system significantly improving the access of man and instruments to space.

SPACE SCIENCE: An unmanned space flight program to further man's knowledge of the earth, the atmosphere, the moon, the sun, the planets, interplanetary space, and the stars.

APPLICATIONS: A research and development program using ground, air, and space systems to demonstrate space techniques to benefit mankind in such areas as weather and climate, pollution monitoring, earth resources survey, earth and ocean physics, communications, and space processing.

AERONAUTICS AND SPACE TECHNOLOGY: A program to acquire fundamental knowledge and develop the technology needed to continue United States leadership in aeronautics and space programs.

TRACKING AND DATA ACQUISITION: A worldwide program to support the manned and unmanned programs of the agency.

TECHNOLOGY UTILIZATION: A program to accelerate the dissemination to industry and other users of the technological and engineering information gained during conduct of the agency missions.

MANNED SPACE FLIGHT

The Skylab program, consisting of the first long duration manned orbiting laboratory, has completed its flight mission and begun an intense interpretation of scientific and technological data. During FY 1975, this

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interpretation will be continued; the final preparation will be made for a July 1975 launch of the Apollo Soyuz Test Project--the first international cooperative manned flight; and activity on the development of the space shuttle will be intensified as we move toward a new era in transportation to and from space.

The completion of the Skylab missions is an historic accomplishment which demonstrated the ability of man to operate effectively and safely in space for extended periods of time. In fact, the three missions demonstration was so successful that the time planned for occupancy by the third crew was extended from 56 to 85 days. Observations of the sun by the Skylab crews have produced data which is expected to alter drastically previous views on solar phenomena. In addition, data was collected in the earth resources area which may lead to a number of discoveries about our resources. Other investigations were concerned with the efforts of the space environment on materials, fluids, and life processes. Of great importance for longer range planning was the demonstration of man's ability to perform experiments in space. This provides the basis for more effective experiment planning for the Apollo Soyuz Test Project and future missions utilizing the space shuttle.

The Apollo Soyuz Test Project, a joint US/USSR effort to develop and test systems for rendezvous and docking of manned spacecraft, is planned for July 1975. During this mission, United States 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. During the mission, joint activities will be conducted by the two crews, including crew transfers between the two spacecraft.

The space shuttle is the key to future space operations in earth orbit. This system will consist of a reusable delta wing orbiter vehicle, a large expendable fuel tank, and reusable twin, solid rocket boosters. The shuttle will provide both placement and retrieval of satellites, in-orbit servicing of satellites, short-duration manned orbital missions, and delivery to earth orbit of payloads and propulsive states for high energy missions. The advent of routinely available transportation to and from earth orbit for both unmanned payloads and for scientists and other personnel without special flight training, will revolutionize our concepts of using space for scientific purposes. In addition to the savings resulting from reduced transportation costs, major savings are anticipated in payload costs, resulting from repair and reuse of payloads and from relaxation of the stringent payload weight, size, and reliability requirements currently imposed.

SPACE SCIENCE

The Space Science program is a broad-based program of scientific exploration using data from manned and automated spacecraft, sounding rockets, balloons, aircraft, and ground-based research. Investigations are directed toward observing and understanding the characteristics and interactions of the earth and its atmosphere, the moon, the sun, the planets, the stars, and interplanetary and interstellar space.

The Skylab mission provided a wealth of new data on the sun, complementing and adding to that being received from the automated Orbiting Solar Observatory-7. These solar observations will be continued through the quiescent period of the solar cycle using another automated Orbiting Solar Observatory, OSO-I, to be launched in 1975. The Orbiting Astronomical Observatory-3, Copernicus, continues to transmit data on the stars and the interstellar matter. The High Energy Astronomy Observatory program will move forward with the development of flight hardware for launch in 1977, 1978, and 1979.

Analysis continues on the data returned by the Apollo missions and on that being received from the Apollo Lunar Surface Experiment Packages left on the lunar surface by the astronauts, as well as the data returned from current and previous planetary missions. Pioneer 10 has completed its flyby of Jupiter, returning close-up imagery and demonstrating the ability of a spacecraft to survive the hazards of both the asteroid belt and Jupiter's intense radiation. A second mission, Pioneer 11, is proceeding toward another Jupiter flyby in December 1974. Mariner 10, meanwhile, is proceeding toward Venus and Mercury using the first gravity assist trajectory. Encounter dates at these planets are February 1974 and March 1974, respectively. International cooperative missions to explore the interplanetary region near the sun are being developed by the United States and West Germany. These missions, designated Helios A and B, are scheduled for launch in 1974 and 1976. Two Viking missions, each of which will contain both an Orbiter and a Lander, will be launched in 1975 with a planned Mars landing in July 1976. The primary purpose of these missions is to search for the existence of life or the possibility of past or future life on Mars. In 1977, two Mariner spacecraft will be launched to fly by Jupiter and, utilizing a gravity assist from that planet, will travel on to investigate Saturn. In 1978, two Pioneer spacecraft will be launched, one to orbit Venus and another to probe its dense atmosphere. These spacecraft will return a wealth of data on Venus and help to answer questions about the earth's atmosphere and dynamics.

The Space Science program also provides launch vehicles for the science and applications missions of the agency, as well as providing launches on a reimbursable basis to other government users and a growing number of international and domestic commercial customers.

SPACE APPLICATIONS

The Applications program conducts research and development to demonstrate the use of space and space-related technology for practical benefits. Specific areas of such investigations include weather and climate, pollution monitoring, earth resources survey, earth and ocean physics, space processing, and communication.

Work continues on development of the TIROS-N, a 1977 prototype for a third generation operational weather satellite system, and on Nimbus-G, a 1978 satellite to demonstrate the use of a space platform to monitor air pollution and to measure ocean dynamics. The second earth resources technology satellite, ERTS-B, is scheduled for launch in 1975 to continue the space-based earth resources survey begun so successfully by ERTS-1. This effort will be supported by airborne sensors similar to those in the satellite.

Understanding of earthquake mechanisms will be enhanced by both ground-based experiments and development work on LAGEOS, a high density, laser reflector satellite. The LAGEOS, when launched in 1976, will provide a stable, long-term reference point for earth crustal motion studies.

Communications satellites include an experimental Applications Technology Satellite (ATS-F) to be launched in 1974 and a joint US/Canadian project - Cooperative Applications Satellite (CAS-C) for 1975 launch.

New activities being undertaken in this program include an ocean dynamics satellite, SEASAT-A, to demonstrate a wide range of physical ocean phenomena, including sea state, the location and motion of currents, global circulation patterns, ocean tides, wind stress and geoid undulations. This satellite should provide global information on the dynamics of the interactions of the air and the sea, which is important to understanding global weather and climate patterns. A second new flight program in FY 1975 is a heat capacity mapping mission to locate and map geothermal sources in the earth's crust and to identify materials contained in surface rocks.

Other new efforts will be undertaken in data management to improve the definition and integration of ground and spacecraft data. Systems analyses and cost/benefit studies will continue to be used to test the effectiveness of space applications.

AERONAUTICS AND SPACE TECHNOLOGY

Aeronautics efforts are directed toward improving the performance and reducing both the energy requirements and the undesirable environmental

effects of civil and military aircraft. Progress toward these goals will help ensure the superiority of our military aircraft and a strong, competitive position for the United States civil aviation industry. Specific efforts will continue on lighter, stronger, and noise-absorbing materials and structures; on clean, quiet, efficient propulsion systems for both short- and conventional take-off and landing aircraft; and on alternatives to petroleum-based fuels, as well as the more efficient use of such fuels.

Coordinated technology programs with other agencies are being conducted to improve operating procedures to reduce terminal area congestion, noise, fuel consumption, and pollution. A technology base is being developed for future military and supersonic cruise aircraft, and for improved short-haul, high density short- and vertical take-off and landing craft.

New FY 1975 activities include the development of active controls technology, the demonstration of the use of advanced materials in advanced turbine engines, the demonstration of highly-maneuvering aircraft technology, and the development of low-cost avionics.

Research and technology in the space and nuclear area is directed at providing a technology base for future space activities, at the methods of providing standardized, low-cost components and systems for the future, and at the application of current and future space technology to civil energy needs.

The FY 1975 effort includes research on advanced spacecraft and spacecraft systems materials and structures; on improved chemical and electrical propulsion systems; on high reliability, efficient electronic components and systems for guidance, control, and information handling; on thermal systems to improve spacecraft design; on efficient nuclear and nonnuclear power systems for spacecraft; and on power generation, storage, and transmission applicable to long-term terrestrial energy needs.

TRACKING AND DATA ACQUISITION

The FY 1975 budget provides for continuation of tracking and data acquisition support for manned and unmanned earth orbiting spacecraft, planetary missions, sounding rockets, and research aircraft. This support is provided by worldwide networks of NASA ground stations, an instrumentation ship, and instrumented aircraft, interconnected by a highly reliable communications system which provides the capability for instantaneous transmission of data and critical commands between spacecraft and the flight control centers. Facilities also are provided to process into meaningful form the large amounts of scientific, applications, and engineering data which are collected from flight projects.

During FY 1975, the support workload will remain high with the Spaceflight Tracking and Data Network continuing to support an average of 35 to 40 spacecraft in earth orbit and the Deep Space Network supporting a full complement of planetary missions. Newly launched spacecraft to be added to the ongoing workload during FY 1975 include the Earth Resources Technology Satellite B, the Atmosphere Explorer D, the Orbiting Solar Observatory I, and the Helios A. Preparations will continue in FY 1975 for support in subsequent years of the Apollo Soyuz Test Project, Viking, Mariner Jupiter/Saturn 1977, Pioneer Venus, International Ultraviolet Explorer, the Laser Geodynamic Satellite (LAGEOS), and the Ocean Dynamics Satellite (SEASAT).

TECHNOLOGY UTILIZATION

This program provides for wide and rapid dissemination of scientific and technical information acquired as a result of the agency programs. Recipients include other government agencies, the university and nonprofit research community, and industry. Also included is a program to identify public sector problems capable of solution by the application of aerospace technology. These efforts are accomplished through a series of publications and through Regional Applications Centers.

FUNDING

The FY 1975 Research and Development budget plan totals $2,346,015,000, an increase of $41,015,000 from FY 1974.

Research and Development outlays in FY 1975 are estimated at $2,422,900,000 up $63,000,000 from the $2,359,900,000 estimate for FY 1974.

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, [$2,194,000,000] $2,346,015,000, 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, 1974; 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		
	1973 actual	1974 estimate	1975 estimate	1973 actual	1974 estimate	1975 estimate
Program by activities:						
Direct program:						
1. Manned space flight:						
(a) Space shuttle	198,575	475,000	800,000	144,469	450,000	850,000
(b) Space flight operations	879,000	580,000	323,300	774,993	658,900	356,300
(c) Advanced manned mission studies	1,500	1,500	1,500	2,462	2,400	1,200
(d) Apollo	56,700	----------	----------	248,516	10,100	2,500
2. Scientific investigations in space:						
(a) Physics and astronomy	144,200	111,900	161,415	143,165	117,900	164,000
(b) Lunar and planetary exploration	389,969	391,300	284,600	410,291	365,450	308,550
(c) Launch vehicle development and support	128,400	84,800	94,400	117,573	87,000	99,300
3. Space applications	205,300	175,000	184,100	201,917	182,800	189,400
4. Space and nuclear research and technology	81,860	69,000	74,800	95,273	73,700	76,600
5. Aeronautical research and technology	150,640	168,000	166,400	117,792	157,600	171,600
6. Supporting activities:						
(a) Tracking and data acquisition	248,331	244,000	250,000	237,953	253,000	257,000
(b) Sustaining university program	----------	----------	----------	2,973	2,000	400
(c) Technology utilization	4,000	4,500	5,500	6,551	5,000	5,200
Total direct program costs, funded	2,488,475	2,305,000	2,346,015	2,503,928	2,365,850	2,482,050
Reimbursable program:						
1. Manned space flight:						
(a) Space shuttle	525	----------	----------	486	112	----------
(b) Space flight operations	6,999	8,345	7,963	4,210	10,200	7,963
(c) Advanced manned missions studies	400	----------	----------	434	----------	----------
(d) Apollo	2	----------	----------	2,575	482	----------
2. Scientific investigations in space:						
(a) Physics and astronomy	3,156	16,922	16,972	1,390	18,072	16,972
3. Space applications	96,079	181,180	150,595	72,061	211,343	150,595
4. Space and nuclear research and technology	632	2,117	2,850	406	2,300	2,850
5. Aeronautical research and technology	21,142	23,261	23,800	16,593	35,100	23,800
6. Supporting activities:						
(a) Tracking and data acquisition	531	450	500	746	469	500
(c) Technology utilization	310	725	1,320	37	900	1,320
Total reimbursable program costs	129,776	233,000	204,000	98,938	278,978	204,000
Total program costs, funded	2,618,251	2,538,000	2,550,015	2,602,866	2,644,828	2,686,050
Change in selected resources (undelivered orders and stores)	----------	----------	----------	—129,081	198,766	—110,135
10 Total	2,618,251	2,538,000	2,550,015	2,473,785	2,843,594	2,575,915

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		
	1973 actual	1974 estimate	1975 estimate	1973 actual	1974 estimate	1975 estimate
Financing:						
Receipts and reimbursements from:						
11 Federal funds	−83,836	−79,766	−112,013	−83,836	−79,766	−112,013
14 Non-Federal sources	−45,940	−153,234	−91,987	−45,940	−153,234	−91,987
21 Unobligated balance available, start of year:						
For completion of prior year budget plans:						
Direct	----------	----------	----------	−159,247	−285,516	−25,900
Reimbursable	----------	----------	----------	−27,092	−45,978	----------
Available to finance new budget plans: Direct	----------	−111,000	----------	----------	−111,000	----------
23 Unobligated balance transferred to other accounts	----------	----------	----------	1,400	----------	----------
24 Unobligated balance available, end of year:						
For completion of prior year budget plans:						
Direct	----------	----------	----------	285,516	25,900	----------
Reimbursable	----------	----------	----------	45,978	----------	----------
Available to finance new budget plans: Direct	111,000	----------	----------	111,000	----------	----------
25 Unobligated balance restored	----------	----------	----------	−2,089	----------	----------
Budget authority	**2,599,475**	**2,194,000**	**2,346,015**	**2,599,475**	**2,194,000**	**2,346,015**
Budget authority:						
40 Appropriation	2,600,900	2,194,000	2,346,015	2,600,900	2,194,000	2,346,015
41 Transferred to other accounts	−1,425	----------	----------	−1,425	----------	----------
43 Appropriation (adjusted)	**2,599,475**	**2,194,000**	**2,346,015**	**2,599,475**	**2,194,000**	**2,346,015**
Relation of obligations to outlays:						
71 Obligations incurred, net				2,344,009	2,610,594	2,371,915
72 Obligated balance, start of year				1,156,675	959,243	1,209,937
74 Obligated balance, end of year				−959,243	−1,209,937	−1,158,952
90 Outlays				2,541,442	2,359,900	2,422,900

Note:—Reconciliation of budget plan to obligations:	*1973 actual*	*1974 estimate*	*1975 estimate*
Total budget plan	2,618,251	2,538,000	2,550,015
Deduct portion of budget plan to be obligated in subsequent years	279,450	22,000	----------
Add obligations of prior year budget plans	134,984	327,594	25,900
Total obligations	2,473,785	2,843,594	2,575,915

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

BUDGET SUMMARY

Research and Development	Budget Plan FY 1973	FY 1974	FY 1975
MANNED SPACE FLIGHT.....	1,135,775,000	1,056,500,000	1,124,800,000
Space shuttle.....	198,575,000	475,000,000	800,000,000
Space flight operations..	879,000,000	580,000,000	323,300,000
Advanced missions.....	1,500,000	1,500,000	1,500,000
Apollo.....	56,700,000	---	---
SPACE SCIENCE.....	679,169,000	602,000,000	547,015,000
Physics and astronomy....	126,200,000	94,000,000	140,515,000
Lunar and planetary exploration.....	331,969,000	333,000,000	266,000,000
Launch vehicle procurement.....	221,000,000	175,000,000	140,500,000
APPLICATIONS.....	188,700,000	161,000,000	177,500,000
Space applications.....	188,700,000	161,000,000	177,500,000
AERONAUTICS AND SPACE TECHNOLOGY.....	232,500,000	237,000,000	241,200,000
Aeronautical research and technology.....	150,640,000	168,000,000	166,400,000
Space and nuclear research and technology.....	81,860,000	69,000,000	74,800,000
TRACKING AND DATA ACQUISITION.....	248,331,000	244,000,000	250,000,000
TECHNOLOGY UTILIZATION.....	4,000,000	4,500,000	5,500,000
TOTAL.....	2,488,475,000	2,305,000,000	2,346,015,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1975 ESTIMATES

DISTRIBUTION OF RESEARCH AND DEVELOPMENT BUDGET PLAN BY INSTALLATION AND FISCAL YEAR
(Thousands of Dollars)

PROGRAM		TOTAL	Johnson Space Center	Kennedy Space 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
OFFICE OF MANNED SPACE FLIGHT, TOTAL	1973	1,135,775	475,204	184,658	445,921	645	802	150	9,240	96	1,441	410	17,208
	1974	1,056,500	614,105	105,779	312,459	822	634	160	9,301	100	1,162	250	11,728
	1975	1,124,800	766,409	101,600	234,730	250	775	---	7,536	100	550	250	12,600
Space shuttle	1973	198,575	150,236	210	45,729	---	---	---	---	---	---	---	2,400
	1974	475,000	347,548	2,600	120,900	---	---	---	178	---	174	---	3,600
	1975	800,000	630,200	11,600	148,700	---	---	---	---	---	---	---	9,500
Space Flight operations	1973	879,000	294,583	182,020	380,322	645	802	150	9,038	96	1,356	410	9,578
	1974	580,000	265,807	102,979	191,059	822	634	160	9,123	100	988	250	8,078
	1975	323,300	135,709	89,800	85,430	250	775	---	7,536	100	550	250	2,900
Advanced missions	1973	1,500	---	---	1,500	---	---	---	---	---	---	---	---
	1974	1,500	750	200	500	---	---	---	---	---	---	---	50
	1975	1,500	500	200	600	---	---	---	---	---	---	---	200
Apollo	1973	56,700	30,385	2,428	18,370	---	---	---	202	---	85	---	5,230
	1974	---	---	---	---	---	---	---	---	---	---	---	---
	1975	---	---	---	---	---	---	---	---	---	---	---	---
OFFICE OF SPACE SCIENCE, TOTAL	1973	679,169	286	3,388	24,643	147,722	63,909	2,708	22,647	---	249,149	117,773	46,944
	1974	602,000	8,282	3,880	10,961	110,200	62,207	2,905	17,206	---	235,259	108,774	42,326
	1975	547,015	13,701	10,415	52,070	106,855	93,365	2,900	42,627	---	109,280	68,675	47,127
Physics and astronomy	1973	126,200	136	---	23,536	68,439	695	2,643	6,746	---	4,315	---	19,690
	1974	94,000	180	---	8,690	54,891	650	2,850	6,705	---	2,708	---	17,326
	1975	140,515	975	---	50,280	55,875	650	2,850	6,905	---	1,705	---	21,275
Lunar and planetary exploration	1973	331,969	150	---	---	4,819	62,452	65	15,901	---	229,060	---	19,522
	1974	333,000	8,102	---	25	6,009	60,947	55	10,501	---	224,286	---	23,075
	1975	266,000	12,726	---	---	8,090	91,700	50	35,722	---	94,110	---	23,602
Launch vehicle procurement	1973	221,000	---	3,388	1,107	74,464	762	---	---	---	15,774	117,773	7,732
	1974	175,000	---	3,880	2,246	49,300	610	---	---	---	8,265	108,774	1,925
	1975	140,500	---	10,415	1,790	42,890	1,015	---	---	---	13,465	68,675	2,250
OFFICE OF APPLICATIONS, TOTAL	1973	188,700	13,979	150	642	148,549	1,058	5,522	3,273	---	6,779	3,332	5,416
	1974	161,000	18,818	255	4,320	80,863	3,884	6,457	7,502	---	8,469	3,840	26,592
	1975	177,500	31,700	1,400	5,000	89,100	3,200	7,700	7,100	---	8,400	2,100	21,800
Space applications	1973	188,700	13,979	150	642	148,549	1,058	5,522	3,273	---	6,779	3,332	5,416
	1974	161,000	18,818	255	4,320	80,863	3,884	6,457	7,502	---	8,469	3,840	26,592
	1975	177,500	31,700	1,400	5,000	89,100	3,200	7,700	7,100	---	8,400	2,100	21,800
OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY, TOTAL	1973	232,500	523	---	3,565	3,761	18,579	91	40,549	13,722	61,923	82,651	7,136
	1974	237,000	729	---	3,537	5,109	15,205	124	50,586	13,976	63,261	80,932	3,541
	1975	241,200	929	---	4,048	5,222	16,282	124	51,678	14,026	76,348	69,002	3,541
Aeronautical research and technology	1973	150,640	205	---	910	---	1,282	91	33,196	12,300	46,970	53,330	2,356
	1974	168,000	164	---	647	---	620	124	43,526	12,898	49,605	58,786	1,630
	1975	166,400	164	---	647	---	620	124	44,153	12,898	60,428	45,736	1,630
Space and nuclear research and technology	1973	81,860	318	---	2,655	3,761	17,297	---	7,353	1,422	14,953	29,321	4,780
	1974	69,000	565	---	2,890	5,109	14,585	---	7,060	1,078	13,656	22,146	1,911
	1975	74,800	765	---	3,401	5,222	15,662	---	7,525	1,128	15,920	23,266	1,911
OFFICE OF TRACKING AND DATA ACQUISITION	1973	248,331	---	---	---	183,665	42,730	6,522	---	1,520	580	---	13,314
	1974	244,000	---	---	---	177,180	44,210	6,100	---	1,700	300	---	14,510
	1975	250,000	---	---	---	180,900	45,500	6,900	---	1,800	---	---	14,900
OFFICE OF TECHNOLOGY UTILIZATION	1973	4,000	---	---	---	---	---	---	---	---	---	---	4,000
	1974	4,500	---	---	---	---	---	---	---	---	---	---	4,500
	1975	5,500	---	---	---	---	---	---	---	---	---	---	5,500
TOTAL BUDGET PLAN	1973	2,488,475	489,992	188,196	474,771	484,342	127,078	14,993	75,709	15,338	319,872	204,166	94,018
	1974	2,305,000	641,934	109,914	331,277	374,174	126,140	15,746	84,595	15,776	308,451	193,796	103,197
	1975	2,346,015	812,739	113,415	295,848	382,327	159,122	17,624	108,941	15,926	194,578	140,027	105,468

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1975 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR

MANNED SPACE FLIGHT PROGRAMS

Programs	Budget Plan		
	FY 1973	FY 1974	FY 1975
Space shuttle.....	$198,575,000	$475,000,000	$800,000,000
Space flight operations.....	879,000,000	580,000,000	323,300,000
Advanced missions.....	1,500,000	1,500,000	1,500,000
Apollo.....	56,700,000	---	---
Total.....	$1,135,775,000	$1,056,500,000	$1,124,800,000

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1975 ESTIMATES

BUDGET SUMMARY

OFFICE OF MANNED SPACE FLIGHT — SPACE SHUTTLE PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1973	1974	1975
Orbiter	$139,480,000	$355,000,000	$647,500,000
Main engine	40,543,000	79,000,000	92,300,000
Solid rocket boosters	---	18,100,000	22,600,000
External tank	---	20,300,000	26,000,000
Launch and landing	---	2,600,000	11,600,000
Technology and related development	18,552,000	---	---
Total	$198,575,000	$475,000,000	$800,000,000
Distribution of Program Amount by Installation:			
Johnson Space Center	$150,236,000	$347,548,000	$630,200,000
John F. Kennedy Space Center, NASA	210,000	2,600,000	11,600,000
Marshall Space Flight Center	45,729,000	120,900,000	148,700,000
Ames Research Center	---	178,000	---
Langley Research Center	---	174,000	---
Headquarters	2,400,000	3,600,000	9,500,000
Total	$198,575,000	$475,000,000	$800,000,000

HIGHLIGHTS OF BUDGET PLAN

Space Shuttle

The FY 1975 program activities include design and development effort on all major elements of the system, start of fabrication of the second orbiter vehicle which will be used for the first orbital flight scheduled in the second quarter of 1979 and of major ground test hardware; the first complete main engine system test firing; and the start of launch checkout system hardware design.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1974 ESTIMATES

OFFICE OF SPACE SCIENCE

LUNAR AND PLANETARY EXPLORATION PROGRAM

FLIGHT SCHEDULE

PROJECT	MISSION	CALENDAR YEAR
Pioneer	Pioneer G	1973
	Helios A	1974
	Helios B	1976
Mariner	Venus Mercury 1973 (1)	1973
Viking	Mars 1975 (2)	1975
Outer Planets Missions	Jupiter-Saturn (2)	1977

ERRATA SHEET

Budget Estimates - FY 1974

Research and Development - Volume I

The attached five pages have been revised and should replace the corresponding page numbers in Volume I, Research and Development, FY 1974 budget estimates. These page numbers are as follows:

RD 9-7
RD 9-28
RD 9-29
RD 9-30
*RD 9-31

* A new additional page not currently in Volume I.

System Technology Programs	1972	1973	1974
Advanced Supersonic Technology - To provide an expanded supersonic technology base in the technical areas critical to (1) future advanced military supersonic cruise aircraft, (2) the assessment of the impact of present and future civil supersonic aircraft, and (3) any future considerations for an environmentally acceptable and economically viable supersonic transport. This does not include funds for initiating development of a supersonic transport or in any way commit the U.S. to such a development	---	$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

Systems Technology Programs

Advanced Supersonic Technology

The overall objective of the Advanced Supersonic Technology program is to provide an expanded supersonic technology base in the technical areas critical to (1) future advanced military supersonic cruise aircraft, (2) the assessment of the impact of present and future foreign civil supersonic aircraft, and (3) any future considerations for an environmentally acceptable and economically viable supersonic transport. This does not include funds for initiating development of a supersonic transport or in any way commit the U. S. to such a development.

Russia with its TU-144 and Great Britain and France with their Concorde programs have developed their supersonic cruise technology through massive research and development efforts which in addition have provided an extremely sound foundation for the development of advanced military cruise aircraft and/or civil supersonic transports. With the cancellation of the U.S. SST program in 1971, the momentum for maintaining our technology base was essentially lost with the exception of the programs which could be carried out by NASA.

Recognizing the need to continue to provide a sound technology base for military supersonic cruise aircraft and for possible decision options for supersonic civil transports in the future, the President's FY 1973 budget provided $11.7 million for specific NASA research in the technology areas critical to either of these potential future developments. The decision to bolster research unique to supersonic cruise vehicles in FY 1974 is in recognition of the need to maintain a strong and balanced aeronautical research program covering all speed ranges for potential future civil and military aircraft. While the advanced supersonic technology program is not directed solely toward civil transport applications, it does address environmental concerns by research on noise minimization and air pollution and economic viability aspects by airframe systems studies and advances in the technical disciplines of propulsion, structures and materials, aerodynamics, and stability and controls.

The design of economically viable supersonic transports and efficient military cruise aircraft requires reduced structural weight fractions attainable through 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 aerodynamically efficient arrow wing configurations and configurations identified in the airframe systems studies with emphasis on thermal stress, static aeroelasticity, 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 for both military and civil applications. 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 polyimide 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 advanced supersonic military and civil aircraft. 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 for determining aerodynamic characteristics 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 applicable to military as well as civil aircraft. The technology effort started in FY 1973 to develop design methods for use in defining practical minimum sonic boom configuration concepts will continue in FY 1974 since this restricts military operations as well as potential civil transport operations over land mass areas of the world.

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. Results of these studies are generally applicable to all supersonic cruise aircraft regardless of their mission.

An advanced supersonic cruise aircraft system must satisfy many different operational requirements such as high thrust at take-off and climb, high efficiency during subsonic hold and cruise, and high efficiency during supersonic cruise; and additionally for civil applications, low noise. To meet these very demanding constraints, new engine cycles or major modifications of existing engine cycles must be considered; thus in FY 1973, broad parametric studies of candidate conventional and variable-cycle engine concepts are being conducted. Engine definition studies of the most promising concepts will be initiated in FY 1974.

For potential civil applications, considerations of noise generation mechanisms and pollution reduction become of increasing importance. Thus 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 impact of jet emissions on the stratosphere.

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 system 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.

The above described program will result in a strong disciplinary data base for both military and civil supersonic cruise aircraft. In addition, this technology base provides the capability for the understanding and evaluation of the potential competition and threat from present and future supersonic aircraft vis-a-vis either future U.S. subsonic or supersonic military or commercial aircraft as well as the potential for implementing new development programs should this, on the basis of evaluation, be determined to be in the national interest.

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.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1975 ESTIMATES

SUMMARY OF APPROPRIATION BUDGET PLANS BY INSTALLATION
(In millions of dollars)

Installation	Research and Development			Construction of Facilities			Research and Program Management			Total		
	1973	1974	1975	1973	1974	1975	1973	1974	1975	1973	1974	1975
Johnson Space Center	490.0	641.9	812.7	.6	---	.9	110.6	116.9	118.2	601.2	758.8	931.8
John F. Kennedy Space Center, NASA	188.2	109.9	113.4	10.1	---	---	91.1	94.5	96.7	289.4	204.4	210.1
Marshall Space Flight Center	474.8	331.3	295.9	---	---	4.1	137.2	140.3	131.2	612.0	471.6	431.2
Goddard Space Flight Center	484.3	374.2	382.3	.6	1.4	2.1	95.7	98.4	100.6	580.6	474.0	485.0
Wallops Station	15.0	15.7	17.6	.4	1.1	1.4	10.7	11.4	11.7	26.1	28.2	30.7
Jet Propulsion Laboratory	127.1	126.1	159.1	.6	1.3	8.8	---	---	---	127.7	127.4	167.9
Ames Research Center	75.8	84.6	109.0	3.3	---	3.7	42.4	45.9	48.0	121.5	130.5	160.7
Flight Research Center	15.3	15.8	15.9	---	---	---	11.6	12.1	12.5	26.9	27.9	28.4
Langley Research Center	319.9	308.5	194.6	4.3	4.0	3.5	78.6	82.4	85.0	402.8	394.9	283.1
Lewis Research Center	204.1	193.8	140.0	9.7	---	3.2	82.3	79.4	78.4	296.1	273.2	221.6
NASA Headquarters	94.0	103.2	105.5	---	---	---	61.6	63.5	67.3	155.6	166.7	172.8
Various Locations	---	---	---	---	4.0	7.5	---	---	---	---	4.0	7.5
Space Shuttle Facilities	---	---	---	27.9	56.3	86.0	---	---	---	27.9	56.3	86.0
Rehabilitation and Modification	---	---	---	11.5	14.8	14.9	---	---	---	11.5	14.8	14.9
Minor Construction	---	---	---	1.7	4.6	4.5	---	---	---	1.7	4.6	4.5
Facility Planning and Design	---	---	---	8.0	13.6	10.9	---	---	---	8.0	13.6	10.9
Total Budget Plan	2,488.5	2,305.0	2,346.0	78.7	101.1	151.5	721.8	744.8	749.6	3,289.0	3,150.9	3,247.1

	1973	1974	1975
Orbiter - Initiation of fabrication and assembly of major ground test articles including the structural, hydraulic control and main propulsion test articles; tooling fabrication, parts procurement and design of the aft fuselage test article; design of the environmental control life support systems test model, continuation of detail design and fabrication of Orbiter #1 which is the horizontal flight configured vehicle; fabrication start of Orbiter #2 for the orbital flight tests; support of major design reviews; development of horizontal flight and shuttle mission simulators and trainers including initiating procurement of two shuttle training aircraft; continuation of extensive ground testing of subsystems and components; procurement of propellants for in-house testing; contract administration services.....	$139,480,000	$355,000,000	$647,500,000
Main Engine - Continued fabrication and assembly of development engines; major test activities, including the first thrust chamber test, heat exchanger test, low and high pressure fuel turbopump tests, integrated subsystem test and a first complete engine test on stand; procurement of long-lead engine and ground support equipment (GSE) hardware; delivery of first controller production unit, first test engine and all GSE development units; logistic support; propellants for development testing; rehabilitation of government-owned equipment and program support tasks.....	40,543,000	79,000,000	92,300,000

	1973	1974	1975
Solid Rocket Boosters (SRB) Continuation of design and development activity; fabrication of initial solid rocket motor tooling; delivery of initial motor case; development of propellant loading procedures; continuation of fabrication and assembly of the structural test article; fabrication of SRB test units; continued in-house design, development and initial testing of selected subsystems e.g., nose cone, thrust vector control and recovery systems by the Marshall Space Flight Center.....	---	$18,100,000	$22,600,000
External Tank (ET) Completion and certification of tooling for test article fabrication; initiation of major component fabrication for the structural and propulsion test units; release of final design drawings; initiation of long-lead item procurement for the dynamic test article and for the first flight tank; program support activities including test facility activation, equipment modification and computer support for engineering and manufacturing operations; procurement of propellants and pressurants..	---	20,300,000	26,000,000
Launch and Landing - Software analysis including detailed documentation of the method of operation and maintenance of computerized systems; initiation of design for the Launch Processing System (LPS) hardware; procurement of selected checkout equipment and testing of prototype hardware; engineering and engineering support services to support the design and activation of launch and recovery facilities.....	---	2,600,000	11,600,000

	1973	1974	1975
Technology and related developments			
No FY 1975 funds requested.....	$18,552,000	---	---
Total, Space Shuttle.....	$198,575,000	$475,000,000	$800,000,000

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1975 ESTIMATES

OFFICE OF MANNED SPACE FLIGHT — SPACE SHUTTLE PROGRAM

FLIGHT SCHEDULE

PROJECT	MISSION	CALENDAR YEAR
Space Shuttle	First Horizontal Flight	2nd Qtr 1977
	First Manned Orbital Flight	2nd Qtr 1979
	Operational Shuttle	1980

OFFICE OF MANNED SPACE FLIGHT — SPACE SHUTTLE PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Space Shuttle, a reusable manned space vehicle, will provide routine low cost access to space to meet civilian and defense needs in the 1980s. It will mark the beginning of a new era of space exploration characterized by a significant advance in the opportunities to utilize the benefits of space for practical applications on earth and for expanding the frontiers of science.

The Shuttle will be capable of transporting into low earth orbit a wide variety of payloads for private industry, universities, research organizations, the United States Government agencies, and national and international organizations. The large cargo-carrying capability of the orbiter will lessen 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, manufacture and test. Payloads to be carried in the orbiter payload bay may range from automated free flying satellites and large telescopes to fully equipped space laboratories designed to permit scientists to carry out orbital experiments in a shirt-sleeve environment.

The Space Shuttle will make it practicable to repair payloads in orbit and to retrieve them for return to earth for refurbishment. The Shuttle can also be used as a research laboratory to test industrial processes in a 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 to orbit of Shuttle replacement components and equipment.

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

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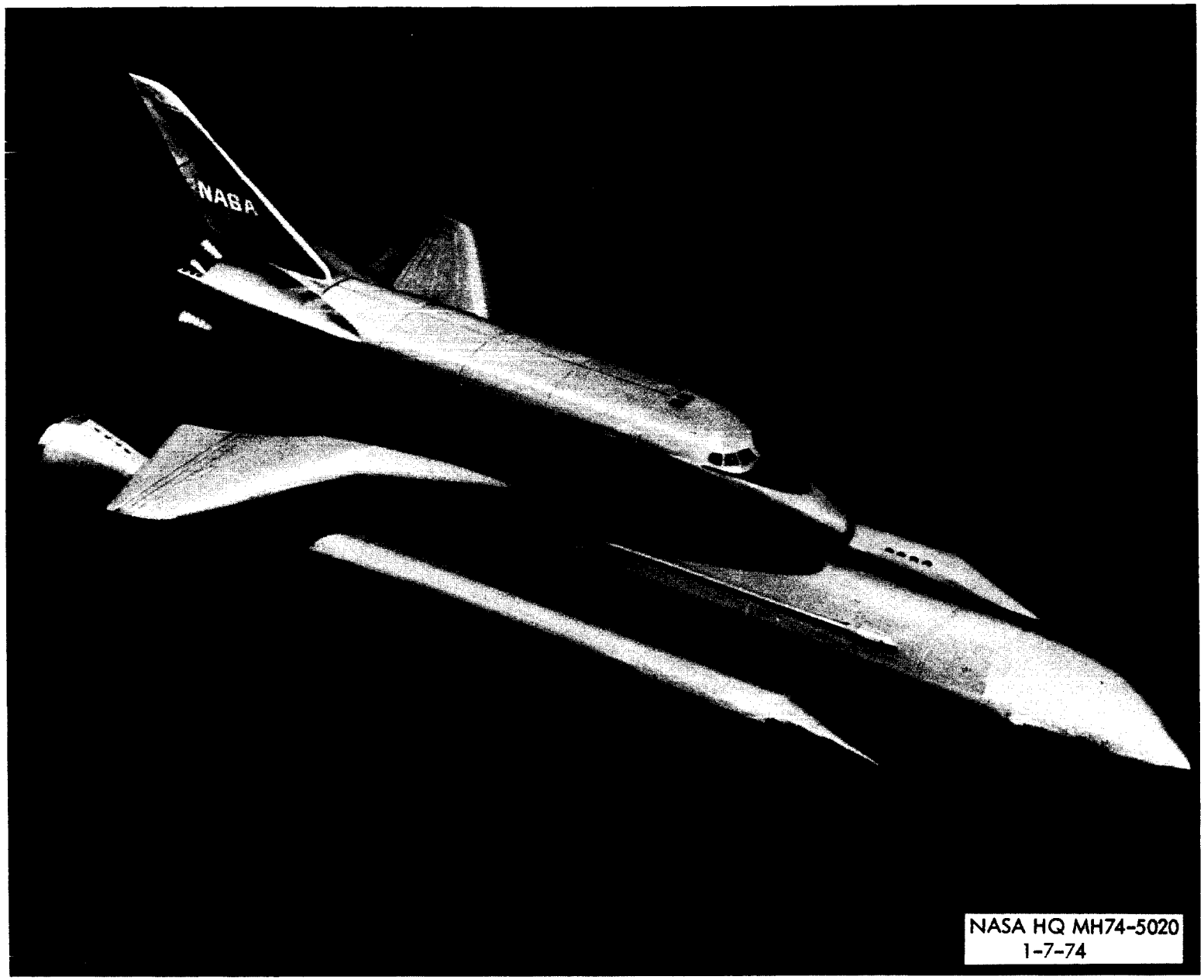
NASA
NASA HQ MH74-5020
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The orbiter will be boosted into space by the simultaneous firing of three high pressure liquid oxygen/liquid hydrogen main engines and twin reusable solid rocket boosters. After burnout at an altitude of about 46 kilometers (25 nautical miles), the booster rockets will separate and descend into the ocean by parachute for recovery and refurbishment. The downrange recovery area varies between approximately 240km (130 nautical miles) and 315km (170 nautical miles) depending on launch site and payload weights.

The orbiter will continue its ascent with the Space Shuttle main engines. Just prior to achieving orbital velocity, the main engines will shut down, the external tank will be jettisoned and, for a launch from the Kennedy Space Center, it will impact approximately 18,500km (10,000 nautical miles) downrange in a remote ocean area. The orbital maneuvering system will be used to achieve final orbital insertion. Following the completion of the mission, the orbiter will re-enter the atmosphere at a flight angle of approximately one degree and an angle of attack of approximately 30 degrees. The orbiter, which has a capability of reaching landing sites as far as 2,040km (1,100 nautical miles) on either side of its initial flight path, will land on conventional jet runways.

The Shuttle will normally carry a flight crew of three--the commander, a co-pilot and a mission specialist. In some cases a payload specialist will be stationed on the upper deck to check out payloads and deploy them in space. In normal operations, the Shuttle will accommodate a total of up to seven people, including the flight crew, who will travel in shirt-sleeve comfort without space suits and will be subjected to no more than 3G forces during launch and landing.

Shuttle Development

The Shuttle program structure has been established and all principal hardware contractors have been selected. Key milestones have been identified to serve as check points for measuring progress with regard to cost, schedule and performance. A comprehensive systems requirements review was held in August 1973 and the orbiter preliminary design review for the first horizontal flight configuration is scheduled for February 1974. Space Shuttle main engine component and subsystem testing will lead to the first main engine system firing at the Mississippi Test Facility in late FY 1975. The first horizontal flight is planned for the second quarter of 1977 and the first manned orbital flight during the second quarter of 1979.

Funds requested for FY 1975 will allow major contractors and their subcontractors to concentrate on hardware design and fabrication of major test articles, and initiate manufacture of the first orbital flight vehicle. Engine component and system testing activities will be greatly increased,

and FY 1975 funds will be used to design and develop launch and landing facilities and equipment. In summary, the program and contractor base established in FY 1974 supports a major expansion of development activities in FY 1975 across all areas of the program.

BASIS OF FUND REQUIREMENTS:

	Orbiter		
	1973	1974	1975
Orbiter.....	$139,480,000	$355,000,000	$647,500,000
Total.....	$139,480,000	$355,000,000	$647,500,000

The orbiter will be a delta-winged airplane-like vehicle comparable in size and weight to a transport aircraft such as the DC-9. It will have a cargo compartment measuring about 18 meters (60 feet) in length and 4.5 meters (15 feet) in diameters, and will be able to place 29,500 kilograms (65,000 pounds) in a 185 kilometer (100 nautical mile) due east orbit.

In August 1972, the Space Division of Rockwell International Corporation, Downey, California was selected as the prime contractor for design, development, and production of the orbiter vehicle and to support the NASA systems integration effort involving all elements of the Space Shuttle system. Since that time significant progress has been made in orbiter design, and detail systems requirements have been established.

Design and development of the orbiter got underway in earnest during FY 1974. The prime contractor and his subcontractors have initiated detailed design and development effort in response to stated requirements.

The following major subcontracts have been awarded by the Rockwell International Space Division:

Flight Control Systems - Honeywell, St. Petersburg, Florida;

Data Processing & Software Requirements, On-board Computer Input/Output Buffer - IBM, Owego, NY;

Vertical Stabilizer - Republic Aircraft Division of Fairchild Industries, Farmingdale, New York;

Wing and Wind Tunnel Models - Grumman, Bethpage, New York;

Mid-Fuselage - General Dynamics, San Diego, California;

Ground Maintenance and Maintainability Analysis and Operations Support - American Airlines, Tulsa, Oklahoma;

High Temperature Reusable Surface Insulation Thermal Protection System (TPS) - Lockheed, Sunnyvale, California;

Leading Edge Structural Subsystem TPS - LTV, Dallas, Texas;

Freon Cooling Loop and Atmospheric Revitalization - Hamilton Standard Division of United Aircraft, Windsor Locks, Connecticut;

Inertial Measurement Units - Singer Kearfott, Little Falls, New York;

Fuel Cells - Pratt & Whitney Division of United Aircraft, East Hartford, Connecticut;

Orbiter Windows - Corning Glass, Corning, New York;

Autoland Landing System - Sperry Rand, Phoenix, Arizona;

Main Landing Gear and Nose Landing Gear - Menasco, Burbank, California;

Low Temperature Reusable Surface Insulation - Lockheed, Sunnyvale, California;

Integrated Orbital Maneuvering System/Reaction Control Subsystem Aft Module - McDonnell Douglas, St. Louis, Missouri.

In addition, the following subsystems will be procured during FY 1974: reaction control system tanks and thrusters, nose wheel steering system, ejection seats and auxiliary power unit, and the orbital maneuvering system thrusters.

An orbiter preliminary design review will be conducted in early 1974 to verify the design approach and to establish the basis for proceeding with detail design and fabrication of ground test and flight hardware. Accomplishments in FY 1974 include release of hardware specifications for major subsystems, procurement of test hardware, including full scale mock-ups; wind tunnel testing, evaluation and analysis of shuttle systems, components and materials, initiation of flight hardware fabrication; and establishment of a Shuttle Avionics Integration Laboratory designed to verify avionics system test article design in the physical and electrical environment of other flight systems.

In FY 1975 the orbiter development program will enter a critical phase. Major activities to be undertaken during the coming fiscal year will include the fabrication of ground test articles, initiation of an extensive development and ground test program, the fabrication of flight hardware, and the completion of a number of major design reviews. In addition, program support effort will increase in scope and intensity.

In FY 1975 Rockwell International will initiate the fabrication and assembly of major ground test articles. These test articles are part of the verification test program necessary to confirm the orbiter design and provide the necessary assurance for the successful development test and flight programs. The design and procurement of parts for the structural test article will be completed and manufacture will be initiated. Setup for the structural test will be designed and the test fixture fabrication will be started. The design phase of the hydraulic control test article and test program will also be completed and manufacturing of the test article and test fixtures will be initiated.

The manufacture of the main propulsion test article will be initiated in FY 1975 along with detailed planning for propulsion tests, to be conducted at the Mississippi Test Facility starting in mid-1977.

During FY 1975, planning will proceed for the vibroacoustic test of the aft fuselage test article. Fabrication of tooling, procurement of parts, and design will be accomplished in preparation for manufacture and subassembly of this test article. Design will be completed and hardware will be purchased for tests to verify the separation mechanism and techniques. The test setup and support equipment planning and design will also be initiated during FY 1975. In addition, an environmental control life support systems boilerplate model will be designed to test the adequacy of the on-board life support systems.

FY 1975 funding will be required by the prime contractor to continue detail design and fabrication of the first orbiter and to start fabrication of the second. The first orbiter is being configured for the first horizontal flight and the second orbiter for the first manned orbital flight. All orbiter subcontractors will be on-board and will be engaged in the development and fabrication of the subsystems and components to be installed in the first two orbiters. Procurements are in progress for the following orbiter subsystems: orbital maneuvering system engine; umbilical disconnects; atmospheric pressurization components; multiplexer/demultiplexer; flight control/displays and controls; main landing gear wheel and brake assembly; auxiliary power unit; space radiator; cryogenic storage containers; air data transducer assembly; propellant feed valves.

Early in FY 1975, a preliminary design review (PDR) of the entire Space Shuttle system related to the first horizontal flight configuration will be held, followed by an orbiter vehicle PDR that will be concerned with the orbital flight configuration of the second orbiter. These reviews will be conducted in this phase of the development program to assure compatibility of design for the orbiter vehicles and the entire system so that component fabrication can proceed.

Program support for the orbiter vehicle during FY 1975 will concentrate on the development of simulators and trainers as well as investigations in a number of critical design areas. Major items include procurement of two Shuttle training aircraft and procurement of the horizontal flight and Shuttle mission simulators. Critical areas under study include thermal protection, communications and tracking, structures and materials, and environmental control. In addition, funding is required for ground testing of subsystems and components at government facilities such as the White Sands Test Facility.

Funds will also be required in FY 1975 to procure propellants; to conduct in-house testing, evaluation and analysis for related engineering and operations support; and to provide for contract administration services supplied by Department of Defense.

Main Engine

	1973	1974	1975
Space shuttle main engine.....	$40,543,000	$79,000,000	$92,300,000
Total.....	$40,543,000	$79,000,000	$92,300,000

The Space Shuttle orbiter vehicle will use three high chamber pressure engines, designed to operate at a vacuum thrust level of about 2,091,000 newtons (470,000 pounds) each. These engines, which use liquid oxygen/liquid hydrogen propellants, will provide thrust for the orbiter from lift-off to a point just prior to orbital insertion.

Engine design provides for a staged combustion cycle in which propellants are raised to high pressure by turbopumps powered by preburners. After use for engine cooling, propellants are mixed with exhaust from the preburners and with an additional oxidizer before injection into the main combustion chamber where the mixture is burned to generate the required thrust. Engine throttling capability is provided by varying the propellant flow at a constant mixture ratio to provide the desired thrust.

Rocketdyne was granted contractual authority to proceed with the design, development and fabrication of the Shuttle main engines on April 5, 1972. A definitive contract was negotiated and signed on August 11, 1972. Development of this high performance engine requires an extensive test program to verify designs and to insure high reliability. After completion of the preliminary design review in 1972, the contractor undertook an extensive component and subsystem test program in FY 1973 and FY 1974 at the engine test facilities located at Santa Susana and Canoga Park, California. This test program will culminate in the first sea level engine test firing scheduled for early 1975 at the Mississippi Test Facility (MTF). In support of these key milestones, FY 1974 funds are being used for design, fabrication and procurement of engine components, both by the engine prime contractor and his subcontractors.

FY 1975 funding will provide for continued fabrication and assembly of development engines, for the continuation of major test activities now underway and the initiation of others including: first thrust chamber tests; first heat exchanger test, first low pressure fuel turbopump tests; and the first high pressure fuel and oxidizer turbopump tests; first integrated subsystems test at Santa Susana with complete powerhead, which includes both low and high pressure pumps, preburners, main conbustion chamber and the controller, and the first complete engine test at MTF. Procurement of long lead hardware for deliverable engines and ground support equipment will be initiated in FY 1975 to support delivery of the first set of flight engines in 1978. During FY 1975, the first engine controller production units will be delivered to Rocketdyne and NASA; the first test engine will be delivered to MTF; and delivery of all development unit ground support equipment will be completed.

FY 1975 funds will provide logistic support, propellants, rehabilitation of government-owned industrial equipment and Mississippi Test Facility support.

In addition, support tasks will be directed towards understanding the effects of logitudinal oscillations as they pertain to the main engine, techniques for measuring dynamic flow in propellant subsystems, materials investigation, and extending engine life and reusability.

Solid Rocket Boosters

	1973	1974	1975
Solid rocket boosters.....	---	$18,100,000	$22,600,000
Total.....	---	$18,100,000	$22,600,000

The booster elements of the Space Shuttle system will consist of two reusable solid propellant rockets which are attached to the external propellant tank. Each rocket is approximately 44 meters (145 feet) long and 3.6 meters (12 feet) in diameter. 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 at an altitude of about 40 kilometers (25 miles). The solid rocket booster system consists of the solid rocket motor (SMR), forward and aft skirts, a nose cone, and subsystems for thrust vector control, recovery, separation and malfunction detection. The solid rocket motor has a propellant-filled case, a nozzle and an igniter. Each SRB will weigh about 52,000 kilograms (116,000 pounds) and produce approximately 11,000,000 newtons (2,500,000 pounds) of thrust at sea level.

The SRBs will be designed for water recovery, refurbishment and reuse. The present development plan provides an extensive test program to verify systems design and to insure a high degree of reliability. The first SRM firing and the SRB critical design review are scheduled for FY 1976. Delivery of initial flight hardware is scheduled for 1978 to support the first manned orbital flight in the second quarter of 1979. Since the SRB represents the most critical item as far as cost per flight, a phased procurement and integration procedure has been selected as the most cost effective approach.

Thiokol Chemical Corporation was selected as the contractor for solid rocket motor development on November 20, 1973. Other booster system elements will be procured at a later date. The Marshall Space Flight Center will perform design, development and initial testing of selected subsystems and has responsibility for overall system integration. Selection of an SRB integration contractor is scheduled for FY 1977.

FY 1974 funding is being utilized for completion of the SRB preliminary design review (PDR) and initiation of design and development of the SRB major subsystems such as those required for thrust vector control, separation and recovery. FY 1974 funding also provides for the start of fabrication and assembly of the structural and propulsion test articles by the SRM contractor and for modification of propellant processing and ground test equipment.

FY 1975 funding will provide for continuation of the design and development activity initiated in FY 1974, leading to the critical design review in 1976. Accomplishments planned for FY 1975 include fabrication of initial SRM tooling, delivery of the initial motor case, and development of propellant loading procedures. Fabrication and assembly of the structural test article will continue in FY 1975, as well as fabrication of SRB test units which will undergo test firings beginning in 1976.

Design, development and initial testing of other selected subsystems of the solid rocket boosters will be continued by the Marshall Space Flight Center. This will include the nose cone, aft skirt, control electronics, recovery systems and thrust vector control. MSFC will continue to perform systems integration tasks in support of SRB development.

External Tank

	1973	1974	1975
External tank.....	---	$20,300,000	$26,000,000
Total.....	---	$20,300,000	$26,000,000

The external tank (ET) supplies liquid hydrogen and liquid oxygen propellants for the orbiter main engines from lift-off to just prior 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 to impact at a predetermined, remote location. Major tank subsystems include the pressurization, feed, separation, and associated electronic controls and mounting brackets for the orbiter and SRB. The present development plan provides for delivery of the initial test articles in 1976 and delivery of the first flight configured tank in 1978.

The external tank is approximately 47 meters (155 feet) long and 8 meters (27 feet) in diameter, with separate liquid oxygen and liquid hydrogen tankage mounted below the orbiter and between the solid rocket boosters (SRB).

In August 1973 Martin-Marietta was selected as the contractor for ET development. Fabrication and assembly will be accomplished at the government-owned Michoud Assembly Facility (MAF) in Louisiana.

FY 1974 funding is being utilized for design efforts leading to a preliminary design review in the latter portion of FY 1974. The ET represents the only element of the Space Shuttle which is completely expendable. Every effort is being made to reduce the cost of ET components to an absolute minimum by using low cost materials and production techniques consistent with safety considerations.

FY 1975 funding will provide for completion and certification of tooling required for fabrication of the major components of the ET structural and propulsion test articles. Design of the ET will have progressed to the point where fabrication of major components of the structural and propulsion test articles can begin. These include the liquid hydrogen tank, the liquid oxygen tank, skirt, nose cone, and intertank structure.

Incremental critical design reviews (CDRs) will be held on major components of the ET during FY 1975 and a final CDR will be held during the latter part of the fiscal year. Final design drawings will be released upon completion of each incremental CDR and procurement of designated long lead items will be initiated for the dynamic test article and the first flight tank.

FY 1975 funding provides program support for ET development including activation of structural test facilities and restoration and modification of existing fabrication equipment at the Michoud Assembly Facility. In addition, funds will allow the ET prime contractor to use the computer facility at Slidell, Mississippi, for support of engineering, manufacturing and business operations.

FY 1975 funding will also provide for manufacturing applications development of thermal protection system materials for the ET to be performed in existing facilities at MSFC. Welding development will be conducted in the MSFC laboratory to verify high risk weld development areas. Late in FY 1975, modifications will begin on the MSFC barge which will be utilized for transporting the test tanks and early flight development tanks. Propellants and pressurants used in the ET program are government furnished and will be procured with this funding.

Launch and Landing

	1973	1974	1975
Launch and landing.....	---	$2,600,000	$11,600,000
Total.....	---	$2,600,000	$11,600,000

Earlier space vehicle launch systems consisted of a large number of non-standard consoles and operators, each dedicated to a single use and not easily responsive to changes in the system being monitored and controlled. Recent technology advances make it practical to use integrated computer technology throughout the launch facilities for automatic checkout, fault isolation, test sequencing and control. Advances in display and control techniques allow for a more universal type of operator station which does not have to be permanently dedicated to specific functions but can be programmed to fit specific requirements. Each operator station will have the capability of monitoring and controlling a large number of parameters through the use of the computers. To reduce launch costs and meet the stringent turn-around requirements imposed by Shuttle operations, the Shuttle program will take advantage of these improvements and a new automated launch processing system (LPS) will be employed.

The LPS will consist of two related, but somewhat separable systems: (1) a monitor and control system for testing, checking out, safing, and operating the vehicle and ground systems during Shuttle ground operations; and (2) a central data system (CDS) for providing supplementary data services. The CDS will make maximum use of computers and other data handling equipment already existing at the Kennedy Space Center. The major system elements of the LPS consist of: consoles (displays and controls), computers, data transmission system (data bus, data handling equipment), interface units to associated ground facilities, and computer programs.

FY 1974 funding is being used to define requirements, to assure compatibility of overall software and hardware design, and to provide preliminary design specifications for computer programs and documentation.

FY 1975 funding is required for software analysis (detailed documentation of the method of operation and maintenance of computerized systems) including the generation of software performance specifications and standards for the LPS. Design for the checkout system hardware will also be initiated.

FY 1975 funding will be required to finalize design requirements, to procure selected check out hardware and to test prototype equipment. In addition, FY 1975 funds will provide for engineering and engineering support services in connection with design and activation of Space Shuttle launch and recovery facilities.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1975 ESTIMATES

BUDGET SUMMARY

OFFICE OF MANNED SPACE FLIGHT — SPACE FLIGHT OPERATIONS PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1973	1974	1975
Apollo Soyuz test project.....	$38,500,000	$90,000,000	$114,600,000
Development, test and mission operations.....	294,000,000	220,200,000	175,200,000
Space life sciences.....	23,500,000	21,000,000	18,000,000
Mission systems and integration.	21,000,000	15,500,000	15,500,000
Skylab.....	502,000,000	233,300,000	---
Total.....	$879,000,000	$580,000,000	$323,300,000
Distribution of Program Amount by Installation:			
Johnson Space Center.....	$294,583,000	$265,807,000	$135,709,000
Kennedy Space Center.....	182,020,000	102,979,000	89,800,000
Marshall Space Flight Center	380,322,000	191,059,000	85,430,000
Goddard Space Flight Center.	645,000	822,000	250,000
Jet Propulsion Laboratory...	802,000	634,000	775,000
Wallops Station.....	150,000	160,000	---
Ames Research Center.....	9,038,000	9,123,000	7,536,000
Flight Research Center.....	96,000	100,000	100,000
Langley Research Center.....	1,356,000	988,000	550,000
Lewis Research Center.....	410,000	250,000	250,000
Headquarters.....	9,578,000	8,078,000	2,900,000
Total.....	$879,000,000	$580,000,000	$323,300,000

HIGHLIGHTS OF BUDGET PLAN

Apollo Soyuz Test Project

Command and Service Module - Completion of spacecraft and launch adapter modification, delivery to Kennedy Space Center; modification

	1973	1974	1975
of backup spacecraft; guidance and navigation programs; preflight checkout and verification; engineering support during assembly, launch preparation and flight, contract administration.....	$12,600,000	$32,300,00	$8,000,000
Docking Module and Docking System - Final checkout and ground testing of test and flight articles; engineering support....	21,000,000	21,700,000	3,400,000
Experiments - Development, testing, qualification and integration of experiments; participation of principal and coinvestigators in appropriate mission activities; data retrieval, reduction and anlysis for one year after the mission.....	---	8,000,000	5,000,000
Launch Vehicle - Stage sustaining engineering, systems engineering and integration.....	---	9,500,000	32,500,000
Launch Operations - Continued contractor support to modify, test and operate the launch facilities and equipment prior to and during launch operations.....	---	8,900,000	45,000,000
Flight Support and Operations - Crew and flight controller training on ASTP equipment; fuels and pressurants for checkout of the command and service module and docking module; module and hardware transportation; cartography; engineering support of command and service module, docking module and docking system; procurement of Government-furnished equipment; crew			

	1973	1974	1975
provisioning and television; equipment to support module and systems testing and checkout; mission analysis and recovery planning; language translation services; modification of the mission control center; conduct of the mission, including recovery.....	$4,900,000	$9,600,000	$20,700,000
Total, Apollo Soyuz Test Project.....	$38,500,000	$90,000,000	$114,600,000
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. Biomedical support of spacecraft design; operational support related to flight crew health; and space flight medical studies.....	56,200,000	56,800,000	52,900,000
Reliability, Quality and Safety - Support activities involving reliability assurance, risk analysis, and test and checkout of subsystems, components, and support equipment as related to development, manufacture, delivery, prelaunch checkout, and launch of space vehicles and payloads...	8,400,000	5,300,000	4,200,000
Total, Research and Test Operations.....	$64,600,000	$62,100,000	$57,100,000

	1973	1974	1975
Crew and Flight Operations			
Crew - ASTP mission and proficiency training of astronauts; hardware update of simulators and trainers; pilot equipment; operational activities involving mission simulators, part task trainers, and aircraft.....	$15,600,000	$10,100,000	$9,400,000
Flight - Mission planning and updating; flight control; computation facility operation including the data reduction complex; computer modifications related to experiment data conversions; crew procedure updates.....	20,721,000	16,900,000	12,100,000
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.....	36,700,000	33,400,000	19,400,000
Total, Crew and Flight Operations.....	$73,021,000	$60,400,000	$40,900,000
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; computer services;			

	1973	1974	1975
chemical purging services; design and drafting involving launch equipment and facilities; telecommunications; and maintenance of technical and production facilities.....	$82,079,000	$51,800,000	$43,100,000
Total, Operations Support....	$82,079,000	$51,800,000	$43,100,000
Launch Systems Operations			
Mechanical Ground Systems - Operation and maintenance of launch complex facilities and related equipment, including the mobile service structure, mobile launchers, altitude chambers, propellant loading systems, pneumatics, and Vertical Assembly Building mechanical systems; launch-related services involving propellant handling, life support, technical shops, chemical cleaning, and systems safety.....	37,300,000	21,900,000	19,900,000
Electrical Instrumentation Systems - Operation and maintenance of electrical/electronic and launch instrumentation systems, including automatic checkout equipment, operational voice and TV communications, and other electrical/electronic systems.....	37,000,000	24,000,000	14,200,000
Total, Launch Systems Operations.....	$74,300,000	$45,900,000	$34,100,000
Total, Development, Test and Mission Operations.	$294,000,000	$220,200,000	$175,200,000

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	1973	1974	1975
Space Life Sciences			
Space Life Research - Medical, behavioral and biological research and biomedical experiment definition to investigate biological and human responses to space flight.....	$12,021,000	$10,500,000	$8,900,000
Life Support and Protective Equipment - Development and testing of improved, cost-effective astronaut life support and safety systems and equipment, including high performance space suits, regenerable atmospheric control and improved waste management....	6,619,000	7,000,000	6,000,000
Bioinstrumentation and Man-Machine Technology - Development of technology and procedures for the measurement of physiological, medical and performance responses in space; studies, advancement of technology and augmentation of human capabilities through use of man-machine systems and devices like teleoperators and robots....	4,860,000	3,500,000	3,100,000
Total, Space Life Sciences...	$23,500,000	$21,000,000	$18,000,000
Mission Systems and Integration			
Payload Integration and Mission Analysis - Studies and analyses involving payload and operational requirements definition for use as design data for Shuttle, Tug and Spacelab; assure hardware and support systems interface compatibility; low cost concepts for payload design and operations; new payload development approaches; new payload applications; the development of low cost, reusable general purpose mission equipment			

	1973	1974	1975
to accommodate differing payloads; and the formulation of procedures and systems for orbital and ground handling operations.....	$6,000,000	$5,500,000	$5,500,000
Spacelab/Concept Verification Testing - Continued operations-oriented studies; fabrication and use of engineering mock-ups; concept verification testing involving acquisition of subsystems for interface testing and development of associated computer software.....	6,000,000	2,500,000	2,500,000
Advanced Development - Development and test of new technology concepts, components and systems, and study of advanced operational procedures and techniques for future programs to reduce program technical risks and development costs; initiation of long-lead hardware development; improvement of in-house technical management and decision-making capabilities; emphasis on multi-program applications and high leverage new technology developments.....	9,000,000	7,500,000	6,000,000
Space Tug - Define NASA requirements for development of initial upper stage system for Space Shuttle; conduct systems analyses and exploratory development of a subsequent advanced technology space tug system; determine technology requirements.....	---	---	1,500,000
Total, Mission Systems and Integration.....	$21,000,000	$15,500,000	$15,500,000
Skylab.....	$502,000,000	$233,300,000	---

FY 1975 funding is not required.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1975 ESTIMATES

OFFICE OF MANNED SPACE FLIGHT — SPACE FLIGHT OPERATIONS PROGRAM

FLIGHT SCHEDULE

PROJECT	MISSION	CALENDAR YEAR
Apollo Soyuz Test Project	International Docking Test	July 1975

OFFICE OF MANNED SPACE FLIGHT — SPACE FLIGHT OPERATIONS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Space Flight Operations program includes the Apollo Soyuz Test Project; the developmental and supporting activities conducted under development, test and mission operations; space life sciences; mission systems and integration; and the Skylab program.

The U.S. and the USSR have agreed to jointly implement the Apollo Soyuz Test Project (ASTP) to develop and test a compatible system for rendezvous and docking of future manned spacecraft and stations that would be suitable for use as a standard international system. The ASTP is a 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 and in-flight experiments 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 its programs, together with the provisions for crew training, and launch, flight, and operational support required for space flight missions.

Space life sciences complements ongoing 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: payload integration and mission analysis, spacelab studies and concept verification testing, advanced development, and the definition of NASA requirements for a space tug.

The planned objectives for the Skylab program have been accomplished. FY 1975 funding is not required.

BASIS OF FUND REQUIREMENTS:

Apollo Soyuz Test Project

The Apollo Soyuz Test Project (ASTP) is a joint endeavor of the United States and the Soviet Union as part of the agreement on cooperation in space which President Nixon signed in Moscow in May of 1972. Both countries have agreed to develop compatible rendezvous and docking systems which will provide a basis for docking and rescue on future spacecraft of both nations, and to conduct a joint experimental mission in mid-1975 to rendezvous and dock a manned Apollo spacecraft with a manned Soyuz-type spacecraft to test these docking systems in orbit. Each nation is separately developing docking systems based on a mutually agreeable single set of interface design specifications.

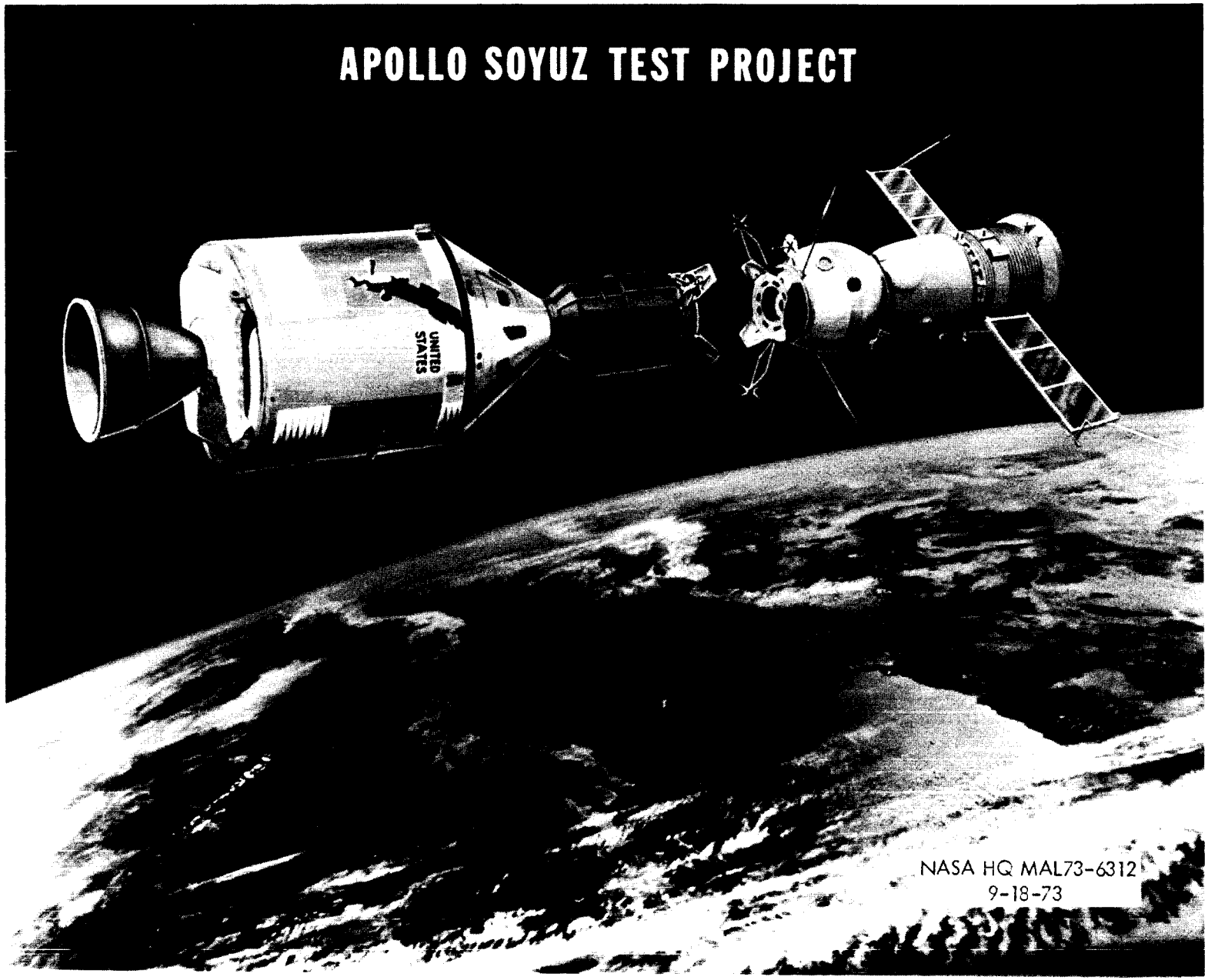
The major new U.S. program elements are a docking module and docking system necessary to achieve compatibility of rendezvous and docking systems with the USSR developed hardware to be employed on a Soyuz spacecraft. The docking module and system together with an Apollo command and service module (CSM) will be launched on a Saturn IB launch vehicle. The docking module and the docking system will be stowed in the spacecraft launch vehicle adapter and extracted by the CSM while in earth orbit in a manner similar to that used with the lunar module on an Apollo lunar mission.

The ASTP mission will include testing a compatible rendezvous system in orbit; testing the compatible docking systems; verifying techniques for transfer of astronauts and cosmonauts; conducting experiments while docked and undocked; developing experience for the conduct of potential joint flights by U.S. and USSR spacecraft, including, in case of necessity, rendering aid in emergency situations.

Joint US/USSR working groups have been meeting on a scheduled basis to review and agree on the technical and operational aspects of the joint project.

Apollo Soyuz Test Project

	1973	1974	1975
Command and service module.....	$12,600,000	$32,300,000	$8,000,000
Docking module and docking system.....	21,000,000	21,700,000	3,400,000
Experiments.....	---	8,000,000	5,000,000
Launch vehicle.....	---	9,500,000	32,500,000
Launch operations.....	---	8,900,000	45,000,000
Flight support and operations..	4,900,000	9,600,000	20,700,000
Total.....	$38,500,000	$90,000,000	$114,600,000


APOLLO SOYUZ TEST PROJECT
UNITED STATES
NASA HQ MAL73-6312
9-18-73

Command and Service Module

The Apollo spacecraft will be a modified version of the command and service module (CSM) flown during the first several lunar landing missions. Major CSM modifications include additional propellant tanks for the reaction control system and the addition of controls and displays required for the proper operation of the docking module and docking system.

Fiscal Year 1974 funding provides for spacecraft modifications; spacecraft launch vehicle adapter modifications including a truss to accommodate the docking module during launch; guidance and navigation requirements; and required ground testing. All the basic modifications to the prime spacecraft for the ASTP mission have been completed and experiment integration modifications are being performed. 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.

Fiscal Year 1975 funding will provide for completion of modifications and checkout and for delivery of the flight spacecraft and launch vehicle adapters to the Kennedy Space Center; modification of the backup spacecraft; and development of compatible rendezvous and docked configuration guidance and navigation programs for the mission, including preflight checkout and verification.

Fiscal Year 1975 funding will also provide for inplant engineering support for the flight spacecraft during the space vehicle assembly and checkout, the preparations for launch and the flight mission. Contract administration services provided by the Department of Defense on a reimbursable basis are also included.

Docking Module and Docking System

The docking module is cylindrical in shape and is approximately 1.5 meters (about 5 feet) in diameter and 3 meters (about 10 feet) in length. It will serve as an airlock for the internal transfer of crewmen between the different atmospheres of the Apollo and Soyuz spacecraft. The docking module will be equipped with radio and TV communications, antennas, stored gases, heaters, and the displays and controls necessary for transfer operations.

The docking module is designed to handle two crewmen simultaneously. Hatches having controls on both sides will be installed at each end of the module. A universal docking system will be located at the Soyuz end of the module and will be capable of functioning with similar components on the Soyuz-type spacecraft.

Fiscal Year 1974 funding provides 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. Joint US/USSR testing of the docking system was successfully accomplished at the Johnson Space Center late last fall.

Fiscal Year 1975 funding will provide for final manufacturing checkout of the docking module test and flight articles; required ground testing; and engineering support involved in such activities as the docking module thermal vacuum qualification tests, the joint docking system qualification tests, and the US/USSR final joint docking system equipment acceptance review.

Fiscal Year 1975 funding will also provide for development center engineering support for the flight docking module at the Kennedy Space Center during space vehicle assembly, final joint US/USSR docking system preflight compatibility tests of the flight hardware, and support of the docking hardware in preparation for launch including the final flight readiness review and the flight mission.

The docking module design emphasized low cost construction made possible by the launch weight margin inherent in the use of the Saturn IB launch vehicle. Thick aluminum plate was used rather than honeycomb, resulting in a considerable reduction in structural cost. In addition, this docking module design approach was undertaken to demonstrate the payload savings opportunities afforded by large lift capabilities such as will be provided by the space shuttle in the 1980's.

Experiments

During the ASTP mission, the crew will conduct important new science, applications, technology and medical experiments.

The science experiments selected for the mission include astronomical observations in a region of the electromagnetic spectrum which has not been systematically surveyed by satellite instruments. The astronomical observations, which are in the low energy X-ray and extreme ultraviolet regions, should significantly advance our understanding of some of the spectacular new classes of objects discovered in the last few years (such as quasars, pulsars, and X-ray sources), and also provide important information on the nature of the interstellar medium. In addition, atmospheric observations will be conducted using a new technique for measuring atmospheric constituents which are too chemically reactive to measure directly with a mass spectrometer. This is a joint experiment with

the USSR and will be accomplished by sending an optical signal from the CSM to a reflector on the Soyuz. The signal will be bounced back and scanned in the Apollo spacecraft to study the effects of the sun on atomic oxygen and nitrogen at orbital altitudes. These observations are important for a better understanding of the chemistry and the energy balance of the upper atmosphere. Data from these experiments could lead to a better understanding of the evolution of stars, of the emission processes which could lead to new methods of energy generation, and of the interaction of the upper and lower atmosphere where weather is generated.

The experiments in the field of applications and technology will investigate the space processing of new material samples in zero gravity utilizing an improved multipurpose furnace, and make earth observations to determine detailed gravity features and geological structures which could indicate the presence of oil and mineral deposits. Also included in this field is the experimentation of electrophoresis processing, a process where an electric field will be used to separate living cells and other biological materials from a flowing medium without decreasing their activity to determine whether the near zero gravity conditions enhance a similar process now involved in work by the Max Planck Institute in Germany on treatment of cancer by cell transfusions and transplants.

The life sciences experiments include extension of work done in the Apollo and Skylab programs, such as additional study of the phenomena of the cosmic light flashes observed by Apollo flight crews and studies of the effects of zero gravity and radiation on organisms. Studies will also be conducted on pre and post flight astronaut blood samples to determine, among other things, immunity retention. There are also joint US/USSR life science experiments planned, such as an experiment designed to determine the degree of transfer of micro-organism and microflora between crew members and the two spacecraft involved in this mission. This experiment is designed to take advantage of a mission involving two spacecraft launched from widely separated ground environments.

Fiscal Year 1974 funding provides for design and development efforts on these experiments. The experiments have been selected and approved for flight on the mission. FY 1975 funding will provide for the continued development, testing, qualification and integration of these experiments into the command and service module and the docking module.

Fiscal Year 1975 funding will also provide for participation of the experiment principal and coinvestigators in premission planning, crew training and flight readiness reviews. Data retrieval, reduction and analysis for one year after the mission is also included.

Launch Vehicle

ASTP will utilize residual Apollo-Skylab Saturn IB launch vehicle hardware. The Saturn IB, consisting of an S-IB stage, an S-IVB stage, and an 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 provides 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 provides for launch vehicle support and for the update of launch vehicle ground support equipment and of the system development facility. The primary launch vehicle final checkout was completed late last fall.

Fiscal Year 1975 funding will provide for stage sustaining engineering and systems engineering and integration activities. The stage engineering capability will provide those engineering skills necessary to carry out contractor stage design responsibilities. These include continuing development of checkout criteria and requirements; checkout data analysis and evaluation; required make-it-work changes, failure analysis, logistics management and other engineering activities required to support the final flight readiness review.

Systems engineering and integration activities include launch vehicle flight mechanics and trajectory studies for design and development of the launch vehicle flight program, flight and propulsion performance predictions and structural assessment of the stacked launch vehicle.

Launch Operations

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

Fiscal Year 1974 funding provides for initiating required contractor support to modify, test, and checkout the launch facilities and ground support equipment and to make preparations for the launch operations.

Fiscal Year 1975 funding will provide for the continuation of this contractor support including final assembly of the space vehicle, movement of the vehicle to the launch pad, final checkout at the launch pad, and launch. Funds are also provided for fuels and pressurants to support the space vehicle checkout at the Kennedy Space Center, and the flight mission, and for the systems engineering effort to provide stage and command service module support necessary to meet all test, checkout and flight readiness activities required for the final readiness review and the launch.

Flight Support and Operations

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

Fiscal Year 1974 funding provides for programmatic engineering support for the CSM, docking module and docking system; maintenance of camera systems;

food and waste systems; bioinstrumentation; and CSM fuels and transportation. Additionally, this funding provides for the initiation of procurement of Government-furnished equipment including space suits, crew provisioning, and television. Communication and docking system tests and evaluations and the use of automatic checkout equipment utilized previously on Apollo and Skylab will also be funded.

Fiscal Year 1975 funding provides for continued procurement of Government-furnished equipment, communication and docking system tests and evaluations, and the use of checkout equipment to support module and systems testing and checkout.

Fiscal Year 1975 funding will also provide for training of crew and flight controllers on ASTP equipment; maintenance of the docking module trainer; CSM fuels and pressurants to support test and checkout of the CSM and docking module; module and hardware transportation; cartography, and programmatic engineering support for the CSM, docking module, and docking system.

In addition, mission analysis and recovery planning; language translation capability including interpreters; operations modifications to the mission control center in support of the flight mission; and the conduct of the mission including recovery will be funded.

Development, Test and Mission Operations

Development, Test and Mission Operations (DTMO) provides for the equipment, supplies and the support contractor augmentation of in-house manpower at Manned Space Flight Centers to maintain the basic capabilities necessary to conduct manned space flight research and development. The nucleus of all Manned Space Flight space activities rests in the Centers with their complement of civil servants. At the Centers, this complement, by design, has been held to a minimum to accommodate essential technical and management expertise. These capabilities are augmented through the use of more than 30 R&D support contractors who provide critical skills not otherwise available. During FY 1975 DTMO will fund approximately 6,500 support contractor personnel employed as part of Manned Space Flight's institutional capability which is required to pursue our ongoing and planned efforts. The retention of this NASA in-house expertise developed during the Mercury, Gemini, Apollo, and Skylab programs is essential for application to and support of future programs.

Institutional capabilities are those common to all programs being conducted or proposed. For instance, in-house capabilities must be maintained to conduct launch and mission operations and to conduct flight crew training.

In-house capabilities must also exist to provide early project definition including conceptual design, project specifications, advanced development, and research and technology; to provide engineering support for in-depth technical examination of the work performed by the prime and major subcontractor on major programs such as the space shuttle and the Apollo Soyuz Test Project; and to provide backup design, testing and analysis in high technology areas of design and development. In addition to providing these basic overall capabilities, in-house efforts, of which development, test and mission operations is a part, can and do support specific programs and this support is so identified. Examples are specific program tasks resulting in required end items that have not been placed under prime contract but are essential to the successful completion of the program.

Specific development, test and mission operations tasks include operation and maintenance of Launch Complex 39 as well as other technical facilities and ground support equipment at the Kennedy Space Center; providing highly technical and specialized engineering support to the research and development laboratories of the Marshall Space Flight Center and the Johnson Space Center; and maintenance and operation of the mission control center, crew training simulators and training facilities at the Johnson Space Center. Also included are the maintenance of astronaut crew training aircraft at Johnson; reimbursement for services provided by the Air Force's Eastern Test Range in support of launch activity conducted by the Kennedy Space Center; on-site technical services involving maintenance, facility refurbishment, documentation and technical report preparation, design engineering, communications, electronic component fabrication, rigging, photographic services and chemical cleaning; and facility operations at the off-site locations: White Sands Test Facility, the Michoud Assembly Facility, the Mississippi Test Facility, and the Slidell Computer Complex.

Fiscal Year 1975 funding will continue support to manned programs, including extensive preflight activities in support of the ASTP mission in July 1975 and in-house support complementing the effort of the space shuttle contractors, as the momentum of the shuttle development activities increases significantly. Additionally, support will be provided to flight supporting activities conducted under life sciences, mission systems and integration, and advanced missions.

Development, Test and Mission Operations

	1973	1974	1975
Research and test operations..	$64,600,000	$62,100,000	$57,100,000
Crew and flight operations....	73,021,000	60,400,000	40,900,000
Operations support.....	82,079,000	51,800,000	43,100,000
Launch systems operations.....	74,300,000	45,900,000	34,100,000
Total.....	$294,000,000	$220,200,000	$175,200,000

Research and Test Operations

	1973	1974	1975
Engineering and test.....	$56,200,000	$56,800,000	$52,900,000
Reliability, quality and safety.....	8,400,000	5,300,000	4,200,000
Total.....	$64,600,000	$62,100,000	$57,100,000

Research and test operations provides a spectrum of technical, engineering, scientific, medical, reliability and quality assurance and safety support operations, and complements the activities of the major development contractors who are spread across the country in contractor-owned facilities or Government plants. During FY 1975 research and test operations will support the Apollo Soyuz Test Project, which is scheduled for launch in July 1975; the rapidly increasing space shuttle activities; the efforts complementing the European spacelab development; the shuttle utilization planning and the other research and development activities in the fields of life sciences, concept verification testing, advanced development, and advanced missions studies.

Specific examples of ASTP support to be provided from FY 1975 funding include: (1) documenting launch vehicle test plans and requirements; verifying Saturn IB vehicle loads analysis for liftoff, thrust, cutoff and separation time points; analyzing flight sequence requirements; and verifying preflight launch vehicle propulsion performance predictions; and (2) supporting astronaut crew training in the use of extravehicular equipment, umbilicals, cameras, crew equipment; (3) monitoring spacecraft systems and crew equipment; and (4) performing tests in small vacuum chambers on a variety of flight items and components including cables, cameras, drive motors, filters, and tools.

Examples of FY 1975 space shuttle support to be provided at the Johnson Space Center include: (1) thermal vacuum chamber testing of the orbiter radiator design in the Space Environmental Simulation Laboratory; (2) the continuation of shuttle orbiter technology and definition testing for propulsion systems, altitude control and translation systems, thermal protection systems, structural systems and materials, and shuttle avionics integration; (3) in-house support to the orbiter contractor by providing hybrid simulator support, orbiter antenna test and evaluation, communications and tracking system ground testing, selected components test and evaluation, sensor studies and evaluation, and development of orbiter displays and controls, orbiter data processing system hardware, and orbiter performance monitoring systems. FY 1975 funding utilized at the Johnson Space Center

will also provide for technical overview of checkout systems, electrical power systems instrumentation, communications, tracking systems, control and display systems, audio systems, telemetry systems, flight control systems, and guidance, navigation, and control systems; and for systems analysis and integration efforts including developing mathematical models for use in mission analysis, performing thermal environmental studies, determining the drag, static stability, and control effectiveness during ascent, and providing aeroacoustic engineering for ground wing loads.

At the Marshall Space Flight Center, FY 1975 funding provides for (1) analysis of the dynamics of re-entry of the solid rocket booster, studying recovery parachute aerodynamics, developing test plans and procedures, performing structural analyses/trade-off studies for design optimization, establishing analysis procedures and ground rules for solid rocket motor failure mode and effects analysis and supporting the development of solid rocket motor design requirements and criteria; (2) support to the shuttle main engine development through preparation and testing of materials, review of detail drawings and test data, development of dynamic math models of engine and components, evaluation of ground handling and operation procedures, and establishment of a hybrid simulation of the engine controller/actuator system; and (3) support of the external tank including performing stress analysis of structures, conducting trade-off studies to optimize structural design, developing test plans and procedures, formulating test criteria for components and performing cost optimization trade-off studies of the propulsion systems.

In addition to the support of program development, the research and test operations FY 1975 funds which are to be provided to the Johnson and Marshall Space Centers support (1) shuttle utilization planning activities; (2) in-house efforts to demonstrate and verify various manned and automated shuttle payload designs and operational concepts including spacelab oriented trade-off studies, developing cost data for systems integration, performing man/systems integration and operations systems analyses, providing materials evaluation, and supporting the updating of logistics support requirements; (3) biomedical activities related to ASTP and shuttle spacecraft design, operational support to manned space flight operations such as flight crew health care and preflight health stabilization, developing and implementing space flight medical studies, conducting primary and basic research in space life sciences, and detailed design of shuttle teleoperator breadboard level control and information transfer subsystems as they are defined through in-house laboratory research; and (4) safety, reliability and quality assurance activities.

Crew and Flight Operations

	1973	1974	1975
Crew	$15,600,000	$10,100,000	$9,400,000
Flight	20,721,000	16,900,000	12,100,000
Mission control	36,700,000	33,400,000	19,400,000
Total	$73,021,000	$60,400,000	$40,900,000

Crew and flight operations includes all activities associated with astronaut training and proficiency, flight operations, operation of the mission control center and operation of the Data Computation Facility. All operations are conducted at the Johnson Space Center where the astronauts are based and the mission control center is located. The requested funding for FY 1975 represents a significant reduction from prior years and results from the reduction in peak flight activities of the Skylab program partially offset by the buildup in shuttle related efforts. During FY 1975 a major portion of the efforts in crew and flight operations will be devoted to preflight activities of the ASTP mission. Preflight activities include operation of proficiency aircraft, operation of procedure and mission simulators, and flight planning. Other operations activities which will be supported include (1) maintenance, modification, and engineering support services relating to the T-38 space flight readiness training aircraft and the KC-135 zero-G aircraft; (2) computation and analysis support of the shuttle program in the Central Data Computation Facility and the Software Development Laboratory; (3) operation, maintenance, and modification of the flight crew simulation and trainer facility including the ASTP configured command module simulator (CSM), the command module trainer and the docking trainer to be utilized for ASTP procedures development and crew training; (4) performance of shuttle mission design studies including detailed studies of mission profiles and sequence of events considering impact of navigation capability, communications, orbiter maneuver capability, crew activities, and systems constraints; (5) ASTP operational support activities including updates, as required, to the operational trajectory plan and the operations launch window plan along with input data for crew training in the simulators, generation of command module computer erasable load, real time computer complex verification, mission simulation support, preparation for real time mission support, verification of targeting procedures, development and implementation of training for flight controllers, and in general, obtaining operational readiness.

Operations Support

	1973	1974	1975
Total	$82,079,000	$51,800,000	$43,100,000

Operations support provides contractor effort and related supplies and equipment to operate and maintain on-site technical services at the three Manned Space Flight centers and their satellite operations at the Michoud Assembly Facility, the Mississippi Test Facility, the Slidell Computer Complex and the White Sands Test Facility. Services involved include maintenance of highly technical facilities and equipment, facility refurbishment and renovation, chemical cleaning, engineering design, documentation and technical report preparation, telecommunications, component fabrication, photographic support and logistics support. A cross section of specific services to be provided in FY 1975 includes (1) ASTP flight control documentation, such as preparing for final publication of the mission-related documents required to meet the flight control operational requirements; (2) precleaning and cleaning of hoses, gauges, tubing, and related flight items that are fabricated in-house; (3) operation of shops to do metal furbishing, anodizing, plating, stripping, and etching of selected items of in-house fabricated flight hardware; (4) engineering, installation, operation and maintenance of closed circuit fixed and mobile television required for support and/or surveillance of tests; (5) photographic sciences including quality control, still and motion picture processing, and audio visual support for the missions; (6) fabrication of models, breadboards, and selected items of flight hardware; (7) research and development supplies and materials which are utilized in Center laboratories or facilities; (8) technical documentation services, telecommunications, and graphics and models; (9) technical services in support of Center operations including operation and maintenance, receipt, storage, issue of supplies and equipment, photographic services, and transportation services; and (10) management services in support of Center operations, including electronic communications, graphics and models, reports, data management, microfilming, storage and distribution of technical documentation.

Fiscal Year 1975 funds will also provide a basic level of maintenance, operation, and support services required at the White Sands Test Facility to support program requirements including materials testing and orbital maneuvering systems test support for the Apollo Soyuz Test Project and space shuttle programs; operation and maintenance of the computer systems at the Slidell Computer Complex; a basic level of maintenance and operation of the Mississippi Test Facility including the technical laboratory services; and a basic level of operation and maintenance of the Michoud Assembly Facility where the external tanks for the shuttle are to be fabricated and assembled.

Launch Systems Operations

	1973	1974	1975
Mechanical ground systems.....	$37,300,000	$21,900,000	$19,900,000
Electrical/instrumentation systems.....	37,000,000	24,000,000	14,200,000
Total.....	$74,300,000	$45,900,000	$34,100,000

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Launch systems operations at the Kennedy Space Center, a complex covering over 140 thousand acres provides for the operation of the checkout and launch facilities, complexes and associated ground support equipment as well as the highly technical services required to support the test, checkout and launch of space vehicles and payloads. During FY 1975 over two-thirds of the funds requested will be devoted to preparing for the Apollo Soyuz Test Project (ASTP) launch scheduled for July 1975.

The flight hardware flow processing at Kennedy Space Center begins with receipt of the prime Apollo Soyuz Test Project spacecraft, the command and service module, in October 1974. The docking module will be delivered in November 1974 and the docking system will be received early in January 1975. Erection of the launch vehicle on the mobile launcher will occur in mid-December 1974. A docking test between the command and service module and the docking module/docking system is scheduled in January 1975. A major test, the flight readiness test, will be conducted in May 1975 to demonstrate that subsystems are in a state of flight readiness. Another major test, the countdown demonstration test, is scheduled for the latter part of June 1975 and is a full rehearsal that includes the performance of the sequence of operations required to prepare the space vehicle for launch in July 1975.

Fiscal Year 1975 funding provides for mechanical ground system activities involving the operation and maintenance of launch complex facilities and related equipment such as mobile transporters, mobile launchers, the converter compressor facility, mobile service structure, altitude chambers, propellant loading systems, pneumatics, and Vehicle Assembly Building mechanical systems. Additionally, launch related services such as propellant handling, life support, technical shops, chemical cleaning, and decontamination and systems safety are provided.

Fiscal Year 1975 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

The space life sciences program provides the understanding and technology necessary to determine man's capabilities and limitations in the space environment and to develop a space environment technology base for the various types of systems which will permit him to live and perform effectively. Many of these research and technology efforts relate very directly to clinical health care on earth. Because gravity profoundly affects many of the body's fluid and gas dynamics, problems of basic physiology can be studied in a different manner by examining the changes which occur when man is moved from

normal gravity to the weightless state. For example, gravity causes a difference in ventilation between the lower and upper parts of the lungs. The reasons for this difference are not generally agreed upon by medical scientists. Zero gravity provides an ideal environment for studying this phenomenon. One of the dividends of space flight in the future will be the opportunity to carry out such investigations.

The primary areas of activity in the space life sciences program are: space life research, life support and protective equipment and bioinstrumentation and man-machine technology. This multidisciplinary program, pursued through ground-based and flight research programs, conducts studies of man as an operator and controller of space equipment, and provides advanced technology and development related to life support, protective and other systems required to support man and 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. These data are to provide the criteria for choosing shuttle crew members.

Space Life Sciences

	1973	1974	1975
Space life research.....	$12,021,000	$10,500,000	$8,900,000
Life support and protective equipment.....	6,619,000	7,000,000	6,000,000
Bioinstrumentation and man-machine technology.....	4,860,000	3,500,000	3,100,000
Total.....	$23,500,000	$21,000,000	$18,000,000

Space Life Research

Space life research provides for the conduct of ground-based and space flight research designed to enhance man's ability to function effectively and safely during space flight, and to conduct life sciences research using the unqiue environment of space to support and advance earth-based science. This multidiscipline research program encompasses medical, behavioral and biological research, and the definition of space flight biomedical experiments. The primary objective is to maintain a research base investigating all pertinent aspects of known and anticipated problems of human response to space flight and to provide rapid response to new problems as they may arise.

Looking forward to the day when scientists without full astronaut training can go into space in the shuttle to make scientific medical observations,

studies were initiated in the FY 1974 space life research program to determine the selection criteria for the shuttle scientific experimenter passengers. Human capabilities, performance limitations, relationships of these things to observed physiological changes, and the techniques or mechanisms for coping with adverse effects of space flight are all under investigation. Likewise, there was a continuation of the ground research on the physiological mechanisms identified by Apollo and Skylab which appear to have a direct bearing on man's ultimate performance capability in space flight.

Skylab produced more medical information on man's adaptation to weightless space flight and his readaptation to one "G" following the mission than all the previous manned space flights to date. Many of the ground-based research postulates have been partially substantiated by the Skylab inflight and post-flight findings. The cardiovascular, vestibular, neurophysiological, metabolic, endocrine, electrolyte, habitability and performance findings have produced in-flight data which will be used by the ground-based research program in focusing its efforts on those facets requiring further concentrated study in preparation for future manned space flights.

As a result of biomedical findings to date, FY 1975 emphasis in the space life research area will concentrate on demonstrated measurable changes, e.g., cardiovascular system dynamics, mineral and muscle mass losses, red blood cell mass loss, and motion sickness. Emphasis will be placed on understanding the relationship of time to these changes in order to facilitate countermeasures research designed to produce effective methods of protecting flight crews and passengers against these physiological changes or any serious related consequences. Such efforts will include refinement of the lower body negative pressure stress test to provide a better assessment of weightlessness adaptation in flight and the resultant effects following re-entry to a one "G" environment. An improved vestibular screening test designed to reduce the impact of postlaunch motion sickness will also be developed for use in selecting shuttle passengers.

Fundamental to the understanding of the effects of space flight on man is a detailed investigation of basic biologic phenomena as they occur in other living systems. Therefore, in FY 1975 emphasis will also be placed on the detailed definition and evaluation of potential biological flight experiments for space shuttle.

Life Support and Protective Equipment

The goal of this element of the program is the improvement of safety and performance of the crew through the development of more cost effective life

support equipment, and the continued advancement of technology through the development and test of improved life support and astronaut safety systems. Areas of continuing development and testing encompass regenerable atmospheric control (including humidity and contaminant control), water reclamation, waste management, sampling (for medical research), and processing. Emphasis is being placed on reliability, maintainability, and automated control requirements, as well as improved operational characteristics.

In FY 1974, fabrication of an 8 pounds per square inch (psi) spacesuit was completed with improvements in design and reduced tooling costs. Testing of this advanced spacesuit with an improved suit glove has been initiated. The new glove features miniaturized convoluted joints of the thumb and fingers and new glove structure to eliminate ballooning and increase hand and finger mobility. In portable life support systems, a regenerable thermal control subsystem capable of rejecting heat in the range from 500 to 3,200 kilojoules per hour has been delivered and is under test. To meet longer range developments in life support systems, a laboratory model which consists of an integrated water vapor electrolysis oxygen generator and hyrdogen depolarized carbon dioxide concentrator has been completed. This atmospheric regeneration system utilizes two operationally-complementary processes thereby minimizing the number of component parts through the use of multifunctional devices and simplification of design. A microbiological sensor, for water quality measuring using the chemiluminescence method, is being tested to verify its completely automatic features and to evaluate scheduled maintenance requirements as well as its performance capability.

In FY 1975, emphasis will be concentrated on: (1) the development of space suits with high performance capability needed for extravehicular operations in support of future shuttle mission requirements and with more economical "universal" fit configurations, and studies aimed at reducing space suit costs for the future space shuttle; (2) continuing the investigation of technology for the reduction of space cabin atmospheric contaminant levels. Carbon dioxide levels will be reduced through the use of an electrochemical concentrator which in addition offers significant reductions in weight and volume requirements. A new module with optimized electrodes will be completed and tested during FY 1975. Organic contaminant removal will be accomplished by activated carbon impregnated with a nonselective oxidation catalyst, eliminating the necessity for carrying large quantities of expendables for air purification; and (3) improvements in waste management technology to integrate medical instrumentation with the onboard waste collection for automated sampling and analysis.

Bioinstrumentation and Man-Machine Technology

Bioinstrumentation and man-machine technology provides for the development of technology and procedures for the measurement of physiological, medical

and performance responses of man and other selected life species living and working in the space environment. It further includes studies and the advancement of technology in the use of man in man-machine systems and the augmentation of human capabilities through the use of devices such as teleoperators and robots for servicing orbiting space vehicles, support experiments and space exploration.

The FY 1974 funding has provided technology for a free-flying, remotely controlled, simulated teleoperator laboratory vehicle with sensor and manipulation subsystems for investigating on-orbit servicing capabilities; analyses and preparation of man-machine interface design criteria for shuttle payloads utilizing Skylab experiences and test results; a prototype blood analysis system to provide inflight real time measurements of blood materials, electrolytes and enzymes. Non-invasive and implantable cardiovascular instrumentation prototypes have also been provided so that the mechanisms involved in cardiac and vascular functions may be quantified. Major medical and related communication links for the development, testing and integration of subsystems which will make up the field test unit of the Integrated Medical and Behavioral Laboratory Measurement System were also provided in FY 1974.

The FY 1975 emphasis will include the development of instrumentation for the measurement of cardiovascular, metabolic, respiratory, musculoskeletal, and other physiological functions for space medical research and onboard health care delivery systems for crew and passengers. Efforts will continue on the advancement of technology in manipulators, sensors, controls and displays and decision making processes for teleoperators and robots in space and on extraterrestrial surfaces. An engineering model applicable to the shuttle-attached manipulator will be completed for test and evaluation.

Design requirements and criteria for the experiment work sites, to be located onboard space vehicles such as the space shuttle and the Spacelab, will be developed and evaluated in ground-based simulators. Extravehicular activity (EVA) concepts involving mobility, restraint and work site equipment will be studied and a baseline document for EVA will be developed for the space shuttle and future man-tended vehicles.

Mission Systems and Integration

Mission systems and integration program activity is classified into four areas of effort: Payload integration and mission analysis, Spacelab/concept verification testing, advanced development and space tug.

The study and analytical effort under payload integration and mission analysis assures hardware and operational compatibility between payloads and

payload carriers such as the space shuttle, the space tug and the Spacelab. It also provides low cost, standardized and reusable equipment to accommodate a wide range of payloads. Spacelab activities involve operations-oriented studies and mockup fabrication in support of the European Space Research Organization (ESRO) spacelab development activities. The concept verification testing effort deals with interface testing and verification of operational concepts resulting from the spacelab studies. 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. Tug studies support development of a shuttle initial upper stage which would transport payloads to orbits beyond the shuttle's capabilities.

Mission Systems and Integration

	1973	1974	1975
Payload integration and mission analysis	$6,000,000	$5,500,000	$5,500,000
Spacelab/concept verification testing	6,000,000	2,500,000	2,500,000
Advanced development	9,000,000	7,500,000	6,000,000
Space tug	---	---	1,500,000
Total	$21,000,000	$15,500,000	$15,500,000

Payload Integration and Mission Analysis

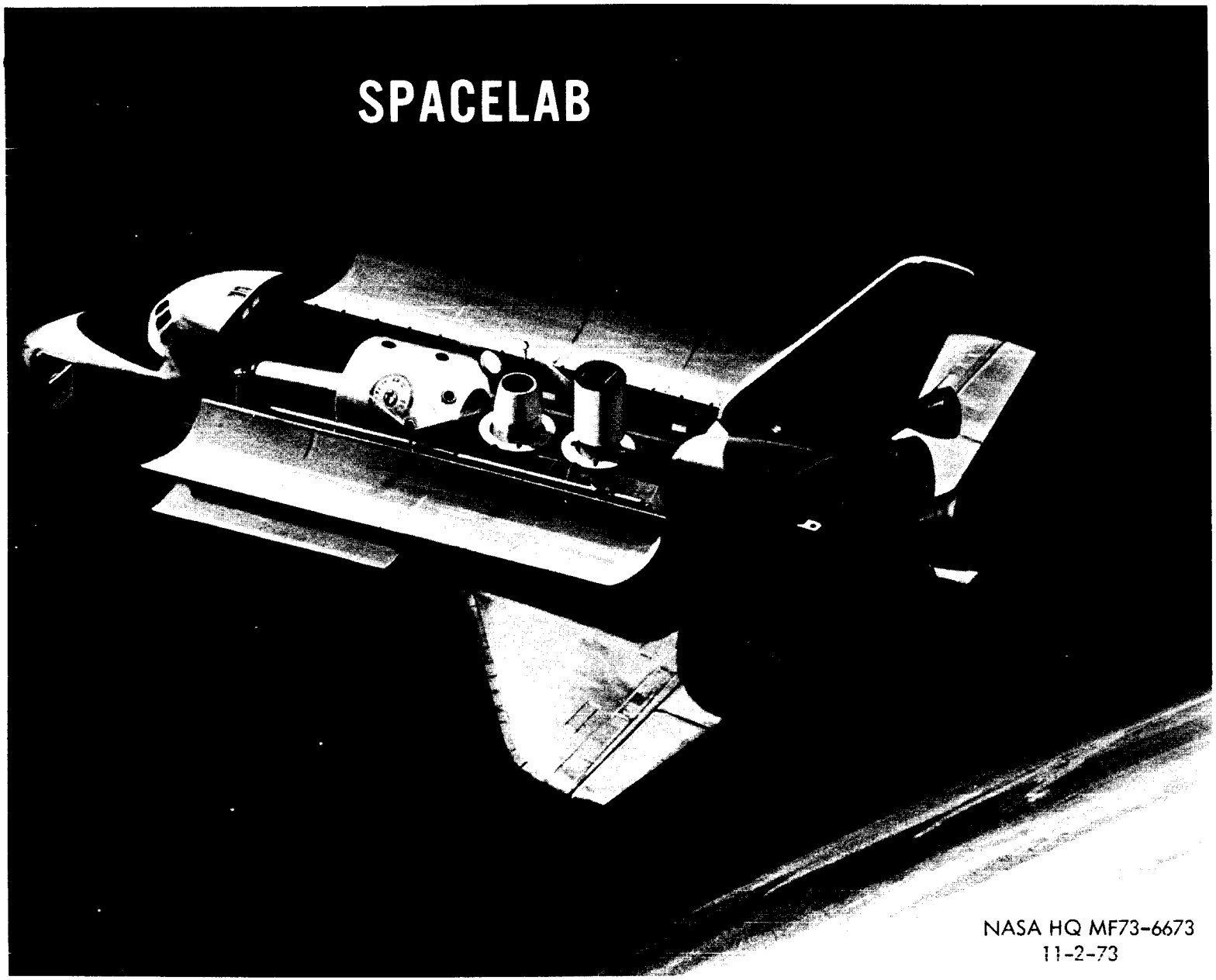
The objectives of the payload integration and mission analysis effort are (1) to assure hardware and operational compatibility between payloads and the space transportation system (STS), which incorporates the space shuttle, the space tug and the spacelab, (2) to obtain the most effective utilization and economical operation of this new space transportation system, and (3) to provide low cost, standardized and reusable equipment to interface with the wide range of payloads to be transported, deployed and serviced by these vehicles.

The principal tasks include defining and projecting user payloads to determine the requirements imposed on payload/carrier vehicle interfaces and on vehicle accommodation modes; examining hardware design variations and scheduling combinations to achieve the most economical mission plans; exploring and defining low cost concepts for payload design and operation made possible by the capabilities of the STS in the spacelab configuration; coordinating with users to incorporate new payload development approaches and to generate new payload applications to most productively operate the

STS; formulating procedures and systems for more efficient operation of the shuttle, tug and spacelab, and for handling payloads both in orbit and on the ground; and defining and developing general purpose mission equipment for use with diverse payloads during all phases of STS operations.

In FY 1974, the payload integration and mission analysis effort involves the development of the 1973 payload model as a projection of user requirements for the shuttle era. Funding supports the initiation of payload definition requirements to establish payload/vehicle interfaces and payload design specifications. These will be incorporated in the final design determinations of the shuttle and in the definition of the spacelab and shuttle upper stage or tug. FY 1974 effort includes an economic assessment of the benefits of the STS versus expendable systems based on the payload model, payload design specifications, and baseline capabilities of the STS. Studies were initiated to provide a preliminary indication of the most attractive of various low cost payload design concepts and operational techniques taking advantage of the novel capabilities of the STS. The FY 1974 efforts also include comparative analyses to extrapolate operational experience with earth-based research such as the Ames Research Center CV 990 aircraft operations, Antarctic expeditions, large observatories (Mount Palomar Observatory, National Radio Astronomy Observatory), etc. to shuttle era operations. Close contact is being maintained with the user community to stimulate interest in shuttle payload activities, to establish an awareness of the potential opportunities provided by the STS and to develop an equitable approach to user funding responsibilities. In addition, preliminary studies were initiated to identify types of general purpose mission equipment needed to satisfy the requirements of the 1973 mission model.

In FY 1975, emphasis will continue to be placed on study effort to define payload criteria and requirements for use in the design of STS elements to ensure payload/vehicle interface compatibility and maximum payload accommodation. Sensitivity studies will be conducted among the hardware elements of the STS to determine the most cost effective designs, schedules, inventories, and operational concepts. Examination of low cost payload design and orbital operations concepts will be continued with emphasis on evaluation of the STS capability to service payloads in orbit. Studies will also be conducted to develop approaches for payload operations to optimize the use of the shuttle system during checkout, launch, in-orbit operations, telemetry, retrieval, and refurbishment. Detailed analysis and planning will be performed for the payloads and operations of the early shuttle flights to ensure an orderly development and checkout of the spectrum of capabilities of the STS. Procedures will be developed to communicate the capabilities of the STS to the users and to stimulate ideas for new applications of the STS. Analyses to develop a policy of charges for the use of the transportation system will



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continue. FY 1975 funds will also support the continued identification, definition, and integration planning of general purpose mission equipment.

Spacelab/Concept Verification Testing

The spacelab will be a versatile experiments payload carrier to be used in conjunction with the space shuttle. By providing the opportunity to duplicate their ground-based facilities in space at low cost, spacelab will allow researchers and scientists to personally conduct their own experiments in the spatial environment. As part of the President's program of promoting greater international participation in the U.S. space effort, spacelab is being assigned and built for NASA by the European Space Research Organization (ESRO). Nine ESRO member nations have mutually agreed to fund ESRO spacelab hardware development to project completion.

Fiscal Year 1974 funds are being used to conduct studies at NASA's Marshall Space Flight Center in support of the European Spacelab development effort. Studies being conducted include engineering cost trades, payloads safety, payload accommodations, and orbital operations. In addition, spacelab funding is supporting the Ames Research Center's airborne Science/Shuttle Experiment System Simulation (ASSESS) program. FY 1975 funding will continue these operations-oriented supporting studies, and initiate fabrication and use of engineering mock-ups.

Concept verification testing (CVT) is a systems integration testing project presently configured to support planning for effective utilization and operation of spacelab. Through breadboards and simulators, CVT provides the means for development of effective interfaces, testing of experiment payloads, and conducting total systems simulations, including software, so that final flight hardware can be designed for high utilization at the lowest possible cost.

Fiscal Year 1974 funding provides for acquisition of most of the subsystems required for full spacelab support capability. FY 1975 funding will complete the subsystem acquisition and the development of associated computer software. Early demonstration experiment activity and testing of commercial equipment for use in spacelab by experimenters will be carried out during both years.

Advanced Development

The objective of the advanced development program is to select and carry forward into development those new technology items that show high promise of advancing the goal to provide more effective means for utilization and advancement of capabilities in space while reducing the cost of space operations.

This program serves as a bridge between the research conducted by the Office of Aeronautics and Space Technology and future manned space flight projects and covers key developments not funded elsewhere. Concentration of effort is made in areas where large payoffs in cost avoidance are expected by performing early development, fabrication and testing of subsystems and components before they are committed to new programs. This early development significantly reduces the technical risk of new programs while providing early understanding of overall capabilities.

Advanced development projects are, in the main, directed toward future systems which have multiple program application and include not only hardware items but also software systems, operational techniques, procedures and testing systems. A major feature of the effort is the development of new technology resulting from the emphasis on developments where the current technology is limited.

This project effort also serves to provide a basis for technical decisions through program planning and integration with the advanced missions studies, contractors' independent research and development efforts and other technology related activity. The following tasks are among those supported in FY 1974:

Communications Advancements - Development of flush mounted antennas for broad application to future spacecraft including shuttle, tug, and spacelab. The system permits the transmittal of wide band data without the usual large dish size and deployment problems. The antennas could be useful for either orbit-to-orbit transmittal or orbit-to-ground transmittal.

Structures and Materials Development and Evaluations - Development of high strength materials and low weight structures for delivery of payloads to orbits. The development of thin gage tankage and composite spacecraft structures relate directly to payload delivery improvement on spacecraft such as the tug. Property improvements in the more usual metallic alloys and improved structural design criteria can lead to reduced weights and/or reduced costs.

Definition, Development and Qualification of Information Management Systems and Software - A reduction in data management cost through the development of onboard, ultra-reliable computers of module design and low weight which are compatible with the software of a variety of commercial computers and through the improvement of required software programs.

Other activities in FY 1974 under advanced development having potential for incorporation into future flight programs include high performance propulsion system components; advanced fuel cell power systems; advanced docking mechanisms; laser systems for scanning radar; and strapdown inertial measurement units.

In FY 1975 the advanced development program will include new work designed to advance man's capabilities and performance in space. Some examples are:

Orbital Operations - Techniques for repair and assembly of large structures in space such as large antennas and telescopes will be investigated. Concepts will be developed for assembly, maintenance and repair accomplished either by EVA or remote procedures. With improved techniques, experience from Skylab and the payload capability of the shuttle, man will be in a position to more effectively use his capability for future space operations in orbit.

Mechanical Systems - On-orbit servicing and retrieval are essential in the expanding role of orbital operations. Docking mechanisms, maneuvering units and de-spin systems will be investigated to support mission requirements.

Inflatable Radiator System - Inflatable, deployable radiator systems will be investigated and demonstrated to provide major advances in thermal control techniques for shuttle, tug, spacelab, and other future systems. This will remove the current restrictions of installing radiators on the limited surfaces available on space vehicles and greatly enhance the capacity, performance, and operational flexibility of future spacecraft.

Self-Contained Autonomous Operation - Data management and checkout functions which on present spacecraft are performed on the ground are to be investigated for incorporation in advanced spacecraft. On-board checkout techniques will provide for automatic status monitoring, diagnostics, control and checkout of subsystems.

Fiscal Year 1975 activity will also include developments initiated in prior years to minimize weight through the use of critical fabrication and inspection techniques, improve cryogenic propellant management, develop high performance engine components, reduce operating costs and qualify advanced computer systems.

Space Tug

The space tug is an integral part of the space transportation system which provides the capability to deliver payloads to higher energy orbits and trajectories than those achievable by the shuttle alone. NASA and the Department of Defense are studying the development of an initial shuttle upper stage to provide this capability on an interim basis. This initial upper stage, a modification of an existing stage, will be capable of meeting most mission requirements in the early years of shuttle operations. NASA is also studying the longer range requirement for an advanced technology tug with increased performance including payload retrieval capability.

NASA activity in FY 1975 will include refinement in detail of NASA and other non-DOD requirements for the initial upper stage system definition effort. In addition, NASA will continue to study the advanced capability tug to identify critical technology requirements, conduct components analyses and tests, and perform systems analyses applicable to the advanced tug. NASA will also study the requirements for an orderly transition from the initial upper stage to the advanced technology tug.

Skylab

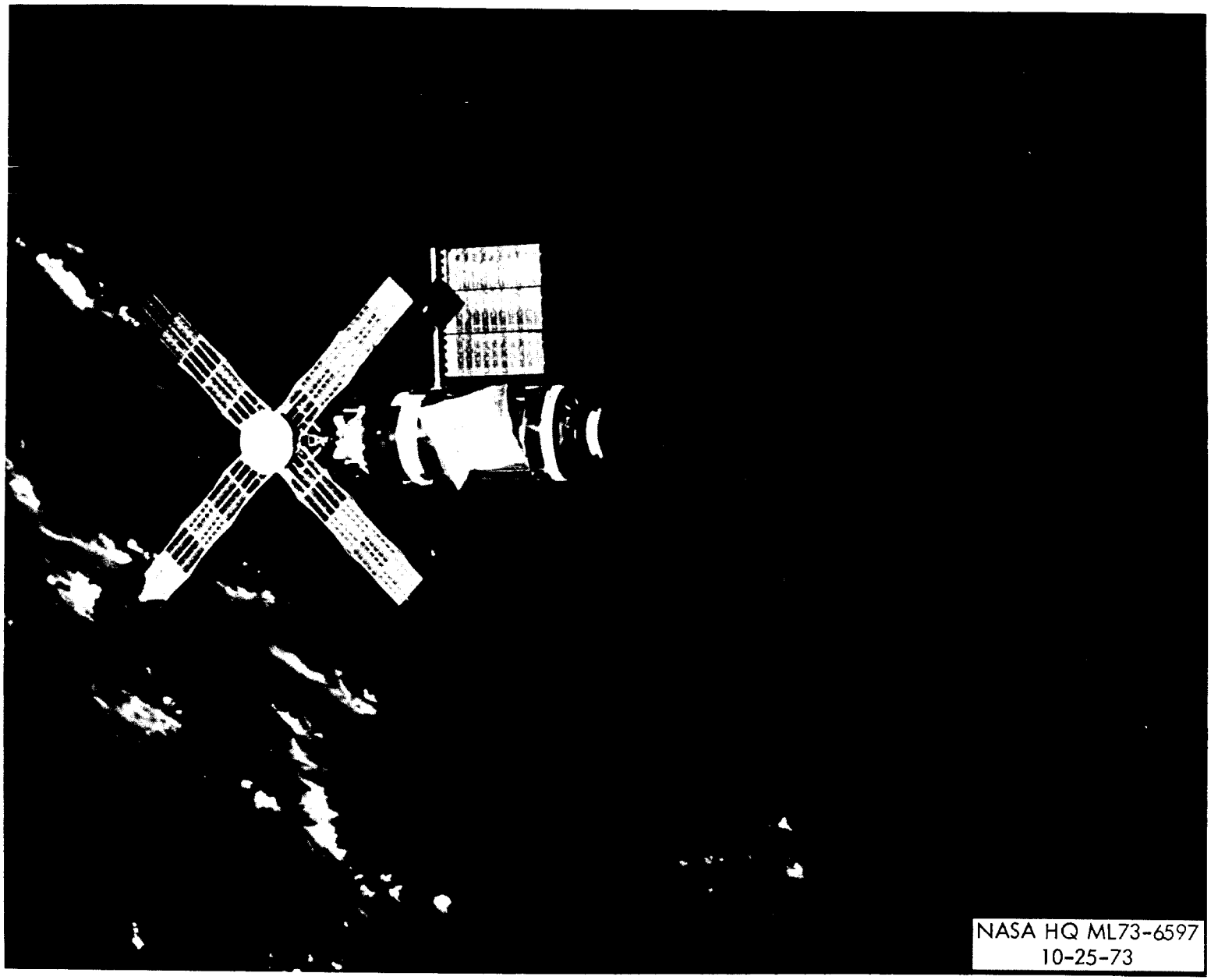
Program Accomplishments

The outstanding success of the Skylab program marks a major turning point in using the vast potential of space operations for the benefit of all mankind. The scope of the Skylab accomplishments not only reaffirms the role of man in space operations but also proves the value of space in advancing science and technology and contributing to the study of the pressing problems facing our planet. The unparalled productivity of the Skylab missions, which are yielding extensive scientific, medical, technological, and earth resources returns, is a preview of the tremendous opportunities ahead in the shuttle era.

Skylab, the nation's first experimental space station, orbits at an altitude of approximately 270 miles above the earth. The Skylab station provided a highly versatile, sophisticated set of laboratories with a capability for multi-pupose scientific and applications experiments. During its nearly nine months of operation, Skylab crisscrossed an area 50° north and south of the equator, where most of the globe's population is concentrated. The three Skylab crews carried out more than fifty major research programs and hundreds of spearate investigations developed by specialists in universities, observatories, medical schools, industry, and Government agencies throughout the United States and abroad. From its unique vantage point in space--beyond the atmospheric veil of earth--Skylab's sensors searched out and recorded new and far reaching information about the solar system, the sun, the earth, and man himself.

The objectives of the Skylab program were to determine man's ability to live and work effectively in space for prolonged periods of time, to extend the science of solar astronomy beyond the limitations of earth based observations, to develop improved techniques for surveying earth's resources and environment from space, and to advanced knowledge in a variety of other scientific and technological disciplines.

The first two Skylab manned missions more than met these objectives and the third and final manned mission, which is nearing completion, is progressing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extremely well. The Skylab 2 mission with Astronauts Conrad, Kerwin, and Weitz as the crew, was launched on May 25, 1973, and completed on June 22. During their 28-day stay, the crew not only carried out a vast array of scientific and applications experiments but also succeeded in repairing the Skylab station, erecting a sunshield to lower the temperature and releasing the jammed solar cell array. Both problems resulted from the loss of the Skylab's micrometeoroid shield shortly after the launch of the Skylab workshop on May 14, 1973. These repairs, which testified to the ingenuity and persistence of a tireless ground and flight team, spelled the difference between program success and failure. The Skylab 2 crew demonstrated the indispensable value of man's judgment and capability to respond rapidly to problems, as well as unforeseen opportunities. The 28-day mission confirmed man's ability to live and work comfortably and efficiently in space. Despite the early difficulties, the major milestone objectives were met. About 80% of the planned solar observations time and 80% of the earth resources passes were accomplished.

The second Skylab manned mission--Skylab 3--was launched on July 28, 1973, and completed on September 25. During almost two months (56 days), the flight crew, composed of Astronauts Bean, Garriott, and Lousma, carried out a highly productive, varied program of experiments. Again, the outstanding efforts of the flight crew and ground team surmounted a series of problems ranging from the command module's reaction control system thrusters to the airlock's cooling system. Among its repair activities, the crew erected a second, supplementary sunshield and installed a special cluster of rate gyros. After an initial adjustment period, the crew found that they could easily work ahead of the preflight plan. Their efficiency and flexibility allowed additional, unscheduled tests and experiments to be conducted. As a result, the yield of experiment data from Skylab 3 exceeded even the most optimistic premission expectations. The crew sustained a high level of performance and capitalized on unforeseen, unique opportunities for solar and earth observations. All sixteen of the medical experiments required by the flight mission plans were accomplished, measuring the course of man's adaption to zero gravity. The Skylab living accommodations were highly satisfactory and zero gravity conditions proved an aid to most activities. As key indicators of the Skylab 3 mission's productivity, about 130% of the scheduled ATM solar observing time was accomplished (305 hours of actual observing time) and all the joint observation program tasks were carried out. In addition, 44 earth observations data runs were conducted, significantly surpassing the total of 28 earth resources experiment passes planned. Student experiments were also successfully conducted.

The third and last Skylab manned mission--Skylab 4-- was launch on November 16, 1973. The Skylab 4 mission, with Astronauts Carr, Gibson, and

Pogue as the crew, is adding significantly to the previous Skylab returns. Assuming that all continues to go well, the mission can last up to 85 days--almost three months' experience in space and a month longer than previously planned. The crew is continuing the solar physics, earth resources and medical experiments. In addition, the crew is using the solar telescopes and special cameras for observations of the comet Kohoutek.

With the completion of the third manned mission--February 8, 1974, for the extended 85-day mission--the flight phase of the Skylab program comes to an end. Its successful completion signals the beginning of a comprehensive, intensive period of activity as the hundreds of Skylab principal investigators all over the globe analyze and interpret the results of the experiments. From preliminary indications, the results will not only exceed all expectations but will also test and perhaps revolutionize many scientific theories. The harvest is just beginning and a new era of increasingly productive space operations--the shuttle era--is opening up. The preliminary Skylab results are a preview of the vast potential in the shuttle era.

Earth Resources Experiments Package

The quality and variety of the returns from the Skylab earth resources experiments dramatically demonstrate the down-to-earth dividends of space operations. From a vantage point in space, the Skylab crews have used remote sensing devices and high resolution cameras to study the earth's environment and resources. Combined with the crews' knowledge and judgment, the complex Skylab equipment furnished an invaluable set of tools for acquiring critical information about spaceship earth. The Skylab data will extend our knowledge about the earth with the purpose of better understanding its resources and processes.

During the first two Skylab manned missions, valuable data on the continental United States and 34 other nations was acquired. The crews also collected detailed data on the Atlantic and Pacific Oceans, the Gulf of Mexico, the Caribbean and the Mediterranean Seas, the South China Sea, the Sea of Japan, and the Gulf of Aden. Over 20,000 earth photographs and 25 miles of computer tapes from the first two missions will be undergoing extensive analysis by 137 principal investigators throughout the United States and abroad. The Skylab 4 earth resources experiments, with up to 50 passes possible, will significantly increase the storehouse of electronic and photographic data.

The Skylab earth resources surveys included research projects in geology that could lead to the discovery of potential sources of oil, coal, and essential minerals. A principal investigator has reported that his study of Nevada geology uncovered a region likely to contain a significant mineral deposit. The Skylab surveys have also yielded initial information on

potential geothermal energy resources in the Western part of the United States and Mexico. Other Skylab geological investigations involved the study of volcanoes in Nicaragua and Italy and earthquake faults in California.

Urban studies are another important facet of the Skylab earth resources experiments. During the first two manned missions, thirteen U.S. urban centers were photographed: Asheville, North Carolina; Aurora and Peoria, Illinois; Cedar Rapids, Iowa; Denver, Colorado; New Orleans, Louisiana; Phoenix and Tuscon, Arizona; Pontiac, Michigan; Riverside-San Bernadino and San Francisco, California; Salt Lake City, Utah; and the Baltimore, Maryland-Washington, D.C. area. The Department of Interior's U.S. Geological Survey will attempt to calculate population growth since the 1970 Census, based on the high spatial resolution Skylab photography. This type of photography holds a great promise for regional planning and land use in urbanized areas. In addition, the Skylab remote sensing techniques were used to acquire survey data on vegetation patterns in states such as California, snow cover depths in Oregon's Columbia River basin, and pollution and weather data in the Great Lakes area.

Meteorological investigations represent another major area of study. Photographic and remote sensing data from Skylab, correlated with the supporting aircraft data, will improve our understanding of weather phenomena, including the development of hurricanes, tornadoes and hailstorms. The Skylab 2 crew, for example, obtained extensive data on the course of Hurricane Ava in the Pacific and storms in Oklahoma and Texas. The influence of eddy currents, observed off the Yucatan Peninsula by the Skylab crews, on ocean currents and weather forecasting techniques is also being assessed.

In addition, the Skylab earth resources surveys are uncovering data that can be used to study conservation of precious water resources. Skylab monitoring of the central Florida lakes is uncovering useful information on the problem of premature aging of a body of water because of excessive nutrients. This information is being provided to local county planning authorities.

The early Skylab results have also yielded valuable data on sea conditions, sedimentation, and marine biology. The Skylab 3 coverage of the Atlantic Ocean's Sargasso Sea, with its millions of tons of seaweed, is also being studied.

The Department of Agriculture is already using Skylab photographs to pinpoint areas along the Texas-Mexico border where insects, such as fire ants and fruit flies, might cross to infect crops.

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Skylab experiment investigators in Mali will use the earth resources data to search dry plains for new water sources. Analysis of the data is expected to provide clues to reverse the southward expansion of the Sahara Desert, which has brought repeated droughts and famine in this part of Africa.

In the final Skylab flight, the crew is concentrating on observations of seasonal changes, sea and lake ice formations, snow cover patterns, and major storms, particularly below the equator. The crew is also conducting comprehensive observations of changes in vegetation in the northern and southern hemispheres.

The Skylab earth resources experiments, performed by well-trained crews using a sophisticated set of cameras and remote sensing devices, are providing a vast storehouse of information about the earth. The results have great potential in advancing the study of geology, cartology, land and water planning and management, agriculture, forestry, weather forecasting, oceanography, navigation and communication, and other areas affecting the quality of life here on earth.

Solar Physics

The Skylab investigations of the sun are opening up a modern era of astronomy. The Skylab solar telescopes, operating in space above the distorting effects of the earth's atmosphere, are yielding new, exciting data about the life-sustaining sun. The data, which are undergoing detailed scientific analysis, promise to revolutionize many of the long-standing theories of solar physics. Scientists are already predicting that the Skylab results will deepen understanding of solar heating characteristics and their influence on the earth.

The importance of Skylab's solar investigations cannot be overestimated. At a time when energy problems are making an increased impact on the world, Skylab data will lead to a far better understanding of the sun's nature and processes. This knowledge may well lead the way to new means of generating and controlling solar energy for use on earth. The staggering power of the sun is illustrated by the fact that in a single second the sun radiates more energy than man has used since the beginning of civilization. Yet the earth receives only one two-billionth part of this energy and uses under one percent of it.

The Skylab data will also advance scientific knowledge of how solar phenomena affect our planet. For example, the Skylab investigations should help to explain the solar flares that periodically disrupt radio communications and trigger magnetic storms, resulting in power blackouts. The observations of sunspots will provide scientific results that will increase insight into the sun's effect on weather.

Before Skylab, the sun's corona was thought to be an essentially unchanging shell of million degree gases. In contrast, Skylab showed that the corona seethes with activity. The crews observed huge solar flares, shooting up over 100,000 miles. During Skylab 2, two "granddaddy" flares produced auroral lights on earth. Each flare, reaching a temperature of a billion degrees, could supply the earth's energy needs for the next 500 years.

The Skylab studies of the comet Kohoutek will test theories on the composition of comets and the origin of our solar system. The Skylab telescopes and cameras provide a matchless opportunity to investigate the nature and evolution of the coma and tails as Kohoutek approaches, passes, and recedes from the sun, not to return for some 75,000 years. Scientists hope to shed new light on the origin of comets. Are comets remnants from the formation of our solar system or are they interstellar matter captured by the sun? Does a solid comet nucleus exist? Comprehensive coverage of Kohoutek provides a rare opportunity to acquire substantive data to help answer these questions.

Space Processing

The success of the Skylab experiments in space processing under zero gravity conditions adds an entirely new dimension to the science and development of materials. The vital role of materials in the course of civilization is seen in the classification of prehistoric periods--the Stone, the Bronze, and the Iron ages--and mirrored in the high strength, high temperature materials, electronics, plastics and other materials that have spurred rapid advances throughout society.

It was anticipated that zero gravity conditions would provide a favorable environment for manufacturing metal alloys, composites, and crystals. Skylab is proving this to be true. Fourteen space processing experiments have been carried out in the first two Skylab manned missions. Although in-depth analysis is continuing, some highly promising preliminary results are already available. For example, initial results show that under two completely different processing conditions, large, perfect single crystals of complex substances were grown in Skylab. The size, perfection, and homogeneity of the Skylab crystals surpassed those grown on earth.

In addition, there are indications that zero gravity conditions lead to the formation of metals and metal alloys with higher strength and better properties than those processed under gravity.

Experience in processes such as welding, brazing, and cutting is a prerequisite for assembling large structures in space. The results of the

Skylab metals melting experiment, in which electron beam cutting and welding techniques were investigated, were excellent. Exothermic brazing techniques were also studied. The Skylab results were better than experienced with ground-processed samples.

The results of the Skylab space processing experiments may well usher in a new era in materials science and engineering. Potential products range from new alloys with highly specialized physical properties to large, perfect crystals with valuable electrical and optical properties. Shuttle-borne laboratories offer tremendous promise for capitalizing on the advantages of space operations in advancing materials science and engineering.

As one Skylab experimenter emphasized: "We have an opportunity to use the unique advantages of research in space to develop the technology we so desperately need to move forward in the science of materials processing. The possibility that we can directly or indirectly transfer to earth the knowledge derived from space research makes this phase of NASA's Skylab program truly exciting."

Life Sciences

Another key area of investigation during the Skylab missions was directed toward increased understanding of the medical effects of space flight on man and the physiological factors that might limit future manned space operations. Before, during and after each mission, repeated tests of the major body functions were conducted. These intensive studies covered the cardiovascular system, nutrition and metabolism, physical work capacity, weight loss and recovery, equilibrium of body fluids, susceptibility to motion sickness, and similar areas. Skylab provided the first opportunity to make detailed measurements in flight that could be used to chart the time course of the various effects. The medical findings revealed no specific effects which set an upper limit on exposure to weightlessness. For the most part, the results confirmed the premission expectations of moderate weight loss, some deconditioning of the cardiovascular system, and very minor loss of calcium in the bones. The crews experienced a higher loss of red cells in the blood than had been expected, and some reduction in the mass of leg muscles.

Vigorous exercise was found to be an effective countermeasure in maintaining general fitness and is thought to account, at least in part, for the fact that the second Skylab crew returned more rapidly to normal than the first crew did. The longer missions showed somewhat greater effects than the 28 days mission, but the process appeared to be leveling off.

Overall, the health and performance of the Skylab crews were highly satisfactory. The Skylab program demonstrated that men can live and work in space for extended periods of time and readapt to the earth environment.

Other Experiments

In addition to the major areas of investigation just described, Skylab supported a wide variety of individual experiments, ranging all the way from ultra-violet measurements of stars, nebulae, and galaxies to studies of the flying characteristics of astronaut maneuvering units. The crews also performed some 19 experiments on behalf of the high school students selected in the Skylab student project. Altogether, there were more than 70 other activities.

Summary

The Skylab missions attained almost all of the individual objectives, and significantly surpassed its broad goals. The high productivity of the Skylab program proves that space is a rich resource that can be used to the benefit of mankind. The success of the Skylab missions provides scientists, engineers, physicians and others with a vast storehouse of data and paves the way for multiplying the beneficial returns from space operations. The end of Skylab marks the beginning of a whole new era of opportunity in space--the shuttle era.

Skylab

	1973	1974	1975
Skylab.....	$502,000,000	$233,300,000	---
Total.....	$502,000,000	$233,300,000	---

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1975 ESTIMATES

BUDGET SUMMARY

OFFICE OF MANNED SPACE FLIGHT — ADVANCED MISSIONS PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1973	1974	1975
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:			
Johnson Space Center.....	---	$750,000	$500,000
John F. Kennedy Space Center, NASA.....	---	200,000	200,000
Marshall Space Flight Center...	$1,500,000	500,000	600,000
Headquarters.....	---	50,000	200,000
Total.....	$1,500,000	$1,500,000	$1,500,000

HIGHLIGHTS OF BUDGET PLAN

Advanced Missions - Studies to provide technical, cost and schedule data as the basis for formulating advanced program plans, including extension and new applications of existing systems to achieve minimum cost. Development of new and improved cost estimating techniques and independent studies of safety aspects of proposed new systems and operational concepts.....	$1,500,000	$1,500,000	$1,500,000

OFFICE OF MANNED SPACE FLIGHT — ADVANCED MISSIONS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objective of the Advanced Missions program is to provide technical, cost and schedule data that can be used in the realistic formulation of future program planning. This includes the extension and new applications of existing systems that can be used to advance the nation's space capabilities at a minimum cost, as well as the study of new missions, systems, and operational concepts that may require totally new developments. In addition, the Advanced Missions program includes the development of new and improved cost estimating techniques and independent studies of the safety aspects of proposed new systems and operational concepts.

BASIS OF FUND REQUIREMENTS:

	1973	1974	1975
Advanced mission studies.....	$1,500,000	$1,500,000	$1,500,000
Total.....	$1,500,000	$1,500,000	$1,500,000

The advanced mission studies are the building blocks for new manned space flight programs. The Skylab, the Shuttle, and the Apollo Soyuz Test Project were originated and carried through Phase A level studies as a part of the advanced mission studies program. During FY 1971 through 1973, the advanced mission studies were oriented almost entirely toward Shuttle and Tug studies. These included considerations of Shuttle interfaces with other systems, Shuttle/Space Tug ground and space operations, safety studies, and Space Tug definition studies.

The FY 1974 study program emphasized activity to seek new and more beneficial uses of the space transportation system (STS), to investigate methods of improving the performance and cost effectiveness of space systems, and to explore new mission concepts.

An orderly transition into the post-Shuttle initial operating cost (IOC) period requires an intensification of our planning efforts now for the development of new and beneficial uses of the STS and for the improvement and extension of the elements of the STS for new applications in earth orbit and beyond.

The FY 1975 study program will examine the requirements for extensions and improvements of the space transportation system. Use of

current Shuttle technology and hardware will be considered for the design of large-lift adaptations of the Shuttle. New on-orbit facilities and operations will be studied, such as extensions of manned space flight in low earth orbit and geosynchronous applications of a manned Space Tug. Integrated launch site operations will also be studied. The effort to improve our cost estimating techniques will be continued by the use of contracted studies to develop new procedures and to expand the data base. Independent studies will also be conducted to assess the safety aspects of new systems and operational concepts and to recommend appropriate safety considerations.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1975 ESTIMATES

BUDGET SUMMARY

OFFICE OF MANNED SPACE FLIGHT — APOLLO PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1973	1974	1975
Total	$56,700,000	---	---
Distribution of Program Amount by Installation:			
Johnson Space Center	$30,385,000	---	---
John F. Kennedy Space Center, NASA	2,428,000	---	---
Marshall Space Flight Center	18,370,000	---	---
Ames Research Center	202,000	---	---
Langley Research Center	85,000	---	---
Headquarters	5,230,000	---	---
Total	$56,700,000	---	---

HIGHLIGHTS OF BUDGET PLAN

The planned objectives of the Apollo program have been accomplished. FY 1975 funding is not required.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1975 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR

SPACE SCIENCE PROGRAMS

Programs	Budget Plan		
	FY 1973	FY 1974	FY 1975
Physics and Astronomy.....	$126,200,000	$94,000,000	$140,515,000
Lunar and Planetary Exploration.....	331,969,000	333,000,000	266,000,000
Launch Vehicle Procurement....	221,000,000	175,000,000	140,500,000
Total.....	$679,169,000	$602,000,000	$547,015,000

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1975 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE — PHYSICS AND ASTRONOMY PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1973	1974	1975
Large observatories	$47,935,000	$18,089,000	$50,410,000
OSO	(20,420,000)	(10,663,000)	(7,630,000)
OAO	(5,700,000)	(2,426,000)	(2,380,000)
HEAO	(21,815,000)	(5,000,000)	(40,400,000)
Orbiting explorers	33,158,000	32,850,000	33,000,000
Suborbital programs	25,100,000	24,350,000	25,000,000
Supporting activities	20,007,000	18,711,000	32,105,000
Total	$126,200,000	$94,000,000	$140,515,000

Distribution of Program Amount by Installation:

Johnson Space Center	$136,000	$180,000	$975,000
Marshall Space Flight Center	23,536,000	8,690,000	50,280,000
Goddard Space Flight Center	68,439,000	54,891,000	55,875,000
Jet Propulsion Laboratory	695,000	650,000	650,000
Wallops Station	2,643,000	2,850,000	2,850,000
Ames Research Center	6,746,000	6,705,000	6,905,000
Langley Research Center	4,315,000	2,708,000	1,705,000
Headquarters	19,690,000	17,326,000	21,275,000
Total	$126,200,000	$94,000,000	$140,515,000

HIGHLIGHTS OF BUDGET PLAN

Large Observatories:

Orbiting Solar Observatories (OSO)

Spacecraft design, development and testing; OSO-I to be launched in 1975	$15,028,000	$7,125,000	$4,687,000
Experiment development for OSO-I and data analysis for OSO-7 and prior missions	5,392,000	3,538,000	2,943,000

	1973	1974	1975
Delta (Launch Vehicle Procurement)	($1,000,000)	($3,500,000)	(---)
Total, OSO	$20,420,000	$10,663,000	$7,630,000
Orbiting Astronomical Observatories (OAO)			
Spacecraft testing and support for launch of OAO-C, 8/21/72	1,931,000	91,000	10,000
Experiments including data analysis, orbital operations, and Guest Observer Program	3,769,000	2,335,000	2,370,000
Atlas/Centaur (Launch Vehicle Procurement)	(100,000)	(---)	(---)
Total, OAO	$5,700,000	$2,426,000	$2,380,000
High Energy Astronomy Observatories (HEAO)			
Preliminary design of spacecraft and experiments for HEAO-A and B and studies on HEAO-C prior to suspension	18,815,000	---	---
Redefinition of HEAO program	3,000,000	5,000,000	---
Design and development of reconfigured spacecraft for HEAO-A, -B, and -C for first launch in 1977	---	---	22,024,000
Design and development of experiment payloads for HEAO-A, -B, and -C	---	---	18,376,000
Atlas/Centaur (Launch Vehicle Procurement)	(---)	(7,600,000)	(8,900,000)
Total, HEAO	$21,815,000	$5,000,000	$40,400,000
Total, Large Observatories	$47,935,000	$18,089,000	$50,410,000
Orbiting Explorers:			
Atmospheric Boundary Explorers			
Three missions in the Atmospheric Explorer (AE) series scheduled for launch in the period 1973-1975	16,000,000	12,711,000	7,480,000

	1973	1974	1975
Delta (Launch Vehicle Procurement).....	($4,800,000)	($4,500,000)	($4,200,000)
Interplanetary and Magnetospheric Boundary Explorers			
Interplanetary Monitoring Platform (IMP) series; 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.....	2,927,000	2,940,000	9,190,000
Delta (Launch Vehicle Procurement).....	(2,400,000)	(2,300,000)	(---)
Magnetospheric Explorers			
Dual Air Density and Hawkeye missions and analysis of data from other missions previously launched.....	4,766,000	3,694,000	1,750,000
Scout (Launch Vehicle Procurement).....	(3,100,000)	(---)	(1,650,000)
Astronomy and Astrophysics Explorers			
Small Astronomy Satellite (SAS) and Radio Astronomy Explorer (RAE) series; also includes international cooperative missions with the Netherlands (ANS), United Kingdom (UK-5), and ESRO (IUE). Analysis of data from other missions launched previously and for advanced studies of potential future missions.....	9,465,000	13,505,000	14,580,000
Delta (Launch Vehicle Procurement).....	(4,100,000)	(---)	(2,000,000)
Scout (Launch Vehicle Procurement).....	(2,500,000)	(---)	(2,800,000)
Total, Orbiting Explorers.....	$33,158,000	$32,850,000	$33,000,000

	1973	1974	1975
Suborbital Programs:			
Sounding Rockets			
Continuation of suborbital rocket-borne experiments.....	$20,000,000	$19,350,000	$20,000,000
Scout (Launch Vehicle Procurement).....	(---)	(---)	(1,350,000)
Airborne Research			
Operation of an infrared telescope in a C-141 aircraft and continued studies in infrared astronomy from other aircraft.....	4,100,000	4,000,000	4,000,000
Balloon Program			
Support for balloon-borne experiments of various types.....	1,000,000	1,000,000	1,000,000
Total, Suborbital Programs....	$25,100,000	$24,350,000	$25,000,000
Supporting Activities:			
Supporting Research and Technology (SRT)			
Support for the development of theory, instrument development, supporting laboratory studies, and ground-based observations.....	14,819,000	13,330,000	14,390,000
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).....	4,880,000	4,881,000	5,000,000
Skylab Data Analysis			
For interpretation of data from ATM and other Skylab experiments in Physics and Astronomy.....	---	---	1,500,000
Spacelab Studies and Experiment Definition			
For payloads to be flown on the space shuttle.....	308,000	500,000	3,500,000

	1973	1974	1975
Large Space Telescope (LST) - Advanced Technological Development			
Spacecraft definition studies, mirror blank work and experiment definition.....	---	---	$6,200,000
Solar Maximum Mission (SMM) - Project Definition.....	---	---	1,515,000
Total, Supporting Activities	$20,007,000	$18,711,000	$32,105,000

FLIGHT SCHEDULE

PROJECT	MISSION	CALENDAR YEAR
Large Observatories:		
Solar Observatories	OSO-I	1975
High Energy Astronomy Observatories	HEAO-A	1977
	-B	1978
	-C	1979
Explorers (Including International Cooperative Satellites)	2 - 4 launches per year	
Suborbital Programs:		
Sounding Rockets	About 70 launches per year	
Balloon Flights	About 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.

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BASIS OF FUND REQUIREMENTS:

Large Observatories

	1973	1974	1975
Orbiting Solar Observatories (OSO)			
OSO Spacecraft.....	$15,028,000	$7,125,000	$4,687,000
OSO Experiments.....	5,392,000	3,538,000	2,943,000
Subtotal, OSO.....	$20,420,000	$10,663,000	$7,630,000
Orbiting Astronomical Observatories (OAO)			
Spacecraft.....	1,931,000	91,000	10,000
Experiments.....	3,769,000	2,335,000	2,370,000
Subtotal, OAO.....	$5,700,000	$2,426,000	$2,380,000
High Energy Astronomy Observatories (HEAO)			
Spacecraft.....	---	---	22,024,000
Experiments.....	---	---	18,376,000
Redefinition of HEAO program....	3,000,000	5,000,000	---
Effort prior to suspension.....	18,815,000	---	---
Subtotal, HEAO.....	$21,815,000	$5,000,000	$40,400,000
Subtotal, Large Observatories.	$47,935,000	$18,089,000	$50,410,000
(Launch Vehicle Procurement Program):			
Delta (OSO).....	(1,000,000)	(3,500,000)	(---)
Centaur (OAO).....	(100,000)	(---)	(---)
Atlas/Centaur (HEAO).....	(---)	(7,600,000)	(8,900,000)
Total (Including Launch Vehicles).....	($49,035,000)	($29,189,000)	($59,310,000)

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. Transients, holes, and the dynamics of streamers in the million degree corona were discovered and their effects on the earth's magnetosphere and outer atmosphere identified; their effects on the weather are being investigated. Other discoveries have included nuclear reactions in solar flares and many related high energy phenomena with terrestrial effects.

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

OSO-I, to be launched in 1975 near solar minimum, will attack the problem of the temperature difference between the outer atmosphere of the sun (one million degrees) and the lower atmosphere (ten thousand degrees) through studies of the structure, evolution, oscillations and circulation in the transition region between the two atmospheric layers. High energy experiments will explore the background component of cosmic X-ray emissions.

Fiscal Year 1974 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 1975 funds will be used for the completion, launch and mission operation of OSO-I as well as the analysis of data obtained from the OSO-7 mission.

Orbiting Astronomical Observatories (OAO)

Since 1968, 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.

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. The UV instrument provides 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 1974 funds support the operation of the OAO-3 and the analysis of data obtained by the Princeton experiment; in addition, OAO-2 data analysis is continuing for the Wisconsin experiment. Support was also provided for a Guest Observer Program which enabled additional astronomers to use OAO to study celestial objects.

Fiscal Year 1975 funds will support OAO-3 in-orbit operations and provide for data processing and analysis of data obtained by the Princeton experiment. Support for the Guest Observer Program will also be continued.

High Energy Astronomy Program (HEAO)

The basic scientific objective of the High Energy Astronomy Observatory program is to explore the previously inaccessible regions of celestial X-ray and gamma ray sources and of cosmic ray flux. This program has the potential substantially to enhance our understanding of newly discovered energy processes and of the creation of matter.

It will also greatly improve our understanding of observed phenomena such as quasars, pulsars, novae, and supernovae. Various advisory boards, including the President's Scientific Advisory Council and the National Academy of Sciences (Woods Hole Summer Study) have given this program the highest priority.

As part of the actions required to reduce Government spending in FY 1973, development effort on the HEAO project was 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.

The restructured program consists of two segments or "Blocks". Block I is planned as three satellites to be launched on Atlas/Centaur rockets from the Eastern Test Range. Block II will be proposed as a future new start to be launched by the space shuttle and carry those heavier and larger instruments which Block I cannot accommodate.

The Block I spacecraft uses the basic structural design previously detailed for the original HEAO by TRW Systems, Inc., the prime contractor.

About 80% of the HEAO subsystem components use existing flight hardware designs from on-going programs such as Orbiting Solar Observatories (OSO), Apollo Telescope Mount (ATM), Small Astronomy Satellite (SAS), and Fleet Satellite Communications (FLTSATCOM). The first launch in 1977, HEAO-A, will be an X-ray survey for which the payload has been selected. The second mission, HEAO-B, will carry a grazing incidence X-ray telescope and will make detailed studies of specific sources. The third, HEAO-C, will carry a combination of gamma ray and cosmic ray instruments. This satellite is planned to be retrieved by the shuttle, refurbished, equipped with a new set of instruments, and launched again on an early shuttle mission.

The restructured program has been reviewed and endorsed by the Space Science Board of the National Academy of Sciences and by the Physical Sciences Committee of the Space Programs Advisory Council (SPAC).

Fiscal Year 1974 funds are being used for definition and design activity pursuant to the effort to achieve the approved HEAO objectives through a lower cost approach.

The FY 1975 budget request will allow for detailed design and initiation of development of the spacecraft and the HEAO-A scientific payload. Design of the HEAO-B instruments will begin, and definition of the HEAO-C payload will continue. In addition, long-lead items, such as telescope mirror blanks, large sodium iodide crystals, star sensors, and tape recorders will be procured. Second tier subcontracts for vendor items will be negotiated.

Orbiting Explorers

	1973	1974	1975
Atmospheric boundary explorers....	$16,000,000	$12,711,000	$7,480,000
Interplanetary and magnetospheric boundary explorers.....	2,927,000	2,940,000	9,190,000
Magnetospheric explorers.....	4,766,000	3,694,000	1,750,000
Astronomy and astrophysics explorers.....	9,465,000	13,505,000	14,580,000
Subtotal, Orbiting Explorers..	$33,158,000	$32,850,000	$33,000,000
(Launch Vehicle Procurement Program):			
Delta.....	(11,300,000)	(6,800,000)	(6,200,000)
Scout.....	(5,600,000)	(---)	(4,450,000)
Total (Including Launch Vehicles).....	($50,058,000)	($39,650,000)	($43,650,000)

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 1975, funds will be used for the following Explorer missions:

Atmospheric Boundary Explorers

Atmospheric 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. The first mission (AE-C) was successfully launched in December 1973. Each mission 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 1975 funds will be used for in-orbit operation of AE-C, analysis of data from AE-C experiments, completion and launch of AE-D, and continuation of work on AE-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 last spacecraft in the IMP series (IMP-J - Explorer 50) was successfully launched in October 1973. Hardware definition studies are underway for both a 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 1975 funds will provide for analysis of data from IMP-J and IMP-H (Explorer 47, launched in September 1972), and for development and procurement of hardware 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 AEROS (launched in December 1972), a cooperative mission with West Germany, as well as the Hawkeye mission scheduled for launch in 1974 and the Dual Air Density mission scheduled for launch in 1975. Also included for FY 1975 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 49 (RAE-B), which was successfully launched in June 1973.

Fiscal Year 1975 funds will support the completion and launch of SAS-C, UK-5, and ANS; the continuation of acquisition, processing, and analysis of data from operational satellites; and the development and construction of the IUE.

Suborbital Programs

	1973	1974	1975
Sounding rockets.....	$20,000,000	$19,350,000	$20,000,000
Airborne research.....	4,100,000	4,000,000	4,000,000
Balloon program.....	1,000,000	1,000,000	1,000,000
Subtotal, Suborbital Program....	$25,100,000	$24,350,000	$25,000,000
(Launch Vehicle Procurement Program):			
Scout.....	(---)	(---)	(1,350,000)
Total (Including Launch Vehicle).....	($25,100,000)	($24,350,000)	($26,350,000)

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 the study of cosmic dust and interplanetary matter, magnetospheric physics, stellar astronomy, solar astronomy, and high energy astrophysics.

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

1. To conduct a coordinated research program utilizing experiments with flight requirements which cannot be covered by lesser performance vehicles and do not require long duration satellite observation. Specific areas of study include:

a. the nature, characteristics, and composition of the upper atmosphere, ionosphere, and near space;

b. the effects of incoming energetic particles and solar and stellar radiation on the upper atmosphere and ionosphere;

c. the nature, characteristics, and spectra of radiation of the sun, stars, and other celestial objects.

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 or airplanes; 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 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 about 70 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 several rocket payloads.

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

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

Fiscal Year 1974 activity also included an expedition to Australia for southern sky observations, and a series of some 30 launches from Wallops Island, to study in detail the atmosphere structure and dynamics in the upper atmosphere between 70 and 160 km (43 and 100 miles).

The Gravity Probe-A project, which was initiated in FY 1972 to confirm with improved accuracy the gravitational redshift (relativistic frequency shift) predicted by Einstein's Theory of Relativity, has proceeded through the design stage, and hardware is now under development and test. In FY 1975, environmental tests will be completed, the flight will be performed using a Scout launch vehicle, and data analysis will be initiated.

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 airflow. Infrared (IR) astronomy of the sun, planets, and galaxies with small telescopes has been undertaken from the CV-990 and Lear Jet aircraft. A large IR telescope, 91 centimeters (36 inches), has been built for observations from a C-141A jet aircraft. This IR observatory is a full-scale, manned facility. The telescope operates through an open port and is separated from the astronomers by a pressurized wall. This permits the astronomers to work in a comfortable, shirt-sleeve environment. The Airborne IR Observatory became a dedicated national facility for infrared astronomy in late 1973.

Infrared astronomers have actively participated in the Lear Jet program utilizing a 30 centimeters (12-inch) telescope. This program currently involves ten groups of astronomers. Based on the large number of proposals for the use of the new 91-centimeters Airborne IR Observatory, as many as 20 groups will probably be using this facility. A study is planned to compare the operational capability of the Airborne IR Observatory with that of a Sortie-Mode Space Science Laboratory.

The FY 1974 Airborne Research program funds have been used to complete the operational testing and initial operations of the Airborne IR Observatory on the C-141A. FY 1974 funds also provided for continuation of the Lear Jet astronomical program.

The FY 1975 airborne research budget will be used mainly to continue operations of the Airborne IR Observatory. These operations include support for the astronomical groups, the acquisition of an inertial navigation system and an observatory simulator system, and the operation of the C-141A.

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 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 about 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 1975 request will support a level of effort approximately equal to FY 1974, although some decrease in total number of flights may be experienced due to the increased emphasis on more complex payloads, higher altitude requirements, and correspondingly larger balloons. The new "superpressure" balloons, in particular, offer unique opportunities for long duration missions.

Supporting Activities

	1973	1974	1975
Supporting research and technology (SR&T).....	$14,819,000	$13,330,000	$14,390,000
Data analysis.....	4,880,000	4,881,000	5,000,000
Skylab data analysis.....	---	---	1,500,000
Spacelab studies and experiment definition.....	308,000	500,000	3,500,000
Large Space Telescope (LST) - advanced technological development.....	---	---	6,200,000
Solar Maximum Mission (SMM) - project definition.....	---	---	1,515,000
Total, Supporting Activities..	$20,007,000	$18,711,000	$32,105,000

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 environment 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 250 tasks are being supported at universities, nonprofit and industrial research institutions, NASA centers, and other Government agencies in 27 states and the District of Columbia. These include continuing studies and Advanced Technological Development (ATD) of subsystems for the Large Space Telescope including mechanical and structural system concepts, studies of the primary telescope optical subsystem, and technological development required for the primary mirror blank, the telescope support system, and the telescope instrumentation.

During FY 1975, 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 instrumentation involving image tubes and solid state devices which will increase sensitivity and resolution of detectors. Superfluid helium research is being continued for cryogenic systems for future application in cosmic ray, relativity, and infrared astronomy. Other technological problems concerning pointing and stabilization, on-board processing, on-board data storage, and detector background will be studied. In addition, studies will be made of advanced techniques for releasing tracers into the upper atmosphere and of such instruments for introducing controlled perturbations into the space environment as space-borne radio transmitters, electron and ion accelerators and lasers. Basic studies will be continued to define future scientific objectives in astronomy and physics that will require the capabilities of early shuttle missions.

Data Analysis

The purpose of this effort is to obtain the maximum return on the investment represented by the data gathered in the Space Science program, including that from a number of spacecraft which are operating well beyond their planned lifetimes.

Limited operation of spacecraft, beyond the times originally planned, has made additional data available for specific investigations, preference being given to correlative operations designed to illuminate physical problems, and the exploitation of unusual and unexpected opportunities such as comets.

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, was established to serve as a central repository and clearinghouse of scientific data resulting from space investigations. Investigators are expected to prepare data, complete with calibrations, in a form suitable for deposit in the NSSDC.

Fiscal Year 1975 funds will provide support for about 100 principal investigators at approximately 46 institutions, including NASA field centers.

Skylab Data Analysis

Skylab activities through FY 1974 were funded under the Office of Manned Space Flight. This project will support the interpretation of data from ATM and other Skylab experiments in Physics and Astronomy, the ATM Guest Investigator program, and symposia and workshops on ATM results. The ATM has acquired the most comprehensive set of high resolution solar data simultaneously at more wavelengths than ever before. An analysis of these data promises to advance man's knowledge of solar atmospheric structure and dynamics far beyond its present state. It is already evident that the ATM data can settle a number of questions about physical connections between many small-side structures in the chromosphere and corona. In addition, the excellent flare data obtained will increase our understanding to a point where an extremely fruitful observing program can be designed for future space efforts planned to help understand the flare problem. Obtaining these results from the data will require vigorous implementation of an intensive program for data analysis, an investment which is vital to reaping the rich harvest that the Skylab mission has made possible.

Spacelab Studies and Experiment Definition

Payloads to be flown in the space shuttle must be designed to fit the standard interface configuration of the shuttle. Difficult choices among various options must be made on the basis of reliable cost estimates and a full understanding of the capability of the instruments which are, in general, more complex than in earlier years. The space shuttle will permit new, low-cost construction methods and operating procedures. It is essential that full advantage be taken of these capabilities to lower the cost of space investigations. Physics and astronomy research facilities will be flown on the space shuttle to be operated by scientists on the shuttle and

on the ground. Each payload could be flown several times per year and would have an operational life comparable to traditional ground-based facilities. Basic research will be performed in astronomy, solar physics, astrophysics, magnetospheric physics, and atmospheric physics. The proposed research will require both passive observations and the performance of active experiments which can be conducted most easily from the space shuttle.

This program will build on the experience and accomplishments of on-going flight projects, including the Skylab mission. FY 1975 funding will be used for the identification and definition of scientific instruments, sensors, and specialized equipment, and the definition and specification of laboratory/observatory modules and special purpose spacecraft subsystems such as scientific airlock, stabilized platform, and subsatellites.

Large Space Telescope (LST) - Advanced Technological Development

The LST, a multiple-purpose 3-meter (118 inch) telescope, will provide the capability for pursuing a very broad range of problems. The spacecraft is being planned as a payload to be launched and serviced by the space shuttle. Designed to provide high resolution and a large light collecting area without suffering from atmospheric diffusion of light which hampers ground observations, this instrument will be able to reach galaxies at distances as great as ten times those available to the 200-inch telescope at the Hale Observatory at Mt. Palomar. The high resolution will enable astronomers to overcome distance limitations which have long constrained the study of quasar redshift.

In FY 1975, the project definition studies continue. These include studies of 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 developing the instruments to be placed behind the primary mirror. Advanced technological development of items such as third generation gyros for the precise pointing and stabilization requirements, optical performance sensors, and structural and thermal subsystems will also continue.

Solar Maximum Mission (SMM) - Project Definition

The SMM will conduct specific problem-oriented solar scientific research during the next maximum in solar activity, projected for the 1978-1979 period. The major scientific objectives of SMM will be to investigate solar flares and related phenomena over a broad spectral range with high time, spectral and spatial resolution. The hardware will be shuttle-compatible to provide rendezvous, retrieval, refurbishment and return to orbit. Initial launch will be by the Delta launch vehicle.

The early OSO's and ATM have demonstrated that the critical observations for the flare mechanism can be made from space. These include gamma ray spectroscopy, X-ray and UV spectroscopy, measurements of magnetic fields in the corona, and certain types of polarimetry and supporting ground-based observations. With the ATM experience, we are in a position to select a solar maximum payload which will cover all of those flare and preflare emissions of the sun which are important for the

- determination of physical conditions in the flaring region
- identification of the physical mechanisms at work
- identification of configurations which are likely to produce flares
- possibly predict flares and their effects on earth and its environment

Studies performed in-house indicate the feasibility of developing a spacecraft system for this mission based on maximum utilization of components and subsystems that were designed for other flight systems. In FY 1975, project definition studies will be performed to define in detail the interfaces of the complete SMM system. This effort will permit detail design and development to proceed in subsequent years with fixed requirements to minimize design changes and costs and to hold the 1978 planning date.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1975 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE — LUNAR AND PLANETARY EXPLORATION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1973	1974	1975
Mariner	$37,683,000	$11,115,000	$4,119,000
Viking	232,249,000	224,655,000	89,016,000
Outer planets missions	6,064,000	30,610,000	69,761,000
Pioneer/Helios	11,573,000	7,370,000	33,500,000
Supporting research and technology/advanced studies	19,364,000	15,018,000	17,800,000
Planetary astronomy	4,800,000	4,200,000	4,200,000
Data analysis	3,036,000	9,251,000	10,473,000
Planetary quarantine	2,200,000	1,500,000	1,500,000
Planetary flight support	15,000,000	22,000,000	25,500,000
Lunar sample analysis	---	5,667,000	5,798,000
Lunar science operations	---	1,614,000	4,333,000
Total	$331,969,000	$333,000,000	$266,000,000

Distribution of Program Amount by Installation:

Johnson Space Center	$150,000	$8,102,000	$12,726,000
Marshall Space Flight Center	---	25,000	---
Goddard Space Flight Center	4,819,000	6,009,000	8,090,000
Jet Propulsion Laboratory	62,452,000	60,947,000	91,700,000
Wallops Station	65,000	55,000	50,000
Ames Research Center	15,901,000	10,501,000	35,722,000
Langley Research Center	229,060,000	224,286,000	94,110,000
Headquarters	19,522,000	23,075,000	23,602,000
Total	$331,969,000	$333,000,000	$266,000,000

HIGHLIGHTS OF BUDGET PLAN

	1973	1974	1975
Mariner			
Mariner Mars 1971			
Mission operations and project management	$7,176,000	---	---
Subtotal, Mariner Mars 1971	$7,176,000	---	---
Mariner Venus/Mercury 1973			
Spacecraft design, development, and testing	25,683,000	$5,265,000	$1,332,000
Science instruments to return ultraviolet and visual television pictures, atmosphere and ionosphere data, and thermal maps from both Venus and Mercury	2,812,000	2,303,000	2,134,000
Mission operations beginning with the November 1973 launch	2,012,000	3,547,000	653,000
Subtotal, Mariner Venus/Mercury 1973	$30,507,000	$11,115,000	$4,119,000
Atlas/Centaur (Launch Vehicle Procurement)	(6,800,000)	(---)	(---)
Total Mariner	$37,683,000	$11,115,000	$4,119,000
Viking			
Orbiter			
Spacecraft design, development, and test leading to delivery of two spacecraft to KSC in early 1975	61,300,000	62,700,000	26,000,000
Science instruments to obtain planetary data, including water vapor and thermal mapping	8,800,000	9,000,000	4,000,000

	1973	1974	1975
Lander			
Spacecraft design, development, and test leading to delivery of three spacecraft to KSC early in 1975	$107,000,000	$91,000,000	$27,008,000
Science instruments to transmit biological, geological, meteorological, and other data from the surface of Mars to earth	42,640,000	35,255,000	14,808,000
Project Management, Integration, and Mission Operations	12,509,000	26,700,000	17,200,000
Titan/Centaur (Launch Vehicle Procurement)	(33,000,000)	(27,000,000)	(2,400,000)
Total, Viking	$232,249,000	$224,655,000	$89,016,000
Outer Planets Missions			
Spacecraft Design and Development			
Spacecraft system design, using existing Mariner/Viking subsystem design where possible; procurement of spacecraft subsystems	$3,314,000	$16,336,000	$47,503,000
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	1,300,000	11,372,000	17,141,000
Project Management and Integration	1,385,000	2,497,000	4,144,000
Mission Operations - Definition of tracking and facilities requirements, mission and sequencing design	65,000	405,000	973,000
Titan/Centaur (Launch Vehicle Procurement)	(---)	(11,300,000)	(9,100,000)
Total, Outer Planets	$6,064,000	$30,610,000	$69,761,000

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	1973	1974	1975
Pioneer/Helios			
Pioneer Venus			
Detailed design, experiment and spacecraft development initiated	---	---	$27,100,000
Pioneer 6-11			
Spacecraft			
Flight performance analysis, contractor fee payments for Pioneer	$4,190,000	$1,125,000	180,000
Science			
Analysis of scientific data collected during the 10 and 11 missions	2,065,000	2,415,000	2,275,000
Operations			
Support of the 6-11 missions at the Space Flight Operations Facility	3,053,000	2,330,000	2,545,000
Subtotal, Pioneer 6-11	$9,308,000	$5,870,000	$5,000,000
Helios A and B			
Science			
Test and integration into spacecraft of experiments for first mission. Assembly and test of experiments for second mission	1,375,000	615,000	755,000
Operations			
Software design for mission operations, data analysis, project management	890,000	885,000	645,000
Subtotal, Helios A and B	$2,265,000	$1,500,000	$1,400,000
Centaur (Launch Vehicle Procurement)	(18,200,000)	(20,000,000)	(7,100,000)
Total, Pioneer/Helios	$11,573,000	$7,370,000	$33,500,000

	1973	1974	1975
Supporting Research and Technology/Advanced Studies			
Lunar Science Scientific studies to understand the origin of the moon and the earth.....	$3,364,000	$2,918,000	$3,500,000
Planetary Science Research in planetary atmospheric phenomena; planetary geology, including geochemistry, geophysics, and photogeology.....	4,700,000	4,500,000	4,600,000
Planetary Advanced Technical Development Technological readiness and detailed advanced planning for candidate planetary missions.....	6,200,000	3,100,000	5,200,000
Planetary Advanced Studies Feasibility of potential future scientific missions to planets; development of up-to-date mission opportunity catalog.....	1,200,000	1,200,000	1,200,000
Exobiology Research toward understanding the controlling factors in the origin of life, and determining the uniqueness of life on earth...	3,900,000	3,300,000	3,300,000
Total, Supporting Research and Technology/Advanced Studies.....	$19,364,000	$15,018,000	$17,800,000
Planetary Astronomy Ground-based astronomy support of the planetary exploration program objectives.....	$4,800,000	$4,200,000	$4,200,000
Data Analysis Support of scientists analyzing data of flight programs after the initial period funded in the basic mission.....	3,036,000	9,251,000	10,473,000

	1973	1974	1975
Planetary Quarantine			
All feasible measures to avoid the transfer of viable terrestrial life forms to the planets	$2,200,000	$1,500,000	$1,500,000
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	25,500,000
Lunar Sample Analysis			
Scientific analysis of the lunar materials returned to earth by Apollo	---*	5,667,000	5,798,000
Lunar Science Operations			
Operation of the still functioning Apollo ALSEP's and subsatellite, and the Lunar Laser Ranging experiment	---*	1,614,000	4,333,000

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

OFFICE OF SPACE SCIENCE

LUNAR AND PLANETARY EXPLORATION PROGRAM

FLIGHT SCHEDULE

PROJECT	MISSION	CALENDAR YEAR
Pioneer/Helios	Helios A	1974
	Helios B	1976
	Pioneer Venus (2)	1978
Viking	Mars 1975 (2)	1975
Outer Planets Missions	Jupiter-Saturn (2)	1977

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 automated spacecraft which fly by, orbit, enter the atmosphere, and/or land on other bodies, as well as ground-based observations to investigate our solar system. The lunar program utilizes ground-based observations, laboratory studies and data from the Apollo, Ranger, Lunar Orbiter, and Surveyor missions 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. Pioneer 10, launched in March 1972, has now successfully traversed the Asteroid Belt and survived the radiation belts of Jupiter. It has provided valuable data on this first mission to this giant planet. Pioneer 11 was launched in April 1973 and is now about halfway through the Asteroid Belt and on its way to a second flyby of Jupiter. Mariner 10 launched in November 1973, is on course to fly by Mercury utilizing the increased velocity to be achieved by its close swingby of Venus in February. Two cooperative US/German spacecraft, Helios A and 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 greatly advanced 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 Saturn and their satellites, thereby extending man's frontier of knowledge about the solar system farther into the outer planets. The heavy veil of the planet Venus will be penetrated by instruments carried on two Pioneer spacecraft scheduled to be launched in 1978. The probe and orbiter missions will investigate the nature, dynamics and evolution of the Venusian atmosphere.

BASIS OF FUND REQUIREMENTS:

	Mariner		
	1973	1974	1975
Mariner Venus/Mercury 1973.....	$30,507,000	$11,115,000	$4,119,000
Mariner Mars 1971.....	7,176,000	---	---
Total, Spacecraft and Support...	$37,683,000	$11,115,000	$4,119,000
Atlas/Centaur (Launch Vehicle Procurement program).....	(6,800,000)	(---)	(---)
Total, (including launch vehicle).....	($44,483,000)	($11,115,000)	($4,119,000)

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).

In FY 1974 primary Mariner activities focused on the final testing, launch, and flight operations of Mariner 10. This spacecraft will be the first to fly a two planet mission as well as making observations of the earth, the moon, and the comet Kohoutek in transit to its rendezvous with Venus and Mercury.

Mariner Venus/Mercury 1973

Spacecraft.....	$25,683,000	$5,265,000	$1,332,000
Science instruments.....	2,812,000	2,303,000	2,134,000
Mission operations.....	2,012,000	3,547,000	653,000
Total.....	$30,507,000	$11,115,000	$4,119,000

A single modified Mariner spacecraft, launched on November 3, 1973, will fly by both Venus and Mercury in 1974 becoming the first two-planet mission. Using solely the rocket boost needed to reach Venus, the MVM 1973 (Mariner 10) spacecraft will utilize Venus' gravity to obtain a change in speed and trajectory that will enable it to continue to 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 of the planets Venus and Mercury. Additionally, it will investigate the space environment at both planets and the unexplored region between Venus and Mercury. This mission will provide valuable experience for future multiplanet, gravity-assist type trajectories. Following initial Mercury encounter on March 29, 1974, the spacecraft will go into a heliocentric orbit in which it will again encounter Mercury (September 22, 1974) 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. The mapping of Mercury will be greatly enhanced by the second flyby.

Funds requested will be used as follows:

Spacecraft - Major activities concluded in FY 1974 are the completion of environmental testing, transfer of the test and flight spacecraft to the Kennedy Space Center for prelaunch operations, and launch of the flight spacecraft on November 3, 1973.

Science Instruments - Immediately after launch scientific data were returned during near-earth sequence operations, including some 1,100 real time TV pictures for constructing earth and moon mosaics. These TV pictures were used for calibration of the television subsystem, checkout of image-processing software, and training of the mission operations teams. Data continue to be returned during the interplanetary transit phase. Over 7,000 TV pictures are planned during the observation of the comet Kohoutek and the flyby encounters of the planets Venus and Mercury. FY 1974 and 1975 science funds will be used for analysis of the data obtained during these flyby operations, and for the production of scientific reports and papers by the science investigators.

Mission Operations - During FY 1974, Mission Operations Systems (MOS) activities are concentrating on training for encounters and conducting flight operations. Flight operations include the command and control of the spacecraft during its interplanetary flight in order to return data, make trajectory correction and calibration maneuvers, and update the automatic mission modes stored in the on-board computer. Navigation and tracking activities make certain the spacecraft arrives at the proper aiming point at the correct time to insure planetary encounter. The MOS teams will support 24-hour operations during the encounters of Venus and Mercury. FY 1975 funding will provide mission operations to attain the valuable second flyby of the planet Mercury, and will support the initial analysis of the data.

Viking

	1973	1974	1975
Orbiter spacecraft.....	$61,300,000	$62,700,000	$26,000,000
Orbiter science.....	8,800,000	9,000,000	4,000,000
Lander spacecraft.....	107,000,000	91,000,000	27,008,000
Lander science.....	42,640,000	35,255,000	14,808,000
Project management and project integration.....	12,509,000	26,700,000	17,200,000
Total.....	$232,249,000	$224,655,000	$89,016,000
Titan/Centaur (Launch Vehicle Procurement program).....	(33,000,000)	(27,000,000)	(2,400,000)
Total (including launch vehicles.....	($265,249,000)	($251,655,000)	($91,416,000)

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 data relevant to questions about the existence of life on the planet.

Two Viking spacecraft will be launched in mid-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. Each Lander will separate from its Orbiter shortly after arrival at Mars and descend through the atmosphere to the surface. After soft landing, the Lander will conduct biological, geological, meteorological, and other scientific investigations. Instruments on the Orbiters will obtain data on dynamic planetary processes, and the Orbiter will act as a communications relay station for both Orbiter and Lander scientific data.

During FY 1974, funds are being used chiefly to complete the peak activity in the design, fabrication, and testing of the hardware for both the Orbiter and the Lander. By the end of FY 1974, assembly effort will begin for the first flight model and testing will have been completed for the thermal and dynamic test models of the Orbiter. Qualification of the Orbiter design will be completed through the accomplishment of the system and environmental test of the Proof Test Orbiter model. Also by the end of this fiscal year, assembly of the three flight models of the Lander will be well underway. Effort will be completed on testing the dynamic and static Lander models, and most of the qualification testing will be completed for the Lander Proof Test Capsule.

Also in FY 1974, the basic planning for the mission design and flight operations will be completed. The majority of the computer software programs needed for flight operations will be prepared. A proof test launch of the recently mated Titan/Centaur vehicle, with a Viking spacecraft Mars simulator, is scheduled for early 1974.

Funds requested for FY 1975 will be used as follows:

Orbiter

Spacecraft Development - The Proof Test Orbiter will be used with a Lander model to conduct compatibility tests. Later, the Orbiter model will be sent to KSC to participate in pathfinder operations, a dress rehearsal for the real launch operations. Assembly and testing of the two flight Orbiters will be completed and they will be shipped from JPL to KSC for launch preparations. The launch period for Viking begins on August 11, 1975 and extends for approximately 40 days.

Science Instruments - Orbiter science instruments are two television cameras, an infrared spectrometer for water vapor mapping, and an infrared radiometer for thermal mapping. During FY 1975, the flight instruments will be installed and tested in the flight model Orbiters.

Lander

Spacecraft Development - Qualification testing will be completed on the Proof Test Capsule during FY 1975. The three flight model Landers will be completely assembled and will undergo their acceptance testing. One of the models will go to JPL for spacecraft compatibility tests and then be shipped to KSC for pathfinder operations. The other two Landers will also be shipped to KSC. All three Landers will be prepared for launch. Only two will be launched, the third, a backup spare, is required to insure that two fully sterilized Landers will be available for launch, should the opening of one be required for repairs.

Science Instruments - Lander science objectives include investigation of whether life exists, has existed, or can exist on Mars. Three separate biology experiments will subject soil samples to various basic tests to determine if metabolic processes are taking place. The entire Lander will be sterilized to ensure that only true Martian organisms are detected, as well as to preserve the planet for future investigations.

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 to determine upper atmosphere composition, and pressure and temperature sensors to determine atmospheric structure.

An important activity during FY 1975 will be a full rehearsal of the total science test sequence conducted with the instruments on a complete Lander under simulated Martian conditions. The flight instruments installed on the three flight Landers will undergo final acceptance testing, environmental testing, and calibration as integral parts of these spacecraft.

Mission Operations - FY 1975 will see an increase in effort on mission design and flight operations planning as the fixed launch opportunity nears. All computer software will be integrated so that the ground system compatibility tests, flight crew training, and flight operation simulation tests can be conducted. Planning and many details will be completed for the flight sequences, trajectories, navigation, and science data reduction. Emphasis will be placed on the launch and cruise phases of the mission since personnel will be available after launch to complete the encounter phase of the mission planning.

Management attention will be concentrated on schedule performance during this period to insure that final hardware assembly, integration, and required testing occur.

Outer Planets Missions

	1973	1974	1975
Project management.....	$1,385,000	$2,497,000	$4,144,000
Spacecraft design and development.....	3,314,000	16,336,000	47,503,000
Science.....	1,300,000	11,372,000	17,141,000
Mission operations.....	65,000	405,000	973,000
Total.....	$6,064,000	$30,610,000	$69,761,000
Titan/Centaur (Launch Vehicle Procurement program).....	(---)	(11,300,000)	(9,100,000)
Total (including launch vehicles).....	($6,064,000)	($41,910,000)	($78,861,000)

In 1977, two Mariner-class spacecraft will be launched on a trajectory to Jupiter, and from Jupiter will continue on to Saturn on a space flight made possible only by a rare alignment of Jupiter and Saturn. This alignment permits a spacecraft launched to Jupiter to reach Saturn and eventually escape from the solar system through the acceleration provided by Jupiter's gravity. The opportunity to carry out such a gravity-assisted swingby mission occurs approximately every 20 years. The spacecraft will encounter Jupiter about 1979 and Saturn about 1981. This important mission affords the chance to conduct comparative studies of the Jupiter and Saturn systems,

including their satellites and the nature of the rings of Saturn, as well as to perform investigations in the interplanetary and interstellar media. One exciting target will be the Saturn 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. This mission should substantially enhance our understanding of the origin and evolution of the solar system and the processes that shape man's environment. With their differences in mass and density, atmospheric composition and circulation, and exposure to solar radiation, Jupiter and Saturn can provide significant new data on the physical processes at work on the earth.

The FY 1974 activities consist primarily of the design and compatibility investigations involving the mission, spacecraft and science experiments and the development of their detailed implementation plans which culminated in a major review and confirmation of mission scope, spacecraft capability and science payload. Procurement actions were initiated for the add-ons to the Viking Orbiter procurements for some of the spacecraft subsystem hardware, for the long-lead time development of new spacecraft subsystems and science instruments, and for long-lead time electronic piece parts. By the end of FY 1974, the spacecraft design will be completed along with initiation of the spacecraft subsystem and science instrument detail design efforts.

Funds requested for FY 1975 will be used as follows:

Project Management - The activities necessary to establish the final mission and system design will be completed, and work will be continued in trajectory, navigation, maneuver, and ephemeris analysis, and the development of a detailed mission profile.

Spacecraft Design and Development - The MJS77 spacecraft detailed design will be completed in mid-FY 1975. All subsystem preliminary designs will be completed by mid-year and hardware work will be in progress on all parts of the spacecraft by the end of the year. Flight hardware fabrication will be completed for those items being obtained from add-ons to the Viking Orbiter procurements such as the Command Detector, Star Tracker and Inertial Reference Unit. The first Command Control Computer units will be obtained in FY 1975 from the Viking Orbiter add-on buy . Some of these processors will be used for the programable attitude and articulation control subsystem. Design breadboard fabrication of new items, such as telemetry modulation, antenna, power conditioning, attitude control electronics, and flight data subsystem will be completed early in FY 1975. Prototype fabrication will be completed by the end of the year for new subsystem elements such as wide angle sun sensors, antennas, traveling wave tube assemblies and propulsion thrusters. By the end of FY 1975 the hard design of all spacecraft subsystems will be complete, parts will have been acquired and preparation for fabrication of the flight hardware will be underway. The testing of subsystem prototypes will be in process to provide the basis for the critical design reviews.

Science - Activities will be primarily focused on the detailed design and development of the science instruments. The preliminary design reviews of all the science instruments are to be held during the first half of the fiscal year. By the end of FY 1975, the science instrument prototypes will have been built and tested and the majority of the critical design reviews will be completed.

Mission Operations - The primary mission operations task in FY 1975 is the functional design of the mission operations complex and the identification of requirements for tracking and data systems and mission control systems facilities. Some effort will be expended in defining mission sequencing concepts and techniques.

Pioneer/Helios

	1973	1974	1975
Pioneer Venus.....	---	---	$27,100,000
Pioneer 6-11.....	$9,308,000	$5,870,000	5,000,000
Spacecraft.....	4,190,000	1,125,000	180,000
Science.....	2,065,000	2,415,000	2,275,000
Operations.....	3,053,000	2,330,000	2,545,000
Helios A and B.....	2,265,000	1,500,000	1,400,000
Science.....	1,375,000	615,000	755,000
Operations.....	890,000	885,000	645,000
Subtotal.....	$11,573,000	$7,370,000	$33,500,000
Centaur (Launch Vehicle Procurement program).....	($18,200,000)	($20,000,000)	($7,100,000)
Pioneer 11.....	(1,000,000)	(---)	(---)
Helios A and B.....	(17,200,000)	(20,000,000)	(7,100,000)
Total (including launch vehicles).....	($29,773,000)	($27,370,000)	($40,600,000)

Pioneer Venus

The objective of the Pioneer Venus program is to conduct scientific investigations of the planet Venus, its atmosphere and its environment. There are two missions in the program: a multiprobe atmospheric mission and an orbiter mission. The multiprobe mission will determine: the nature and composition of the clouds; the composition and structure of the atmosphere, including the minor constituents; the general atmospheric circulation pattern; and the structure of the ionosphere. The orbiter mission will: determine the detailed structure of the upper atmosphere; investigate the solar wind/ionosphere interaction region; determine atmosphere and

surface characteristics on a planetary scale by remote sensing; and measure the gravitational field harmonics. The primary thrust of these missions is to determine the nature, dynamics and evolution of the Venusian atmosphere. This goal has profound significance with respect to one of the objectives of the NASA Planetary program, namely, that of "determining the dynamic processes that shape earth's environment by investigation of other bodies of the solar system." Dynamic modeling of earth's atmosphere for prediction of atmospheric weather, climatic changes, and of pollution effects should be materially aided by the Pioneer Venus program. A second objective of this mission is to provide data to understand the origin and evolution of the solar system, by determining the relative abundances of the constituents of the Venus atmosphere and the mass properties of the planet.

The program concept is structured to yield the science objectives at the lowest possible cost. Ample weight margins are being allowed to minimize the need for new development--the spacecraft will be largely comprised of existing subsystems.

This spacecraft will also be "standardized" for easy adaptation to either a probe carrier or an orbiter configuration. This commonality concept will serve to minimize the total development cost for the two missions.

The orbiter mission will be launched with an Atlas/Centaur launch vehicle in May 1978. The orbiting spacecraft will weigh 320 kg (706 lb.) in orbit and will carry 37 kg (81 lb.) of science. The multiprobe mission will be launched with an Atlas/Centaur in August 1978. A probe bus carrying 12 kg (26 lb.) of science will deliver one large probe with 28 kg (62 lb.) of science and three small probes with 2.1 kg (4.6 lb.) of science into the Venus atmosphere. Both missions will encounter Venus in December 1978 to provide synergistic study of the planet.

Project definition studies with competitive contractors were completed at the end of FY 1973 utilizing advanced technical development funds. Probe experiments have been selected and orbiter experiment selection is imminent. The experiment definition phase will continue through FY 1974. Preliminary design activity at a low level will also be carried on through FY 1974; hardware development is scheduled to begin in FY 1975. FY 1975 activity will commence with a design review of the conceptual and preliminary designs previously accomplished and will then proceed with detailed design and development. Experimenters will be funded for instrument development and fabrication of breadboard hardware. Procurement of spacecraft hardware will begin, and some qualification testing of components and/or subsystems will be initiated. Project management for Pioneer Venus will be at the Ames Research Center.

Pioneers 6-11

The Pioneer 6, 7, 8, and 9 spacecraft, launched 1965-1968, are continuing to obtain valuable 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 earth and the sun.) FY 1974 funds and the funds requested for FY 1975 will be used 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 the Pioneer 10 and 11 spacecraft.

Objectives of the Pioneer 10 and 11 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 meteoroids) of the Asteroid Belt, and measure the environmental and atmospheric characteristics of the planet Jupiter. As the Pioneer spacecraft pass near Jupiter, instruments measure the magnetic fields, electromagnetic emissions, charged particles and thermal balance associated with this largest planet of the solar system. Pioneer 10 was launched in March 1972 and has now successfully traversed the Asteriod Belt and survived the radiation belts at Jupiter. Excellent data have been obtained both during the trip to Jupiter and in the vicinity of the planet. Preliminary results have revealed new information about Jupiter's magnetic field and intense radiation belts much different from those of earth. Helium has been detected in Jupiter's atmosphere for the first time, and valuable new data on this planet's mass and shape characteristics and its energy balance have been obtained. New information concerning Jupiter's moons has also been gathered, considerably changing previous conceptions of mass, density and size. Tracking of Pioneer 10 will continue as it moves into interplanetary space beyond Jupiter. Pioneer 11 was launched in April 1973 and is now passing through the Asteroid Belt on the way to Jupiter.

Spacecraft - FY 1974 funds are being used to support the flight performance analysis of Pioneers 10 and 11 and for performance fee awards to the spacecraft contractor. FY 1975 funding provides for contractual fee awards.

Science - FY 1974 and FY 1975 funds are being used to support the analysis of the scientific data from Pioneers 10 and 11.

Operations - FY 1974 funds are being used for flight operations and for production of data tapes for Pioneers 6-11. This effort will continue in FY 1975, when Pioneer 11 will reach Jupiter while Pioneer 10 continues on its way out of the solar system.

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 region near the sun, to within about 0.3 AU. The spacecraft, to 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 launch vehicle and the tracking and data support for the first phase of the mission. West German technical personnel will conduct the spacecraft operations and will operate the tracking systems and acquire the data during the later mission phases.

Science - Fiscal Year 1974 funds are being used to support construction and testing of the prototype and flight models of the U.S. instruments for Helios A. Technical support is also provided for integration and testing of the equipment on the spacecraft and for development of the necessary instrument testing and operations software. During FY 1975 these efforts will continue. In addition technical support will be provided for Helios A instruments during launch and flight operations, and fabrication and test of Helios B instruments will proceed.

Operations - Mission operations planning and development of procedures and software are being supported in FY 1974. In FY 1975, this work will continue, and launch and flight operations for Helios A will be supported.

Supporting Research and Technology/Advanced Studies

	1973	1974	1975
Lunar science.....	$3,364,000	$2,918,000	$3,500,000
Planetary science.....	4,700,000	4,500,000	4,600,000
Exobiology.....	3,900,000	3,300,000	3,300,000
Planetary advanced studies.....	1,200,000	1,200,000	1,200,000
Planetary advanced technical development.....	6,200,000	3,100,000	5,200,000
Total.....	$19,364,000	$15,018,000	$17,800,000

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 they establish scientific competence which can be drawn upon for flight experiments; and they assure technological and planning readiness at the time of project starts.

Lunar Science

This program is directed to scientific research, with emphasis on studies that will provide a broader, sounder scientific base for the scientists in their analysis and synthesis of lunar data. With the exception of the still operating Apollo Lunar Surface Experiment Package (ALSEP) experiments, the program is presently the only source of significant new lunar data. In FY 1975 activities will emphasize studies in the following science areas: (a) earth-based observations, (b) Analog studies, (c) Theoretical studies, (d) Laboratory simulations, and e) Extraterrestrial materials (primarily meteorites) studies. Efforts will be increased in the area of earth-based, multispectral, telescopic studies of the lunar near side using promising new infrared techniques and equipment. The "ground truth" data provided by Apollo samples will thus be extrapolated to the unexplored visible regions of the moon.

The rapidly expanding knowledge gained from Apollo and previous lunar flight programs has enabled us to identify the remaining highest priority unanswered scientific questions about the moon. Our advanced mission studies, utilizing these questions, are aimed at identifying the optimum systems (flight and earth observations) needed to collect the required data. To obtain a comprehensive understanding of a planet such as the moon requires a global-scale knowledge of certain aspects of its composition, structure and fields. This can be accomplished by mapping from polar orbit both the radioactive and major rock-forming elements and the gravity and magnetic fields over the 80 percent of the moon not covered by Apollo, especially the critical farside and polar regions. A relatively inexpensive method of accomplishing this is by means of a small automated spacecraft in lunar polar orbit. A study will be undertaken in FY 1975 to define mission parameters, requirements and constraints; perform preliminary spacecraft and subsystem design; and develop mission implementation, cost, and project plans.

This project also supports the activities of the Lunar Science Institute (LSI) adjacent to the Johnson Space Center (JSC) and operated by the Universities Space Research Association (USRA). The LSI acts as a portal to the outside scientific community since it serves as an important data respository and research facility open to all qualified scientists.

Planetary Science

This program is subdivided into two major areas of research, planetary atmospheres and planetology. Research conducted under the planetary atmospheres program will emphasize the discovery and development of new techniques and experiments required for exploration and study of comets and the major planets in the late 1970's and early 1980's. The supporting theoretical studies and laboratory research necessary to lay the science foundation for future missions will be continued as will similar tasks exploiting the results of previous flight experiments to arrive at a better understanding of the planets and their atmospheres. In pursuing the basic objective of

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obtaining an understanding of planetary atmospheres, considerable progress has been made in understanding the nature and dynamics of the earth's atmosphere, and in describing the gross characteristics of the atmospheres of Mars and Venus. Experiments developed over the past five years are now assigned to or planned for flight missions to Mars and Venus to obtain a more detailed understanding of their atmospheres. Similarly, the knowledge, techniques, instruments, and experiments being developed in the mid-1970's will form the basis for flight missions to comets and the major planets in the early 1980's.

Tasks in planetology are directed at developing experimental concepts for determining the composition and structure of planetary surface materials and the nature and composition of planetary bodies. During FY 1975, particular emphasis is being directed toward experiments to determine the planetary surface composition by in-situ and remote sensing techniques; such experiments are candidates for future Mars and comets and asteroids missions. During FY 1975, emphasis will also be placed on the development of imagery experiments suited to particular requirements of investigations of Mars, Venus, and the outer planets, and on Mars-Earth comparative geology studies. Efforts will be directed toward Mars-Earth analog studies to determine similarities between these two planets.

Exobiology

This program is directed toward producing the answers to the fundamental questions of extraterrestrial life and the origin of life. The Mariner 9 results have heightened the prospects of finding life on Mars and have further confirmed the value of the Viking missions. In past years, the program brought to breadboard status the key instruments that were selected for flight on the Viking Mars landers. Work is now being directed toward follow-on Viking exploration of Mars as well as toward investigations of the complex and potentially "organic" atmospheres of Jupiter and Titan. During FY 1975, planetary biology will continue to support specific tasks in approximately 60 universities and two NASA Centers in the areas of organic chemistry, organic geochemistry, the biology of environmental extremes, and the development of techniques of life detection. These tasks pursue the overall objective of studying other planets for evidence related to the presence of life and/or life related molecules. In addition, feasibility demonstration instruments will be developed for future missions to the planets, and ground-based research will be aimed at aiding in the ultimate interpretation of data returned from such investigations.

Planetary Advanced Studies

The purpose of the advanced studies project is to define mission concepts that are feasible for performing a systematic exploration of the solar system and to develop a rationale with schedule and resource requirements for planning such missions in a logical, timely, and cost-effective manner. Only with such advance effort can new mission opportunities be identified (e.g. multiple outer planet flyby opportunities) and new flight projects defined to the point where realistic cost estimates can be made. Advanced studies are performed both in-house at NASA centers and under contract. The studies cover the range from mission analysis and system feasibility to preliminary mission design and engineering.

The FY 1974 and FY 1975 program includes mission studies for the inner and outer planets, their satellites, and small bodies of the solar system and general studies on adapting planetary spacecraft to the Space Shuttle/Tug.

Emphasis in the mission studies will be placed on the use of the Pioneer Venus spacecraft for extended exploration of the inner solar system, on the use of the Pioneer Saturn/Uranus Probe to investigate the Saturnian satellite Titan, and on the use of a modified Mariner Jupiter/Saturn spacecraft to orbit Jupiter. Missions to the comets (e.g. Encke) will be studied also.

Planetary Advanced Technical Development

The Advanced Technical Development (ATD) program supports the planning and the advanced development of new and improved spacecraft technologies critically required for future planetary missions. It is under this program that the detailed planning for potential projects is performed and the technology readiness achieved that will place them on a firm basis for the development of realistic schedules and cost estimates. Methods for achieving cost-effective missions through optimum utilization of existing spacecraft and subsystem design will be a prime consideration.

During FY 1974, the major emphasis is on completing the preparation for the Pioneer Venus project initiation. In FY 1975, emphasis will be placed on the extension of Pioneer-class capability to probe missions to Uranus, Saturn and Saturn's moon Titan.

Planetary Astronomy

	1973	1974	1975
Planetary astronomy.....	$4,800,000	$4,200,000	$4,200,000
Total.....	$4,800,000	$4,200,000	$4,200,000

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 more information about the planets from the vicinity of earth than previously possible. 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 1975, 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 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.

Presently underway is 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. The radar system will increase planetary astronomy radar capability to the point where scientists will be able to "map" the surface of Venus in considerably greater detail than presently possible, as well as study the surface properties of Mars, Mercury, and several Jovian satellites. The completion of the installation and testing is scheduled for mid-FY 1975 and Venus will be the first planet to be examined at high spatial resolution with this system.

Data Analysis

	1973	1974	1975
Lunar data analysis.....	$1,636,000	$7,851,000	$9,073,000
Planetary data analysis.....	1,400,000	1,400,000	1,400,000
Total.....	$3,036,000	$9,251,000	$10,473,000

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 growing body of knowledge about the characteristics and history of the moon and the planets.

Lunar Data Analysis and Synthesis

The immediate objective of this program is to interpret the large and still growing body of data acquired by lunar missions and SR&T research and, by integrating these results, to enhance our knowledge of the origin, present characteristics, and history of the moon. The longer term objective is to integrate such knowledge with that from terrestrial, planetary and solar studies, in order to gain a better understanding of the earth and the solar system.

During the Apollo phase of the lunar program, the primary scientific effort was limited largely to reducing and analyzing the results of individual experiments. However, the vast body of acquired Apollo data, additional data from the still operating Apollo lunar experiments, and data from the past automated lunar flight programs now require a new program of interdisciplinary analysis and synthesis which will provide the major scientific pay-off from the lunar flight programs. This new and growing data analysis and synthesis program is receiving enthusiastic support from researchers with broad scientific backgrounds who desire to utilize these data in attacking the major problems of lunar origin and history. This will continue to be the major thrust in FY 1975.

Planetary Data Analysis

During FY 1975 major emphasis in Planetary Data Analysis will be placed on continuation of analysis of the wealth of data obtained during the 11-month period in which Mariner 9 studied Mars, and on the analysis of data obtained by the very successful Pioneer 10 spacecraft on its Jupiter flyby. Especially meritorious tasks analyzing the results of earlier Mariner and Pioneer missions to the planets and in interplanetary space will be continued as will tasks involving the interdisciplinary correlation and interpretation of data obtained by satellites and rockets investigating earth's upper atmosphere.

Planetary Quarantine

	1973	1974	1975
Planetary quarantine.....	$2,200,000	$1,500,000	$1,500,000
Total.....	$2,200,000	$1,500,000	$1,500,000

The objectives of the Planetary Quarantine program are to insure that no detrimental extraterrestrial life is introduced into the environment of earth, and that no other planet is detrimentally contaminated by terrestrial organisms through operations by U.S. spacecraft. The high priority of this activity has been repeatedly emphasized by the Space Science Board and the International Committee on Space Research. The results of this program are also required for compliance with Article IX of the Space Treaty of 1966.

Planetary Quarantine research in FY 1975, as in FY 1974, will emphasize lower-temperature sterilization and investigation of factors that mitigate against the survival and growth of organisms in space with particular regard to quarantine problems unique to the outer planets. Studies begun in FY 1973 and continued in FY 1974 will be expanded in FY 1975 toward solving the problems that will be encountered in maintaining effective quarantine against any detrimental extraterrestrial life brought to earth from other planets. In FY 1974 required Planetary Quarantine operations (bioassays, sterilization, pre- and post- launch analyses) have been carried out in support of the Mariner-Venus/Mercury launch and have begun in preparation for the Viking 1975 mission. During FY 1975 Planetary Quarantine operations will increase to provide adequate support to the Viking mission.

Planetary Flight Support

	1973	1974	1975
Planetary flight support.....	$15,000,000	$22,000,000	$25,500,000
Total.....	$15,000,000	$22,000,000	$25,500,000

Planetary Flight Support provides the integrated computing and computer-related activities pertaining to the mission control of deep-space automated spacecraft and general purpose scientific and engineering computing at the Jet Propulsion Laboratory.

FY 1974 funds are being used to support Pioneers 6 through 11, including the highly successful Pioneer 10 flyby of Jupiter in December 1973; the Mariner 10 mission to Venus and Mercury; final preparations for the Helios A mission to be launched in late 1974; and continuing preparations for the Viking A and B launches in mid-1975. The communications and computer facilities are being upgraded as necessary to accommodate this increasing level of planetary activity.

During FY 1975 the funds will be used to continue support of Pioneer 6 through 11, the Mariner 10 mission, and the Helios A mission. Preparations for the Viking A and B launches will peak during FY 1975 and preparations will start for support of the Mariner Jupiter/Saturn 1977 missions.

Support of the tracking system analytic calibration effort, the formulation of the planetary programs data systems standards, and management of operations support at the Jet Propulsion Laboratory will continue during FY 1975. Also, support will continue for general scientific and engineering computing needs, and for selected project-peculiar activities such as preparation of data records.

The activities associated with Planetary Flight Support are not level-of-effort activities, but vary from year to year depending upon the planetary program content. The increase in funding from FY 1974 to FY 1975 reflects increasing program support requirements (Pioneer, Mariner, Helios, Viking), build up in support facilities, and the developmental effort involved in the planned replacement of obsolete equipment and equipment which is no longer serviceable.

Lunar Sample Analysis

	1973	1974	1975
Lunar sample analysis.....	---	$5,667,000	$5,798,000
Total.....	---	$5,667,000	$5,798,000

Among the most important scientific information so far obtained from the moon is the extensive set of data on the chemical, isotopic, and physical characteristics of the lunar rocks and soil samples. These samples have already provided the essential elements of an absolute lunar chronology, and have led to models of lunar composition and evolution quite different from those anticipated prior to the return of lunar samples. In addition, data on the interactions of solar and interstellar products with lunar surface materials is leading to a far better understanding of the history of the sun and stellar processes in general. In order that these major lunar questions can continue to be answered, detailed investigations are being carried out by highly qualified Principal Investigator teams at institutions where unique research capabilities and skills have been developed. The success of the lunar sample program depends on our ability to fund and maintain these centers. In addition, keeping these centers viable will insure that their skills and capabilities are adopted by the scientific community and applied to significant earth applications.

This project involves over 130 domestic principal investigators and 55 foreign investigators as well as over 700 co-investigators. The funds are used to furnish salary support, computer efforts, supplies, and instruments for only the U.S. investigators. In FY 1974 the program was significantly reduced by eliminating successfully completed studies such as the search for biological material in the lunar samples and other less significant investigations. This resulted in some 30 principal investigators no longer being funded. FY 1975 funds will be used to bring into the program new investigators with fresh approaches and ideas. Program funding for FY 1975 also includes funds to update many of the instruments that are now over five years old.

Lunar Science Operations

	1973	1974	1975
Lunar science operations.....	---	$1,614,000	$4,333,000
Total.....	---	$1,614,000	$4,333,000

The full scientific potential of six successful Apollo missions clearly cannot be realized without the continued operation of the five long-lived Apollo Lunar Surface Experiment Packages (ALSEPs) and the three laser ranging retroreflectors emplaced at the Apollo 11, 14, and 15 landing sites. Most of the ALSEP instruments, the majority of which were designed for a minimum lifetime of 12 months, are still furnishing important, valid scientific information. We will continue to operate these lunar systems as long as they furnish valuable scientific data. Continued observations under this task require support at Johnson Space Center (JSC): (1) to operate these instruments and to record and format raw data for principal investigators, (2) for principal investigators, who are familiar with instrument characteristics to reduce raw data from these instruments to useful scientific observations, and (3) for these data to be placed in data banks where they will be available to scientific investigators.

The Sample Curatorial Facility is a major component of the post-Apollo scientific effort. Its implementation involves support of JSC for handling, storing, preparing and distributing lunar materials as well as documenting the history and data obtained on each sample and assuring their security. This practice will continue in order to preserve these unique materials for study by innovative techniques which may be developed in the future as well as for second generation analyses. The Curatorial Facility will remain the repository of the major portion of lunar samples. As an added precaution a small, selected portion of this irreplaceable material will be placed in CY 1974 in an especially prepared secondary storage site at White Sands, New Mexico.

The laser ranging program is continuing at McDonald Observatory and the new observatory at Mt. Haleakala in Hawaii is scheduled to begin its observing program in late FY 1974. The primary objectives of this investigation include the study of physics of the moon, gravitation and relativity, and the physics of the earth. Significant secondary benefits that will increase our understanding of the earth are more accurate measurements of the wobbles of the earth's axis of rotation, which could enhance our capacity for earthquake prediction; and measurements of the relative motions between the continental United States and Hawaii, which would refine our theories on continental drift.

FY 1975 funds will support the continual collection and processing of ALSEP data, continued characterization, cataloging and distribution of the lunar samples, and the operations of the McDonald and Haleakala observatories.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1975 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE — LAUNCH VEHICLE PROCUREMENT PROGRAM

	1973	1974	1975
Scout	$15,700,000	$8,300,000	$13,800,000
Centaur	120,700,000	112,200,000	75,000,000
Delta	76,000,000	50,500,000	47,700,000
Titan IIIC	5,500,000	---	---
Supporting research and technology/advanced studies	3,100,000	4,000,000	4,000,000
Total	$221,000,000	$175,000,000	$140,500,000

Distribution of Program Amount by Installation:

Kennedy Space Center	$3,388,000	$3,880,000	$10,415,000
Marshall Space Flight Center	1,107,000	2,246,000	1,790,000
Goddard Space Flight Center	74,464,000	49,300,000	42,890,000
Jet Propulsion Laboratory	762,000	610,000	1,015,000
Langley Research Center	15,774,000	8,265,000	13,465,000
Lewis Research Center	117,773,000	108,774,000	68,675,000
Headquarters	7,732,000	1,925,000	2,250,000
Total	$221,000,000	$175,000,000	$140,500,000

HIGHLIGHTS OF BUDGET PLAN

Scout			
Incremental funding of hardware procurement in support of SAS, UK, San Marco, Dual Air Density, German, ANS, Hawkeye, and Relativity Probe missions	$5,600,000	---	$5,800,000
Management and engineering support, test and checkout, launch operations, maintenance, and field support	10,100,000	8,300,000	8,000,000
No improvements are planned for FY 1975	---	---	---
Total Scout	$15,700,000	$8,300,000	$13,800,000

	1973	1974	1975
Centaur			
Incremental funding of hardware procurement in support of Viking, HEAO, Mariner Venus/Mercury 1973, Helios, Pioneer, and Mariner Jupiter/Saturn missions...	$58,065,000	$65,875,000	$27,500,000
Management and engineering support, test and checkout, launch operations, maintenance, and field support	31,509,000	40,210,000	47,200,000
Major improvements encompassing the improved Centaur, Titan Centaur integration and proof flight, and selective redundancy and quality control to improve vehicle reliability.....	31,126,000	6,115,000	300,000
Total Centaur.....	$120,700,000	$112,200,000	$75,000,000
Delta			
Incremental funding of hardware procurement in support of RAE, Atmosphere Explorers, Nimbus, GEOS, IMP, OSO, ERTS, SMS, LAGEOS, IUE, and CAS missions.....	$23,370,000	$24,304,000	$12,800,000
Management and engineering support, test and checkout, launch operations, maintenance, and field support..	38,670,000	21,196,000	32,900,000
Reliability improvements to first and second stage pneumatics, second stage hydraulics, guidance components, POGO suppression.....	13,960,000	5,000,000	2,000,000
Total Delta.....	$76,000,000	$50,500,000	$47,700,000

	1973	1974	1975
Titan IIIC			
Incremental funding of hardware procurement and related services from USAF for the ATS-F mission.....	$5,500,000	---	---
Total Titan IIIC.....	$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.....	$1,135,000	$1,310,000	$1,535,000
Propulsion and Energy Conversion.....	1,375,000	1,650,000	1,330,000
Guidance, Control and Navigation.....	112,000	605,000	735,000
Instrumentation and Electronics.....	90,000	125,000	125,000
Structures and Materials..	100,000	100,000	100,000
Vehicle Engineering.....	288,000	210,000	175,000
Total Supporting Research and Technology/Advanced Studies.....	$3,100,000	$4,000,000	$4,000,000

OFFICE OF SPACE SCIENCE

LAUNCH VEHICLE PROCUREMENT PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

Launch Vehicle Procurement provides for the centralized procurement of launch vehicle and launch support services for NASA's automated spacecraft missions. This includes the procurement of vehicle hardware, launch services, engineering and maintenance, and, as required, development of improved vehicle systems including the necessary ground support equipment.

In addition, efforts have been undertaken and are continuing in the area of Supporting Research and Technology/Advanced Studies to investigate new technological developments. Launch vehicles currently being procured are: Scout, Delta, Atlas Centaur, and Titan III/Centaur.

The budget request for each launch vehicle includes 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 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		
	1973	1974	1975
Hardware.....	$5,600,000	---	$5,800,000
Supporting activities.....	10,100,000	$8,300,000	8,000,000
Major improvements.....	---	---	---
Total.....	$15,700,000	$8,300,000	$13,800,000

The Scout launch vehicle was initiated by NASA in 1959 with the goal of launching economically a large variety of small scientific satellites, space probes, and re-entry experiments.

The first Scout launch occurred in July 1960. In the ensuing 13 years, there have been 84 launches. The vehicle has sustained a 100 percent launch record in its last 29 launches.

The Scout vehicle is the smallest launch vehicle employed by NASA. It is a four stage, all solid propellant launch vehicle. 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 mile) orbit.

The Langley Research Center, located near Hampton Roads, Virginia, has managed the Scout project since its inception. The prime contractor for the production, checkout, and launch of Scout is the Ling-Temco-Vought Aerospace Corporation located in Dallas, Texas.

Scout vehicles are launched from the Western Test Range, California; from Wallops Island, Virginia; and from the San Marco Platform off the African coast near Kenya.

Funds requested for FY 1975 will be used as follows:

Hardware - Funds will be utilized to continue hardware procurement to support Small Astronomy Satellite-C, Dual Air Density, Hawkeye/Neutral Point Explorer, Relativity Probe, and cooperative scientific missions with the Italian, German and Dutch governments.

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 1975.

Centaur

	1973	1974	1975
Hardware.....	$58,065,000	$65,875,000	$27,500,000
Supporting activities.....	31,509,000	40,210,000	47,200,000
Major improvements.....	31,126,000	6,115,000	300,000
Total.....	$120,700,000	$112,200,000	$75,000,000

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 payloads or high energy missions beyond the lifting capability of Atlas Centaur. A proof flight development test launch is planned for early 1974 and the first operational launch is scheduled with the Helios-A mission in the third quarter of 1974. The Titan Centaur is 49 meters (160 feet) high and has a payload shroud diameter of 4.3 meters (14 feet).

Funds requested for FY 1975 will be used as follows:

Hardware - Funds are required to continue incremental procurement of hardware to support Helios-A and -B, Viking-A and -B, Mariner Jupiter/Saturn A and B, and High Energy Astronomy Observatory (HEAO) -A and -B missions.

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 small improvement effort is continuing in FY 1975 primarily in quality control and workmanship to improve vehicle reliability.

Delta

	1973	1974	1975
Hardware.....	$23,370,000	$24,304,000	$12,800,000
Supporting activities.....	38,670,000	21,196,000	32,900,000
Major improvements.....	13,960,000	5,000,000	2,000,000
Total.....	$76,000,000	$50,500,000	$47,700,000

The Delta launch vehicle is the most used vehicle in the NASA launch vehicle family. Since its first use in 1960, this vehicle has been utilized in 100 launches and has experienced a success record of 90 percent. 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, which provides 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 solid motor which is spin stabilized. This vehicle in its three stage configura-

tion 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 1975 will be used as follows:

Hardware - Funds will be used to continue the hardware procurement contracts initiated in FY 1973 and FY 1974 in support of Atmosphere Explorer-D and -E, Cooperative Applications Satellite, Nimbus G, Earth Resources Technology Satellite-B, Lageos-A and International Ultraviolet Explorer-A.

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 - Reliability improvements for this vehicle system during this period include redesign of the attitude control, hydraulic, and pneumatic systems of the second stage Delta. Additionally, plans include procurement of second source flight guidance computers to insure that the launch schedule commitments can be met.

Titan IIIC

	1973	1974	1975
Hardware	$5,500,000	---	---
Total	$5,500,000	---	---

The Titan IIIC 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. The ATS-F mission is planned to be launched in the second quarter of 1974.

No FY 1974 or FY 1975 funds are required to complete the vehicle procurement and support of this mission, and no other NASA missions are planned to be launched by this vehicle at this time.

Supporting Research and Technology/Advanced Studies

	1973	1974	1975
Advanced studies.....	$1,135,000	$1,310,000	$1,535,000
Propulsion and energy conversion....	1,375,000	1,650,000	1,330,000
Guidance, control and navigation....	112,000	605,000	735,000
Instrumentation and electronics.....	90,000	125,000	125,000
Structures and materials.....	100,000	100,000	100,000
Vehicle engineering.....	288,000	210,000	175,000
Total.....	$3,100,000	$4,000,000	$4,000,000

The objective of the Supporting Research and Technology (SR&T)/Advanced Studies project is to provide preliminary data and alternatives to management so that decisions concerning the space transportation system may follow a well defined, integrated course in future years.

In FY 1974, the Advanced Studies program is directed toward investigations of a solar electric propulsion stage for use with the Shuttle/Tug or conventional launch vehicles, and the adaptation of existing vehicles for use as upper stages to the Space Shuttle. The SR&T program is directed at improving reliability, cost, and safety of launch vehicles and determining their environmental effects. Activities include testing and evaluation of the use of small liquid dual mode rocket engines for spacecraft use, investigation of pyrotechnic reliability, and evaluation of cost effective use of new astrionic technology in guidance applications.

Funds requested for FY 1975 will be used as follows:

Advanced Studies - Space Shuttle upper stage applications and solar electric propulsion advanced studies will be continued. Launch vehicle phase out studies will be initiated in order to insure an orderly and cost effective utilization of the Space Shuttle.

Propulsion and Energy Conversion - Solar array technology for solar electric propulsion and research in solar electric propulsion system capabilities will be continued.

Guidance, Control, and Navigation - Development, test, and evaluation of strap down guidance system components consisting of inertial sensors and computer technology will be continued.

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

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Structures and Materials - Continue to provide the technology required for effective design, fabrication, maintenance and operation of thermal protection systems for use with cryogenic propellants.

Vehicle Engineering - Continued investigation during FY 1975 of atmospheric effects resulting from effluents produced during vehicle launching activities.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1975 ESTIMATES

BUDGET SUMMARY

OFFICE OF APPLICATIONS — SPACE APPLICATIONS PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1973	1974	1975
Weather and climate.....	$60,345,000	$51,100,000	$35,000,000
Pollution monitoring.....	2,300,000	11,800,000	29,800,000
Earth resources survey.....	55,155,000	47,400,000	58,600,000
Earth and ocean physics.....	7,200,000	10,400,000	18,500,000
Space processing.....	---	3,000,000	3,500,000
Energy applications.....	---	2,000,000	2,000,000
Communications.....	58,106,000	22,100,000	8,300,000
Data management.....	---	---	4,000,000
Earth observatory satellite definition.....	900,000	3,000,000	1,000,000
Shuttle experiment definition....	---	4,500,000	4,500,000
Advanced applications experiment studies.....	4,694,000	4,700,000	4,700,000
Applications systems analysis....	---	1,000,000	5,000,000
Applications explorers heat capacity mapping mission.....	---	---	2,600,000
Total.....	$188,700,000	$161,000,000	$177,500,000

Distribution of Program Amount by Installation:

Johnson Space Center.....	$13,979,000	$18,818,000	$31,700,000
John F. Kennedy Space Center.	150,000	255,000	1,400,000
Marshall Space Flight Center.	642,000	4,320,000	5,000,000
Goddard Space Flight Center..	148,549,000	80,863,000	89,100,000
Jet Propulsion Laboratory....	1,058,000	3,884,000	3,200,000
Wallops Station.....	5,522,000	6,457,000	7,700,000
Ames Research Center.....	3,273,000	7,502,000	7,100,000
Langley Research Center.....	6,779,000	8,469,000	8,400,000
Lewis Research Center.....	3,332,000	3,840,000	2,100,000
NASA Headquarters.....	5,416,000	26,592,000	21,800,000
Total.....	$188,700,000	$161,000,000	$177,500,000

HIGHLIGHTS OF BUDGET PLAN

	1973	1974	1975
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.....	$15,388,000	$9,538,000	$3,430,000
Advanced instruments for determination of the vertical structure of the atmosphere.....	12,330,000	5,466,000	2,270,000
Ground control operations for missions beginning in late 1972.....	1,082,000	1,396,000	1,300,000
Delta (Launch Vehicle Procurement).....	(3,500,000)	(1,000,000)	---
Total, NIMBUS 5&F.....	$28,800,000	$16,400,000	$7,000,000
Cloud Imaging from Synchronous Satellites (SMS A&B)			
Spacecraft design, development and test leading to launch of two spacecraft in 1974.....	$13,234,000	$8,960,000	$1,400,000
Sensors to provide continuous high resolution day and night cloud cover data.....	2,627,000	500,000	---
Fabrication and installation of ground station equipment.....	839,000	540,000	---
Delta (Launch Vehicle Procurement).....	(3,800,000)	(5,500,000)	---
Total, SMS.....	$16,700,000	$10,000,000	$1,400,000

	1973	1974	1975
Operational Temperature Sounding Satellite (TIROS-N)			
Spacecraft design and development leading to launch in 1977.....	---	$3,000,000	$7,000,000
Sensor development to provide capability for making advanced atmospheric soundings and sea-surface temperature measurements.....	$4,250,000	7,000,000	2,000,000
Total, TIROS-N.....	$4,250,000	$10,000,000	$9,000,000
Operational Satellite Improvements			
Advance sensor design work and studies to improve subsystem and operational procedures for TIROS and SMS operational systems including advanced instruments to provide vertical temperature soundings from synchronous altitudes.....	$1,755,000	$2,500,000	$3,500,000
Global Atmospheric Research Program (GARP)			
Data systems test support.....	$642,000	$1,359,000	$1,340,000
Simulation studies.....	2,299,000	3,100,000	3,601,000
First GARP global experiment.....	---	400,000	956,000
GARP Atlantic tropical experiment support (GATE).....	---	624,000	1,165,000
Technology development.....	299,000	217,000	338,000
Total, GARP.....	$3,240,000	$5,700,000	$7,400,000

	1973	1974	1975
Meteorological Sounding Rocket Programs			
Procurement and launch of research sounding rockets.....	$200,000	$500,000	$700,000
Development of sounding rocket systems.....	350,000	200,000	100,000
Field experiment support.....	650,000	800,000	900,000
Total, Meteorological Soundings..	$1,200,000	$1,500,000	$1,700,000
Advanced Techniques in Observing and Forecasting.....	$4,400,000	$5,000,000	$5,000,000
Total, Weather and Climate.....	$60,345,000	$51,100,000	$35,000,000
Pollution Monitoring			
Oceanographic and Air Pollution Observing Satellite (NIMBUS G)			
Spacecraft design and development for launch in 1977.....	---	$520,000	$11,800,000
Continuation of sensor development which will allow measurements of atmospheric and oceanographic parameters on a global basis.....	---	8,480,000	14,700,000
Initiation of development of ground support equipment.....	---	---	500,000
Delta (Launch Vehicle Procurement)...	---	---	(400,000)
Total, NIMBUS G.....	---	$9,000,000	$27,000,000
Sensor Definition and Feasibility Evaluations.....	$2,300,000	$2,800,000	$2,800,000
Total, Pollution Monitoring.....	$2,300,000	$11,800,000	$29,800,000

	1973	1974	1975
Earth Resources Survey			
Earth Resources Technology Satellites (ERTS)			
Spacecraft development and fabrication for ERTS-B mission in 1975....	$5,997,000	$7,569,000	$3,200,000
Sensor development to provide imagery and earth resources data for agriculture, geology, hydrology, oceanography and geography.....	4,411,000	1,700,000	---
Ground data handling and mission operations and generation of image products.....	6,929,000	1,131,000	2,300,000
Support of investigators conducting experiments and developing techniques to utilize ERTS data.....	15,263,000	6,000,000	5,600,000
Delta (Launch Vehicle Procurement).	---	(3,500,000)	(1,000,000)
Total, ERTS.....	$32,600,000	$16,400,000	$11,100,000
Multispectral Scanner-5th Band Development			
Continue development of an advanced multispectral scanner containing a thermal channel capable of observing resources characterized by temperature and thermal pollution.....	---	$1,000,000	$4,000,000
Earth Observations Aircraft Program			
Aircraft operations and logistics in support of ERTS, EREP and regional programs.....	$6,710,000	$6,733,000	$7,255,000
Aircraft sensor development and procurement.....	1,100,000	1,491,000	1,505,000

	1973	1974	1975
Aircraft equipment and maintenance and modification.....	$3,050,000	$2,173,000	$2,300,000
Data handling and processing.....	2,140,000	4,403,000	5,340,000
CV 990 replacement.....	---	2,000,000	900,000
Total, Aircraft Program.....	$13,000,000	$16,800,000	$17,300,000
Earth Resources Experiment Package Investigations			
Support of investigators conducting experiments utilizing data acquired by Skylab sensors.....	($2,500,000)	($3,200,000)	$3,800,000
Data Interpretation Techniques, Special Investigations and Data Analyses.....	$9,555,000	$13,200,000	$13,000,000
Earth resources survey data processing, evaluation and analysis, photographic services, related supplies, and equipment.....	(8,500,000)	(9,500,000)	9,400,000
Total.....	$9,555,000	$13,200,000	$22,400,000
Total, Earth Resources Survey....	$55,155,000	$47,400,000	$58,600,000
Earth and Ocean Physics			
GEOS 1&2			
Completion of operations, data reduction, and analyses.....	$1,145,500	---	---
Geodynamic Experimental Ocean Satellite (GEOS-C)			
Spacecraft design, development and test leading to launch in 1974...	$2,400,000	$2,400,000	$70,000

	1973	1974	1975
Instrumentation to determine the feasibility of measuring the ocean topography and to provide more accurate geoscience data.....	$1,595,500	$600,000	$402,000
Ground support preparation for mission beginning in 1974.....	200,000	400,000	428,000
Delta (Launch Vehicle Procurement).	(3,800,000)	---	---
Total, GEOS-C.....	$4,195,500	$3,400,000	$900,000
Laser Geodynamic Satellite (LAGEOS)			
Spacecraft design, development and test leading to launch in 1976.....	---	$830,000	$1,455,000
Ground support preparation for mission beginning in 1976.....	---	470,000	845,000
Delta (Launch Vehicle Procurement).	---	(3,000,000)	(1,600,000)
Total, LAGEOS.....	---	$1,300,000	$2,300,000
Ocean Dynamics Satellite (SEASAT-A)			
Spacecraft design, development and test leading to launch in 1978.....	---	---	$3,200,000
Instrument design, development and testing.....	---	---	4,800,000
Total, SEASAT-A.....	---	---	$8,000,000
Tectonic Plate Motion			
Measurement and analysis of tectonic plate and crustal motions...	---	---	$2,000,000
Measurement Systems Forecasting Techniques and Modeling.....	$1,859,000	$3,000,000	$2,600,000

	1973	1974	1975
Experiment Data Analysis			
Data analysis of GEOS, LAGEOS, SEASAT and related ground-based experiments.....	---	$2,700,000	$2,700,000
Total, Earth and Ocean Physics...	$7,200,000	$10,400,000	$18,500,000
Space Processing			
Ground-based investigations.....	($3,100,000)	$3,000,000	$3,100,000
Sounding rocket missions.....	---	---	400,000
Total, Space Processing.....	($3,100,000)	$3,000,000	$3,500,000
Energy Applications			
Studies of solar power conversion and delivery systems; hydrogen production and utilization systems; and energy and environment conservation systems.....	---	$2,000,000	$2,000,000
Communications			
Canadian Cooperative Satellite (CAS-C)			
Spacecraft testing.....	$339,000	$460,000	$790,000
Experiments.....	2,247,000	2,200,000	560,000
Mission analysis and operations....	100,000	100,000	200,000
Delta (Launch Vehicle Procurement).	---	(1,000,000)	(3,600,000)
Total, CAS-C.....	$2,686,000	$2,760,000	$1,550,000

	1973	1974	1975
Multi-User Communications Experiment Satellite (ATS-F)			
Spacecraft design, development and test leading to launch of the spacecraft in 1974.....	$40,189,000	$12,174,000	---
Instrumentation development for communications experiments at synchronous altitudes such as health and education telecommunications experiments and advance spacecraft subsystems demonstration.....	9,477,000	1,819,000	---
Procurement and modification of ground station equipment.....	2,188,000	2,007,000	---
Titan III-C (Launch Vehicle Procurement).....	(5,500,000)	---	---
Total, ATS-F.....	$51,854,000	$16,000,000	---
Experiments Coordination and Operations Support			
Provides support to users in communications experiments validation and operations for ATS-F and CAS-C..	---	$800,000	$3,700,000
Technical Consultation and Support Studies.....	($720,000)	$2,540,000	$1,650,000
Advanced Communications Research....	---	($1,000,000)	$1,400,000
ATS 1-5			
Operations and data analysis.....	$1,333,000	---	---
Systems Technology and Techniques...	$2,033,000	---	---
Traffic Management Studies			
Studies in support of DOT/FAA.....	$154,000	---	---

	1973	1974	1975
Cooperative Applications Satellites (CAS-A)			
Completion of operations, data reduction and analysis.....	$46,000	---	---
Total, Communications.....	$58,106,000	$22,100,000	$8,300,000
Data Management			
Systems requirements studies.....	---	---	$500,000
Conduct research in onboard processing to optimize spacecraft and ground station systems requirements and hardware configurations.....	---	---	1,000,000
Develop technology and technical data to improve data transmission links.....	---	---	1,000,000
Improve ground processing systems through application of digital data systems.....	---	---	1,500,000
Total, Data Management.....	---	---	$4,000,000
Earth Observatory Satellite (EOS) - Definition			
Continuation of the definition studies for an earth observing satellite (EOS).....	$900,000	$3,000,000	$1,000,000
Shuttle Experiment Definition			
Identify and define the applications experiments to be conducted during the period when the space shuttle will be the principal space transportation system (STS).....	---	$4,500,000	$4,500,000

	1973	1974	1975
Advanced Applications Flight Experiments			
Design and development of experimental flight instruments to meet future instrument requirements. This includes the fabrication of engineering models.....	$4,694,000	$4,700,000	$4,700,000
Applications Systems Analyses			
Includes advanced studies of new directions in current applications programs and the study of entirely new applications in order to establish need and economic or other practical benefit justification in the early life of a program.....	---	$1,000,000	$5,000,000
Applications Explorers: Heat Capacity Mapping Mission			
Initiation of spacecraft subsystem design and instrument modification leading to launch in 1977.....	---	---	$2,600,000

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 Launch of SMS-B	1974 1974
Global Atmospheric Research Program	DST, GATE, FGGE	1974, 1977-78
Meteorological Sounding Rockets	Launch about 280 annually	
Pollution Monitoring:		
Oceanographic and Air Pollution Observing Satellite	Launch of NIMBUS G	1978
Earth Resources Survey:		
Earth Resources Technology Satellites	Launch of ERTS-B	1975
Earth and Ocean Physics:		
Ocean Dynamics Monitoring Satellite	Launch of GEOS-C	1974
Ocean Dynamics Satellite	Launch of SEASAT-A	1978
Terrestrial Measurement Referencing Satellite	Launch of LAGEOS	1976

PROJECT	MISSION	CALENDAR YEAR
Space Processing:		
Sounding Rocket Missions	Launch about 6 annually	
Communications:		
Multi-User Communications Experiment Satellite	Launch of ATS-F	1974
Canadian Cooperative Satellite	Launch of CAS-C	1975
Applications Explorers:		
Heat Capacity Mapping Mission	Launch of HCMM	1977
Reimbursable Missions:		
ITOS*	Launch of ITOS D-I	1973-1978 (Subject to call-up by NOAA)
GOES*	Launch of GOES A-C	1974-1976 (Subject to call-up by NOAA)

*National Oceanic and Atmospheric Administration (NOAA) Funded.

OFFICE OF APPLICATIONS SPACE APPLICATIONS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The major objective of the Space Applications program is to conduct research and development activities that demonstrate the application of space-related technology, systems and other capabilities which can be effectively applied and used in the civil sector for practical benefits to mankind. Generally, these R&D activities are grouped in the following areas: Weather and Climate, Pollution Monitoring, Earth Resources Survey, Earth and Ocean Physics Applications, Space Processing, Communications, Energy Research, Data Management, and Application Experiments and Studies.

The FY 1975 Applications program is directed toward the successful accomplishment of the objectives of a number of flight projects which were initiated in previous years. These flight projects have progressed through the various developmental phase. In CY 1974 the launch schedule calls for a total of five launches; the NIMBUS F and Synchronous Meteorological Satellites A&B in the Weather and Climate area; GEOS-C in the Earth and Ocean Physics area; and the Applications Technology Satellite F in the Communications area.

In addition, several new or augmented activities, both flight and ground-based, which provide interesting and unique future application opportunities, are included in the proposed program. The most noteworthy of these are discussed below.

SEASAT-A Mission--Earth and Ocean Physics: The SEASAT-A mission and system have been jointly conceived and defined by NASA and the oceanographic user community as the first research and development satellite addressing the scientific and applications aspects of Ocean Dynamics.

Scientifically, SEASAT-A will, for the first time, provide synoptic, global data on wave heights and directions, surface winds, and ocean temperatures. This information will be especially valuable in improving our understanding of air/sea interactions both on a worldwide basis, and in local regions, for example, where hurricanes are evolving. This research will lead to better models for forecasting ocean surface conditions. SEASAT-A will also provide our first data on deep ocean tides, the total ocean topography, and new information about the dynamics of polar ice formations.

The assessment and experimental use of application information obtained by SEASAT-A will include the monitoring and forecasting of sea state, currents, storm surges, and ocean surface winds. This information can be used for such purposes as improved ship routing; the siting and design of offshore structures; the extension of worldwide weather forecasting (14-day); long-range climate prediction; and the monitoring of ocean pollution, to mention a few.

Applications Explorer--Heat Capacity Mapping Mission: The Heat Capacity Mapping mission is designed to collect medium spatial resolution data for the development of thermal maps of the surface of the earth. This information is of major value and has many applications. It is useful in mineral exploration, and in major civil works such as highway development. In addition, thermal image data has great potential for monitoring the location of the ocean currents and the temperature variations of coastal waters. To date, thermal imagery has demonstrated effectiveness in detecting and monitoring river and pollution plumes, sea ice and soil moisture. The basic instrument (radiometer) to accomplish these tasks has been developed and tested under our Advanced Applications Flight Experiment (AAFE) program.

Tectonic Plate Motion Experiments: For the past year, experimental data has been collected and major progress has been made in precision measurement systems and modeling capabilities for the purpose of measuring the almost infinitesimal movements of the tectonic plates which make up the crustal surface of the earth. The hypothesis for experimentation is represented by the following: When two of these plates are moving at certain places and are locked elsewhere, strain builds up and ultimately an earthquake occurs. The FY 1975 funds will be used to continue those projects and experiments already started to determine our ability to measure these plate motions with the required precision. These three experiments are involved: The San Andreas Fault Experiment in California which is to demonstrate the feasibility of using satellite-tracking lasers to determine relative surface motion across the fault; the Astronomic Radio Interferometric Earth Surveying (ARIES) experiment which will use the distant stars as an alternative to laser tracking of satellites for the measurement of regional crustal motion; and, the Pacific Plate Motion Experiment (PPME), the primary objective of which will be to determine the relative motion of the Pacific plate, the North American plate and the Eurasian plate. Data from these experiments will be used as input for the development of a tectonic plate motion model on a global scale.

Energy Applications: Systems studies in the possible use of solar power, hydrogen fuel, and microwave energy distribution are being conducted in FY 1974. These studies will continue in FY 1975, and some of the most

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promising systems and required technologies will be pursued in more detail. Study objectives are currently oriented toward the feasibility of using these potential sources of power. From these studies, plans will be developed for setting forth the need for advanced technology and system development efforts.

Earth Observing Satellites (EOS) Definition: Work will continue in the the EOS definition effort initiated in FY 1973. The primary objective in FY 1975 is to establish the detailed hardware feasibility and approach to second-generation sensors that may be required for terrain observations. Such instruments can extend the applications of remote sensing from space to permit more detailed classification and monitoring of land use. Agriculture yield prediction accuracy can be increased by the ability to recognize more subtle differences in crop type and crop vigor, and the extension of accurate identification from fields of 20 acres in size to those close to an acre. The work proposed in this effort is directed toward long-lead instrumentation development with the intent of phasing this work into a future Earth Observatory spacecraft.

Data Management: Data Management activities are directed towards the study, design, development and demonstration of the technology for improving the flow of data from onboard satellite systems to user terminals and/or facilities. Satellite systems now being developed in the Applications program require the extension of current data management technology to accomodate the increased volume, complexity, and exceedingly high rates of data involved; to reduce origin-to-user data transmission times; and to provide improved capabilities for the rapid storage, maintenance and retrieval of data products. Within this context, the planned objectives are to study and identify total systems requirements for: (1) collecting, processing, compressing and storing most efficiently, with respect to users needs, the sensor-collected data aboard the spacecraft and preparing for transmission to the ground; (2) improving data transmission from satellite-to-satellite, satellite-to-ground stations, and ground station-to-data processing facility; and (3) improving ground data processing systems.

Applications Systems Analyses: The Applications Systems Analyses effort is aimed at assuring that the research and development activities defining the current and future Applications program are practical and cost effective, and based on established user needs and requirements. To accomplish this objective, special emphasis is placed on user-oriented economic analyses and assessment of on-going programs and projects, and on new applications analyses and evaluations. A major consideration in all such investigations is to establish need and economic justification as early in the life of a program activity as possible and to update these assessments through follow-on studies as more detailed information and data are developed.

During 1974 studies will be conducted to assess and analyze the cost effectiveness and cost benefits of several applications programs and projects, e.g., Communications as a Substitute for Transportation; the Practical Utility of Earth Resources Remote Sensing; and the Identification of Beneficial Space Processing Techniques. Studies for FY 1975 will encompass additional analyses and assessments, e.g., Water and Waste Management; Satellite Census and Demographic Systems; the Application of Teleoperator Systems to Industrial Processes; Community Safety and Citizen Conveniences.

Summary: The baseline NASA Applications program in FY 1975 includes R&D efforts in each of the discipline areas delineated in the opening paragraph to this statement. Each of these disciplines and their attendant projects are described in detail in the appendages to this summary.

BASIS OF FUND REQUIREMENTS:

Weather and Climate

	1973	1974	1975
All weather atmospheric soundings experimental satellites (NIMBUS 5&F).....	$28,800,000	$16,400,000	$7,000,000
Cloud imaging from synchronous satellite (SMS A&B).....	16,700,000	10,000,000	1,400,000
Operational temperature sounding satellite (TIROS-N).....	4,250,000	10,000,000	9,000,000
Operational satellite improvements.....	1,755,000	2,500,000	3,500,000
Global atmospheric research program (GARP).....	3,240,000	5,700,000	7,400,000
Meteorological sounding rocket program.....	1,200,000	1,500,000	1,700,000
Advanced techniques in observing and forecasting.....	4,400,000	5,000,000	5,000,000
Total.....	$60,345,000	$51,100,000	$35,000,000

Polar orbiting satellites of the ITOS/NOAA series developed by NASA are providing quantitative soundings of the global atmosphere for use in numerical weather prediction, and global viewing of clouds and storm systems, with direct readout to local ground stations. With the launch of the Synchronous Meteorological Satellite (SMS) spacecraft in early 1974, the second basic objective of the national program for operational use of meteorological satellites will have been achieved. These geostationary orbiting satellites of the SMS/Geostationary Operational Environmental Satellite (GOES) series will add the capability for continuous surveillance of changing weather

features over most of the Pacific and Atlantic Oceans and the American Continents. This will mark the inauguration of the total National Operational Meteorological Satellite System, with both the global monitoring and continuous surveillance components in operational use.

In FY 1975 and ensuing years, the main thrusts of the Weather and Climate program will be directed toward the application of satellite data to vital problems in (1) the detection, prediction, and early warning of severe storms, (2) the improvement of our capability for long-range weather prediction, and (3) the development of advanced sensors and satellite systems for application to these two major environmental problems.

In FY 1975 attention will focus on major applications of satellite systems to short- and long-term weather prediction. Operational use of the SMS/GOES spacecraft by the national weather services will permit continuous surveillance of tropical hurricanes, thunderstorms, tornadoes, snow storms, and other severe storms providing early warning capability as well as data for research on these phenomena. Imaging sensors at geostationary altitude will provide this capability to monitor continuously, on a day-and-night basis, the occurrence, development, and track of severe storms affecting most of the U.S. and its surrounding oceans. Quantitative temperature profile sensors will be under development for use at geostationary altitude for the accurate measurement of the thermal structure which causes and fuels these storms, providing information essential to their understanding and prediction. In FY 1975 two highly important field exercises of the international Global Atmospheric Research program--the GARP Atlantic Tropical Experiment (GATE) and the Data Systems Test (DST)--will contribute to the GARP objective of improved long-range prediction. NASA participation in the World Weather program and GARP, where NOAA is the lead agency, includes the development of space weather instruments and the development of techniques for handling the large quantities and varied sources of data required for extension of weather forecast periods.

Important efforts in spacecraft systems and sensor subsystems development will also be conducted in FY 1975, contributing to the research objectives of the GARP program and to the operational requirements of the National Weather Service. Data from the NIMBUS 5 and NIMBUS F experimental satellites will be used in support of GATE and the DST. In addition, advanced techniques for sounding the atmosphere by both remote and in-situ sensors associated with NIMBUS F will be tested; the High Resolution Infrared Sounder (HIRS), containing channels in the 4.3 micrometer channel, is expected to provide a significant improvement in accuracy of the measurements of the temperature structure associated with severe storms; and the Scanning Microwave Sounder (SCAMS) will provide near-global coverage of the atmospheric structure, even through cloud layers, all the way to the earth's surface.

Design of a third-generation operational polar satellite series, TIROS-N, will be initiated and instrument development will be continued to meet operational requirements of the national weather services and the research requirements of the First GARP Global Experiment of 1977-78. The Operational Satellite Improvements Program (OSIP) will concentrate on the development of improved temperature sounders for use with both the TIROS-N polar orbiting satellite series and the SMS/GOES and other geostationary orbiting satellites. A modification of the Visible and Infrared Spin Scan Radiometer (VISSR) of the SMS/GOES satellites will provide the capability for determining temperature profiles on a near-continuous basis; study will also be made of the feasibility of advanced temperature sounders for use with 3-axis stabilized geostationary satellites in order to provide the improved horizontal and vertical resolution and absolute accuracy required for definition of small-scale severe local storms.

Supporting research and technology development will be continued on advanced techniques in observing and forecasting to improve the meteorological value of space sensors and their acquired data and the application of these data to weather prediction. The development and employment of meteorological sounding rockets will be carried out in support of upper-atmosphere research and the improvement of space-borne atmospheric sounding technology.

All-Weather Atmospheric Sounding
Experiment Satellites (NIMBUS 5&F)

	1973	1974	1975
Spacecraft	$15,388,000	$9,538,000	$3,430,000
Sensors and data analysis	12,330,000	5,466,000	2,270,000
Ground operations	1,082,000	1,396,000	1,300,000
Total	$28,800,000	$16,400,000	$7,000,000
Delta (Launch Vehicle Procurement)	(3,500,000)	(1,000,000)	(---)
Total (including launch vehicles)	($32,300,000)	($17,400,000)	$7,000,000

For the first time, satellite measurements of the atmosphere's vertical temperature and moisture profiles have been extended to the surface in cloud covered areas and to the upper reaches of the stratosphere. This was accomplished using sensors aboard NIMBUS 5, launched in December 1972. NIMBUS F, to be launched in mid-CY 1974, will flight test advanced infrared and microwave sensors designed to provide fully global all-weather data with improved vertical resolution. These experimental satellites will contribute

vital data to the initial phases of the Global Atmospheric Research Program (GARP), being conducted in the 1974 period. NIMBUS F also carries a Tropical Wind, Energy Conversion and Reference Level Experiment (TWERLE), and supports the Carrier Balloon System Test. These two experiments will provide essential information on tropical and southern hemisphere wind and temperature structures for the GARP field experiments.

In FY 1974 the final fabrication, integration, systems test and launch of the NIMBUS F spacecraft and its payload will be completed. Funds are also being used for spacecraft operation and the acquisition and analysis of NIMBUS 4&5 data.

FY 1975 funds will provide for NIMBUS F spacecraft operation, data acquisition, and analysis. Operation and data acquisition and analysis of NIMBUS 4&5 will also be continued as appropriate depending upon requirements for the data and the operating status of the spacecraft and sensors.

Cloud Imaging from Synchronous Satellites (SMS A&B)

	1973	1974	1975
Spacecraft	$13,234,000	$8,960,000	$1,400,000
Sensors	2,627,000	500,000	---
Ground station equipment	839,000	540,000	---
Total	$16,700,000	$10,000,000	$1,400,000
Delta (Launch Vehicle Procurement)	(3,800,000)	(5,500,000)	(---)
Total (including launch vehicles)	($20,500,000)	($15,500,000)	$1,400,000

During FY 1974 the SMS prototype model gesotationary meteorological satellite (SMS-A and SMS-B) and the first operational flight model (GOES-A), are being fabricated, assembled, integrated, and tested. The primary instrument, the Visible Infrared Spin-Scan Radiometer (VISSR), has been delivered for each of these spacecraft. The two prototype spacecraft will be launched from the Eastern Test Range in the first half of CY 1974, followed by the launch of GOES-A in the second half of CY 1974.

During FY 1975 operational control of these spacecraft will be transferred to the National Environmental Satellite Service where they will be employed as the geostationary satellite arm of our National Weather Service. By being stationed over the Atlantic Ocean and over the Pacific Ocean, these satellites will provide continuous, day-and-night surveillance of both

oceans and most of the North American and South American continents. This capability will be used for the monitoring and prediction of severe storms such as tornadoes and thunderstorms, as well as providing timely data for detecting and tracking larger and longer-lived disturbances such as hurricanes.

Operational Temperature Sounding Satellite (TIROS-N)

	1973	1974	1975
Spacecraft and support.....	---	$3,000,000	$7,000,000
Sensor development.....	$4,250,000	7,000,000	2,000,000
Total.....	$4,250,000	$10,000,000	$9,000,000

Increasing demands for more accurate measurements of atmospheric structure for both operational and research aspects of global numerical weather prediction have outpaced the capabilities of the current operational satellites and their instruments. TIROS-N, a third-generation polar-orbiting operational satellite is to be developed in response to these demands. It will incorporate recent advances in infrared and microwave sounders for the high-resolution, all-weather measurement of temperature and moisture profiles. Microwave soundings in the 5mm band are of great importance since they present the only means of penetrating cloud fields which cover much of the earth's surface. Microwave soundings also augment and improve the accuracy of temperature and moisture profiles which are based on infrared soundings. The ability to sound the lower troposphere when such extensive cloudiness exists is of utmost importance for diagnosing and forecasting the evolution of severe weather because clouds always prevail around a storm system during its entire life cycle. TIROS-N will also include an operational data-collection system for the acquisition of in-situ data from buoys, balloons, aircraft, and remotely-located ground stations. The capability to track constant-density superpressure balloons provides very important support to the Global Atmospheric Research Program (GARP) since there is no other feasible way to obtain meteorological measurements in tropical and Southern Hemisphere ocean regions.

In FY 1974 the design and development of new sensor subsystems--the Advanced Very High Resolution Radiometer (AVHRR) and the TIROS-N Operational Vertical Sounder (TOVS)--were started. In FY 1975 the spacecraft development and integration contracts will be awarded; the execution phase for

spacecraft hardware development will begin, and the hardware development for the sensor subsystem will continue.

TIROS-N is planned for launch in 1977 to meet operational requirements of the National Weather Service and the research requirements of the international Global Atmospheric Research Program (GARP).

Operational Satellite Improvements

	1973	1974	1975
Operational satellite improvements.	$1,755,000	$2,500,000	$3,500,000
Total.....	$1,755,000	$2,500,000	$3,500,000

Through the Operational Satellite Improvements Program (OSIP), NASA conducts research and development for the improvement of sensors, equipment and subsystems associated with operational satellite programs to ensure that advances in technology related to solving critical problems, such as severe storm detection, are available for incorporation into the operational programs.

In FY 1974, at NOAA's request to provide temperature sounding from geosynchronous orbit, development was initiated on a Vertical Atmospheric Sounder (VAS) as a modification of the Visible Infrared Spin-Scan Radiometer (VISSR) of the SMS/GOES spacecraft. In FY 1975 an engineering model of the VAS will be completed, and procurement will be placed for long-lead items for the flight prototype instrument. FY 1975 funds will also be used to determine modifications necessary to the SMS/GOES spacecraft to accommodate the VAS.

Work is to be initiated in FY 1975 on a geosynchronous sounding instrument to operate in conjunction with a three-axis stabilized satellite for possible use in the late 1970's. This approach affords much greater measurement accuracy than is available with a spinning satellite, such as SMS, and is needed for adequate data acquisition in small scale, but very severe storms such as tornadoes. In addition, funds will be used to continue the FY 1974 work on spacecraft systems improvements and achievement of better ground data handling systems.

Global Atmospheric Research Program (GARP)

	1973	1974	1975
Data systems test support.....	$642,000	$1,359,000	$1,340,000
Simulation studies.....	2,299,000	3,100,000	3,601,000
GARP Atlantic tropical experiment.	---	624,000	1,165,000
Technology support.....	299,000	217,000	338,000
First GARP global experiment.....	---	400,000	956,000
Total.....	$3,240,000	$5,700,000	$7,400,000

In FY 1975 two major field experiments of the international Global Atmospheric Research program will be conducted--the Data Systems Test (DST) and the GARP Atlantic Tropical Experiment (GATE). Both experiments are designed to provide essential steps toward the GARP objectives: (1) the improvement of the accuracy and time extent of global numerical weather predictions; (2) assessment of the feasibility of large-scale weather modifications; and (3) determination of the long-term effects of pollutants on the earth's atmosphere. Both experiments and the entire GARP program will depend heavily on the space technology of NASA's experimental satellite program and the operational satellite program of the National Oceanic and Atmospheric Administration (NOAA).

The DST will reach its maximum level of effort with the receipt of data from NIMBUS F in the summer of 1974. This test will integrate elements of experimental and operational satellite systems and special experimental observing systems, with conventional observational systems available in 1974. The DST, a precursor to the First GARP Global Experiment (FGGE) during 1977-78, will focus attention on problems related to the acquisition and processing of global data from many data sources for the largest coordinated international weather research effort yet attempted.

During FY 1975 the DST will focus on the acquisition, processing and near-real-time assimilation of global data in atmospheric circulation models, testing the effectiveness of the acquisition and processing systems and the usefulness of these data in global numerical weather prediction schemes.

Computing efforts will concentrate on the development of new techniques for insertion of meteorological satellite data in atmospheric circulation models and operational weather forecast models in producing and experimenting with global data sets of higher quality than previously obtained. They will also test the effectiveness of combinations of data from satellites and other sources in reducing errors in predicted wind fields in planning for the observational systems for FGGE. This involves continuing research on numerical methods for solving the equations of atmospheric dynamics, and the development of computer hardware and software for these specialized applications. NASA has the overall responsibility for the conduct of the DST.

The GARP Atlantic Tropical Experiment, to be conducted June-September 1974, will investigate the high energy air currents and clouds and severe tropical storms, and their influence on the general motions of the atmosphere, as an essential research step toward an understanding of the global circulation. NASA will continue to provide observational support to the GATE during this period. 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.

The NASA Convair 990 aircraft will be used for in-situ observations in support of the GATE as well as serve as the airborne command center for the investigator team.

Technology support during FY 1975 will be directed toward the establishment of an atmospheric reference level in the southern hemisphere and the determination of wind at all altitudes in the tropics. The Tropical Wind, Energy Conversion and Reference Level Experiment (TWERLE) on NIMBUS F is the most promising method for obtaining meteorological information at altitudes both in the tropics and in the southern hemisphere. Flight testing of a satellite-carrier balloon subsystem, for the measurement of wind profiles in the tropical regions, will also be conducted during the GATE period. Further efforts to develop techniques for the determination of wind fields from a continuous sequence of satellite cloud pictures are also planned.

Planning and associated research for the FGGE will be accelerating in FY 1975 and NASA will provide detailed planning for this experiment, as well as space-related technology development to support the experiment.

Meteorological Sounding Rocket Program

	1973	1974	1975
Research sounding rockets.....	$200,000	$500,000	$700,000
Development of sounding rockets systems.....	350,000	200,000	100,000
Field experiment support.....	650,000	800,000	900,000
Total.....	$1,200,000	$1,500,000	$1,700,000

In FY 1975, development and test of advanced meteorological sounding rockets will be continued, and rocket soundings will be conducted to obtain data on the chemical constituents and meteorological parameters of the upper atmosphere.

Research is urgently needed to determine the effect of high-altitude aircraft and spacecraft on the composition and chemical processes of the upper portions of the atmosphere, and the effect of changes in this composition on earth's atmosphere and human health. In FY 1975, Nike Cajun, Arcas, and boosted-dart type meteorological sounding rockets will be launched from various sites to obtain these data. Data will also be obtained by rockets launched from Wallops Island to increase the worldwide upper-atmosphere climatological data base and our knowledge of the global stratospheric circulation. This program is conducted in accordance with international agreements for the acquisition and exchange of rocket data on the stratosphere and mesosphere.

Agreements between the U.S. and USSR for space cooperation include an agreement on the establishment of an Eastern and Western Hemispheric Meridional Network of meteorological rocket stations, and the exchange of data and investigation of the processes characterizing the state of the stratosphere and meosphere. To meet the intent of this agreement, the program includes efforts directed 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.

Data from meteorological sounding rockets are also highly useful in calibrating data obtained by satellite remote temperature sensors. This comparative data provides corrections to the satellite radiance weighting functions, thereby increasing the accuracy of temperatures derived from satellite observations. Sounding rockets also provide a more detailed vertical resolution of atmospheric temperature profiles, complementing data obtained by satellite.

There will also be continued effort on the development and flight tests of solid state pressure transducers and thin-film temperature sensors for use on an improved rocket system. This system is designed to provide data up to about 80 km instead of the existing 60 km height system. Measurements obtained at these altitudes will be much more useful in analyzing and evaluating data obtained from satellite systems and are also important for support of aerospace vehicles and in studies of the total atmospheric affects on man.

Advanced Techniques in Observing and Forecasting

	1973	1974	1975
Advanced techniques in observing and forecasting.....	$4,400,000	$5,000,000	$5,000,000
Total.....	$4,400,000	$5,000,000	$5,000,000

Within this program are conducted the supporting research and technology efforts, which interconnect the scientific requirements and the ability to achieve hardware design and developments capable of meeting the needs of both research and operational meteorology. It consists of two major efforts--the development of the physical principles upon which remote sensors can be developed and employed, and the development of techniques for the application of data acquired by remote sensors to the definition and prediction of the earth's atmospheric state.

During FY 1975 the focus of activities will center on advanced techniques for observing and forecasting the short-term problems of severe local storms--

in particular thunderstorms, tornadoes, and hurricanes--and on the long-term problems of climatic variations. The short-term severe storm problems will be addressed in conjunction with research using aircraft observations and concurrent developments in geostationary satellites and instrumentation, such as quantitative sounders for use from geostationary altitude. Our capability to continuously monitor from space the genesis, growth and decay of these short-lived storms, and the ability to quantitatively probe the interior structure and the driving forces of these storms, will present us with new and possibly revolutionary tools for the understanding and prediction of their behavior. Techniques for the processing, display, and application of these data will be developed, and studies will be conducted on the assimilation of the data into models of severe storm dynamics. These tasks will require the development of unique equipment for the monitoring of small-scale phenomena in near-real-time, and research into models of intense atmospheric behavior involving these short times and small scales.

At the other extreme, quantitative measurements from space of the factors which influence the long-term variations in climate are being introduced through advances in remote sensing technology, such as are found on NIMBUS 5, NIMBUS F, and NIMBUS G. A new line of investigation is being opened with the availability from these satellites of sophisticated measurements of atmospheric composition, solar radiation, sea-surface temperature, and the thermal structure of the earth's entire atmosphere. Application of these data in long-term models of atmospheric behavior can be expected to provide a new insight into the causes and effects of deviations in regional and global climates, and may lead to prediction of such vital problems as drought or floods. In order to make optimum use of these data, techniques must be developed for their processing, display and application to numerical models. At the same time, research must be conducted to adapt and refine short-term numerical prediction models to accept long-term influencing parameters and to comply with the laws of climatic behavior.

Efforts will also be continued in FY 1975 for the application of advanced techniques in infrared and microwave sounding of atmospheric moisture profiles. Methods for the assimilation of these data into numerical prediction models must be improved, and data reduction and inversion techniques must be refined in order to produce a maximized yield without sacrifice of accuracy and resolution. Research will also be continued on the physical processes of radiative transfer as it affects the earth's heat budget and the quality of the environment.

Pollution Monitoring

	1973	1974	1975
Air pollution and oceanographic observing satellite (NIMBUS G)....	---	$9,000,000	$27,000,000
Sensor definition and feasibility evaluations, modeling, operational methodology.....	$2,300,000	2,800,000	2,800,000
Total.....	$2,300,000	$11,800,000	$29,800,000

Both man and nature contribute significant quantities of gaseous and particulate pollutants into the atmosphere causing possible changes in atmospheric composition, thereby affecting the heat balance of the earth and the ability of the earth's atmosphere to support life, and producing other detrimental effects on planet earth. Therefore, the concentrations and the distributions of constituents, including pollutants, must be determined and monitored for changes which might prove annoying and/or harmful to man, the biosphere or other aspects of the earth's environment. The Pollution Monitoring program is applying space technology and remote sensing from space to the problems of monitoring the quality of our atmosphere. Knowledge of changes in atmospheric composition will also contribute to climatological prediction and can provide a scientific basis for the establishment of criteria for pollution control. Inadvertent climatic changes have occurred as a consequence of pollutant emissions from industrial complexes, ultimately having effects on public health, agriculture, transportation, hydrology, beauty, recreation, etc. In some cases, control of pollutants affecting weather can be used for beneficial purposes. A large scale overview, and in depth studies using remote sensing techniques, should be brought to bear to effectively understand these phenomena and processes, since they occur on a global scale.

Earth orbiting satellites constitute an ideal platform for the overall measurement and synoptic monitoring of air, water, and land pollutant concentrations and distributions as demonstrated by the dramatic ERTS-1 results obtained over the past year and a half. An Air Pollution and Oceanographic Observing Satellite (NIMBUS G) is being developed to explore the feasibility and utility of this concept and to provide essential data on the current levels of atmospheric contaminants. Models of the photochemistry and dynamics of the atmosphere for studying the space and time variations of minor atmospheric constituents are under development. Information on sources, magnitudes, and distributions of atmospheric constituents is also needed for incorporation into atmospheric circulation models and related environmental quality models. Flight instruments capable of detecting certain of the important constituents, including contaminants, have been developed under the AAFE program, and their feasibility has been verified by tests on aircraft and at ground-based stations.

Research is also needed to develop the technology for remote sensing of water quality. To establish sensor design criteria, basic laboratory measurements will be carried out to define the physical and chemical characteristics of water containing known pollutants. The oceanographic role of NIMBUS G offers the opportunity to explore the possibilities for global monitoring of such important water quality factors as chlorophyll content, sediment distribution, salinity, and temperature.

Air Pollution and Oceanographic Observing Satellite (NIMBUS G)

	1973	1974	1975
Spacecraft	---	$520,000	$11,800,000
Sensors and data analysis	---	8,480,000	14,700,000
Ground support equipment	---	---	500,000
Total	---	$9,000,000	$27,000,000
Delta (Launch Vehicle Procurement program)	(---)	(---)	(400,000)
Total (including launch vehicles)	(---)	($9,000,000)	($27,400,000)

NIMBUS G will provide the first capability for global acquisition of well integrated repetitive, synoptic, remotely-sensed data required for atmospheric pollution and oceanography investigations. Data acquired by the sensors on NIMBUS G will be applied to studies on the concentration, distribution, and time-variations of atmospheric and oceanographic contaminants.

Five sensors on NIMBUS G will provide measurements of important atmospheric gaseous and particulate pollutants. The gases to be measured are directly related to such large scale pollution problems as the use of fossil fuels and the effect of high altitude aircraft operations on the stratosphere. The gases to be measured include ozone, methane, nitric acid, nitric oxide, nitrogen dioxide, carbon monoxide, carbon dioxide, water vapor, sulfur dioxide and ammonia. In addition, concentration of particulates will be studied to measure long term effects on climate; and another experiment will obtain heat budget measurements of the earth for the establishment of thermal baselines and to detect changes, particularly those attributable to the activities of man. The other three instruments will obtain data for use in oceanography investigations to support studies in ocean-food sources and surveys of ocean pollution, and to improve our knowledge of the interactions between the ocean and the atmosphere. The measurements to be obtained are (1) very high accuracy sea-surface temperature measurements; (2) high spatial resolution ocean color measurements near the coastlines (relating to nutrients, pollutants, and salinity); and (3) microwave measurements of the ocean/atmosphere interface characteristics.

During FY 1974 contracts for sensor development of engineering and flight models, and the spacecraft long-lead time work essential to accomplish launch in CY 1978, will be initiated. During FY 1975 work will continue on the sensors and spacecraft.

Sensor Definition and Feasibility Evaluations, Modeling, Operational Methodology

	1973	1974	1975
Sensor definition and feasibility evaluations, modeling, operational methodology.....	$2,300,000	$2,800,000	$2,800,000
Total.....	$2,300,000	$2,800,000	$2,800,000

This effort is the foundation for the NASA program of applying aerospace technology for assessing the quality of our environment and evaluating the impact of candidate strategies for enhancing the quality of our air, water, and land. The primary emphasis is on remote sensing techniques; however, the need is also recognized for application of in-situ sensing and analysis as a means for validating and calibrating remote sensors.

The development of techniques and sensors to measure atmospheric trace constituents is based on the unique physical and chemical properties of the gases involved. Laboratory investigations initiated in FY 1974 on the properties of some key gases will be completed in FY 1975 and other constituents will be identified for detailed study. These data will be combined with theoretical models to define the signal levels available for remote sensing. Techniques will also be developed to allow the separation, qualitatively and quantitatively, of particulate effects from those of the gaseous constituents. For the definition of the particles themselves, techniques must be developed to permit the inference of particle size and distribution, particle composition, and chemical reactions leading to and caused by the particles. The remote sensors for making such measurements will be evaluated in aircraft tests with in-situ sampling and analysis providing truth data for verification and analysis of the effectiveness of the techniques.

The remote sensing of water quality has received less emphasis than that for air quality, and, consequently, more fundamental research is required. Basic laboratory measurement of the absorption and reflectance spectra of water containing known pollutants, and combinations of pollutants, are currently inadequate to permit scientific judgments concerning the specification of spectral bands for pollutant discrimination, or engineering judgments concerning detector, optics, and filter technology for the required measurements. New techniques need to be developed and tested with regard to both remote and in-situ sensing of water pollutants. These

investigations should also be valuable for application to the detection, identification, and differentiation of municipal and industrial wastes, as well as understanding the chemical reactions involved in creating new pollutants and toxic substances. This technology will also be of value in conjunction with urban and regional water quality surveys.

Earth Resources Survey

	1973	1974	1975
Earth resources technology satellite (ERTS-1&B)	$32,600,000	$16,400,000	$11,100,000
Multispectral scanner 5th band development	---	1,000,000	4,000,000
Earth observations aircraft program (EOAP)	13,000,000	16,800,000	17,300,000
Earth resources experiment package (EREP) investigations	---	---	3,800,000
Data interpretation techniques, special investigations and data analyses	9,555,000	13,200,000	22,400,000
Total	$55,155,000	$47,400,000	$58,600,000

Today, more than ever, man recognizes that the capability of the earth to support life has limits and that to survive he must seek more efficient ways to manage his limited resources. The objective of the Earth Resources Survey program is to provide technological means for acquiring and interpreting the information which such large-scale management will require, leading to the identification and development of practical applications. NASA's role is to determine the uses of space technology in accomplishing these objectives. A sizable commitment of many organizational elements has been made and enthusiastic cooperation developed with user agencies at federal, state, and local levels, as well as in the international area.

Because of the high quality of the data from the Earth Resources Technology Satellite, ERTS-1, and the favorable results of the investigators' analyses, there exists confidence that such space technology will play a major role in the monitoring, timely evaluation, and management of the earth's resources. The investigations conducted with the data from the ERTS-1 satellite have already identified a great many potential uses for the data, a significant number of which have already been or are being put to practical use. Additional effort will be made in FY 1975 to broaden the scope of the investigations being carried out to the point where they can be used to evaluate the utility of the data with a closer approach to practical operational conditions.

One very important conclusion resulting from the investigations is the great variation of many classes of observable phenomena with the time of year and weather and climatic conditions. This has emphasized the value of repetitive and continuous data and is one of several reasons that has caused NASA to change its plan of launching ERTS-B in 1976 to one of being in a position to launch as soon as possible after failure of the ERTS-1 satellite. It is planned to have this replacement capability available by late 1974, at which time ERTS-1 would have been in orbit nearly 2 1/2 years--well over twice its design life. The thermal channel, which will not be incorporated in ERTS-B, will continue in development for possible use on a subsequent earth observing satellite.

In part, the loss of experimental information caused by deletion of the thermal channel will be regained by the launch of the Heat Capacity Mapping Mission proposed as a new start in FY 1975. This mission will utilize a Scout launch vehicle and a small relatively low-cost spacecraft, instrumented with the surface Composition Mapping Radiometer flown on NIMBUS 5. The small single-purpose satellite will be flown in a special orbit to maximize the precision of measurement of surface temperatures for many special applications, particularly those associated with geothermal effects.

Skylab's successful missions have provided the experimenters on the Earth Resources Experiment Package (EREP) with a great quantity of very valuable data taken with instruments that extend the observations of the ERTS system into new areas of the visible and infrared spectrum and in spectrum resolution. The FY 1975 program will enable the further analysis of these data, which is expected to provide NASA with the specific requirements for its next generation of earth resource sensors, as well as indicate new areas for the application of remote sensing.

The FY 1975 program includes funds to initiate the early stage of the development of two second-generation sensors to observe from space man's use of, and impact on, the land. One will increase the spectral resolution (7 bands) beyond the ERTS multispectral scanner (4 bands) with increased spatial resolution for investigations of land use management and pollution monitoring. The other is a pointable, high resolution (10 meter) imager for investigations of urban land use and planning. Both instruments are being funded in FY 1973 and 1974 in the AAFE program; final specifications will be defined by results of ERTS and Skylab EREP investigations.

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Earth Resources Technology Satellite (ERTS 1&B)

	1973	1974	1975
Spacecraft	$5,997,000	$7,569,000	$3,200,000
Sensors	4,411,000	1,700,000	---
Ground operations	6,929,000	1,131,000	2,300,000
Investigations	15,263,000	6,000,000	5,600,000
Total	$32,600,000	$16,400,000	$11,100,000
Delta (Launch Vehicle Procurement program)	(---)	(3,500,000)	(1,000,000)
Total (including launch vehicles)	($32,600,000)	($19,900,000)	($12,100,000)

The Earth Resources Technology Satellite (ERTS-1), launched in July 1972, has proven effective in identification and acreage measurement of major crops on a global basis, and the multispectral scanner imagery has exceeded National Map Accuracy standards at the 1:1,000,000 scale. Many "photo-maps" have been made at scales of 1:250,000 from ERTS-1 imagery, and classification of land use has been accomplished for 18 national and regional categories proposed by the U.S. Department of the Interior for National Land Use Mapping (Circular 671); previously unrecognized major faults have been identified and correlated with earthquake epicenters from conventional data; mineral alteration halos have been enhanced near Goldfield, Nevada; and pollution plumes, strip mining and reclamation efforts have been identified. Mapping of floods (including the entire Mississippi River), snow covered areas, and regional water resources, has been accomplished. The location of menhaden fish schools has been precisely correlated with coastal water turbidity imaged by ERTS-1 and sea ice affecting ocean shipping has been detected and its movement mapped.

Comprehensive actions are in progress to exploit those applications which require further development of analytical techniques and assessment of cost effectiveness for operational use. Follow-on ERTS investigations to develop these operational applications will be conducted during late FY 1974 and FY 1975.

Review by the federal user agencies concluded that continuity of data is necessary for practical use of ERTS information. Experience with repetitive coverage of test sites has shown the importance of understanding changes caused by the seasons and the weather. Continuity is needed to establish realistic operation modes and to implement personnel training and ground equipment. These are the factors in NASA's decision to prepare ERTS-B for launch as soon as possible after failure of ERTS-1.

The FY 1974 and 1975 effort includes continued operations of the ERTS-1 and support of ongoing and follow-on investigations, as well as the preparations for launch of ERTS-B. In FY 1975 the integration of the sensors with the spacecraft will be completed and tested to be available for launch when ERTS-1 fails, providing such failure does not occur earlier than near the end of 1974.

Multispectral Scanner - Fifth Band Development

	1973	1974	1975
Multispectral scanner - fifth band development.....	---	$1,000,000	$4,000,000
Total.....	---	$1,000,000	$4,000,000

The purpose of adding a thermal infrared channel on the Multispectral Scanner is to provide the capability required to observe those resources and conditions characterized by temperatures that require intercomparison of thermal data with those simultaneously obtained at visible or near infrared wavelengths. Such information has high utility for locating, mapping, and measuring thermal pollution of large lakes, bays and estuaries; and providing information about the heat capacity of soils and geological structures. It should, in addition, provide important information on stresses in vegetation. Observations of ocean currents from their temperature differences will provide data needed for investigations of ocean shoreline changes and effects upon coastal land and water uses.

Funding in FY 1975 will provide for continued development and testing of flight hardware components and initiation of flight model assembly. The flight hardware will be completed in time for flight in the 1977-78 time period. While there is no specific satellite selected for this instrument at the present time, the importance of its potential use makes it imperative that its development be continued.

Its configuration as part of the Multispectral Scanner insures that it would be capable of being launched on an operational satellite, such as that being studied for development by the Department of the Interior, or on a follow-on R&D satellite.

Earth Observations Aircraft Program

	1973	1974	1975
Earth observations aircraft program.....	$13,000,000	$14,800,000	$16,400,000
CV 990 replacement.....	---	2,000,000	900,000
Total.....	$13,000,000	$16,800,000	$17,300,000

NASA remote sensing aircraft will focus on developing measurement and interpretive techniques, defining and evaluating new space sensors, and demonstrating the application of remote sensing.

In FY 1974 and FY 1975, a total of approximately $2.9 million has been added for the acquisition and modification of a replacement aircraft for the NASA Convair 990 lost in a crash in April 1973. The Convair 990 availability as a research aircraft is keyed to the GARP Atlantic Tropical Experiment (GATE), which will be conducted in early FY 1975. The remaining funds indicated for FY 1975 ($16.4 million) will be used to support Application programs research efforts and will involve more varied efforts than in the past, where aircraft flights were largely confined to Earth Resources Survey. Specifically, the FY 1975 budget provides for aircraft operations related to environmental pollution monitoring, including stratospheric surveillance and studies of severe storms.

Continuing support for ERTS follow-on investigations will be provided in FY 1974 and FY 1975, in addition to new underflight requirements associated with SMS and NIMBUS-F. An increasing number of flights required for NIMBUS-G are planned beginning in FY 1975 to facilitate the planned investigative programs, and the development and evaluation of sensors, to be flown in this spacecraft. For NASA Supporting Research and Technology programs, considerable aircraft capability will be devoted to Applications Systems Verification Tests. These Applications Systems Verification Tests involve principally regional land use studies, tornado studies, water and atmospheric pollution, ice monitoring, continental shelf circulation and lake eutrophication.

Earth Resources Experiment Package (EREP) Investigations

	1973	1974	1975
Data analysis.....	($2,500,000)	($3,200,000)	$3,800,000
Total.....	($2,500,000)	($3,200,000)	$3,800,000

The EREP, launched aboard Skylab I on May 24, 1973, has been used to acquire data during the three manned Skylab missions for 150 applications investigations. The 150 investigations include studies related to agriculture, range land, and forestry; geological applications; continental water resources; oceans; atmospheres; coastal zones, shoals and bays; regional planning and development; cartography; and remote sensing technique development. Data in the form of measurements in the visible, infrared, and microwave portions of the spectrum have been acquired using a variety of sensor techniques.

Development of the EREP sensors, acquisition and processing of the data collected, and funding of the initial data analysis and investigations have been supported by the Skylab program in the Office of Manned Space Flight through FY 1974.

The Office of Applications, the sponsor for EREP, is responsible for supporting the investigations and managing the investigator's data analysis starting in FY 1975. The FY 1975 funds are required for completing the EREP studies and reporting on the results of this very significant earth observations effort.

Data Interpretation Techniques, Special Investigations and Data Analyses

	1973	1974	1975
Data interpretation techniques, special investigations and data analyses.....	$9,555,000	$13,200,000	$13,000,000
Earth resources survey data processing, evaluation and analysis, photographic services, related supplies, and equipment..	(8,500,000)	(9,500,000)	9,400,000
Total.....	($9,555,000)	($13,200,000)	$22,400,000

This effort forms the research and technology base for the Earth Resources Survey program and as such is fundamental to the continuing development and extension of remote sensing techniques and their application to practical problems. The scope of the work covered includes the following: (1) definition, development, and tests to increase the reliability and resolution of scanners and other imaging systems to obtain microwave sensors leading to all weather sensing capability; (2) definition, development, and test of data handling techniques and data processing equipment for increasing efficiency, throughout, and precision; and preprocessing techniques to serve the rapidly increasing need of the user community to apply the data in ditigal form; (3) development of interpretation and classification techniques including improved speed and accuracy of machine-aided classification and the documentation of procedures for users; and (4) the classification, verification, and demonstration of the application of remote sensing data to earth resources information needs. This activity includes experimental verification, documentation of methodologies and analysis of the cost effectiveness and benefits of the use of the developed techniques.

The thrust of Earth Resources Survey research in FY 1975 is shifting from a multiplicity of exploratory applications experiments toward fewer large-scale tests of potential information gathering systems under realistic conditions. Analyses of the results of these tests and the required implementation procedures will be documented to enable user agencies to reach decisions on the desirability of implementing operational programs. System verification tests are being planned for applications, such as crop acreage inventories and land use surveys.

Agricultural remote sensing research is planned in corn, soybeans, and wheat acreage inventory; in detection of crop stress due to drought and disease; in soils survey; and in soil moisture measurement for irrigation control.

Land use survey research will concentrate on classification and mapping, using automated remote sensing data. These results are required for management and planning decisions.

Mineral resources research will continue involving the promising relationship between image ratio mapping and distinction of rock type. Successful development of this technique has application to mineral exploration, planning of major engineering works, and exploration for geothermal areas. Other geological evaluations will continue in areas of high promise such as petroleum explorations.

Water resources surveys include snow line mapping flood assessment, including snow melt monitoring, data relay of stream flow parameters and modeling of large-scale water systems. Remote sensing provided repetitive data to each of these important applications. A significant effort is planned to use ice surveys in the Great Lakes to extend the winter navigation season. The Coast Guard, the Corps of Engineers, shipping industry, and Canada will use radar imagery techniques developed by NASA.

Fisheries research will continue on the sensing and study of ocean color, which indicates nutrient-rich upwellings, and chlorophyll detection--a measure of plankton concentration. Currents and wave processes will be modelled in combination with repetitive observations, including radar.

The development of microminiaturization and modular design of instruments for location and tracking of wildlife will contribute to monitoring food resources and endangered species (e.g., whales) in the future.

Cooperative efforts will continue with the States (Texas, California, Mississippi, Arizona) and Federal agencies (USDI, USDA, USACE, TVA) in transferring technology developed by NASA to the responsible operating departments. International interest and involvement is extremely high.

FY 1975 funding also provides for program support services primarily at Johnson Space Center, the location of the Earth Resources Program Office (lead center). The services involve computer operations, engineering, photographic services, and data analysis.

Earth and Ocean Physics Applications Program (EOPAP)

	1973	1974	1975
Geodynamic experimental ocean satellite (GEOS-C).....	$4,195,500	$3,400,000	$900,000
Laser geodynamic satellite (LAGEOS)	---	1,300,000	2,300,000
Ocean dynamics satellite (SEASAT-A)	---	---	8,000,000
Tectonic plate motion.....	---	---	2,000,000
Measurement systems, forecasting techniques and modeling/advanced studies.....	1,859,000	3,000,000	2,600,000
Experiment data analysis.....	---	2,700,000	2,700,000
Geodetic satellites (GEOS 1&2).....	1,145,500	---	---
Total.....	$7,200,000	$10,400,000	$18,500,000

The Earth and Ocean Physics Applications program (EOPAP) provides the focus for those applications which make use of space and space derived techniques for very precise monitoring of the earth crustal motion, polar movement and changes in rotation rate; as well as monitoring numerous ocean phenomenon, such as sea state, currents, surface winds and general ocean circulation on a global basis.

The Geodynamic Experimental Ocean Satellite (GEOS-C) project has the objective of demonstrating a much improved altimeter which can not only measure the topography of the earth's oceans to an accuracy of approximately 30 cm, but which can also measure the wave height (or sea state). The measurements of the ocean topography will provide the capability to make a more precise mathematical description of the earth's gravity field and improve the measurements of the variations in solid earth geometry and other geophysical areas. In addition, it will also lead to a better understanding of the ocean currents and the general ocean circulation.

The Laser Geodynamic Satellite (LAGEOS) project, with its very dense spherical satellite covered with laser reflectors, has the objective of providing the capability to make very accurate measurements of the earth's crustal motions (tectonic plate movement, fault motions, polar wobble and rotation rate). These data will lead to a better understanding of earthquake mechanisms by providing extremely accurate knowledge of changes in positions of crustal elements on the surface of the earth. In addition,

the data collected from reflecting laser beams off the satellite will permit tracing the movements of the tectonic plates which make up the earth's surface, and determining how the rotational axis and spin of the earth about this axis are affected by these movements.

The first Ocean Dynamics Satellite (SEASAT-A) will demonstrate on a global scale an integrated monitoring and data gathering capability for a wide range of physical ocean characteristics, including wave height and shape, the location and motion of currents, global circulation patterns, ocean wind, and the ocean geoid (topography of the oceans). SEASAT-A will provide data for user applications, including predictions of sea state and ocean wind fields for ship routing; improved design information for ships; coastal disaster warning; coastal protection and development; and design and siting criteria for deep water ports and offshore facilities, such as nuclear power plants and large oil drilling rigs. The same data will be very useful in determining the distribution of foreign materials dumped in the oceans as well as long term (seasonal) climate prediction and weather forecasting.

The Tectonic Plate Motion project is concerned with the use of existing capabilities to measure precise motions between defined points, using both laser tracking and very long baseline interferometry. This project will commence in FY 1975 after data from specific preliminary field experiments and feasibility demonstrations already conducted are completely analyzed.

Measurements Systems and Forecasting Techniques activities involve the planning and implementation of scientific and technical research and other supporting activities in universities, non-profit and industrial organizations, NASA centers, and other Government agencies. These activities include: planning and conducting field experiments and feasibility demonstrations, conducting studies aimed at improvement in various measurement capabilities, and supporting research directed toward improvement in earth and ocean dynamics model development.

Experiment Data Analysis provides for the analysis and synthesis of data obtained in EOPAP investigations, e.g., the processing, evaluation and initial analysis of preliminary San Andreas Fault Experimentation data taken during a feasibility demonstration in 1973; and the analysis and evaluation of the data taken during aircraft experimental flights which carry developmental instruments to be used in future missions; e.g., an imaging radar planned for SEASAT-A.

Geodynamic Experimental Ocean Satellite (GEOS-C)

	1973	1974	1975
Spacecraft	$2,400,000	$2,400,000	$70,000
Sensors	1,595,500	600,000	402,000
Ground operations	200,000	400,000	428,000
Total	$4,195,500	$3,400,000	$900,000
Delta (Launch Vehicle Procurement program)	(3,800,000)	(---)	(---)
Total (including launch vehicles)	($7,995,500)	($3,400,000)	($900,000)

The GEOS-C program will demonstrate the feasibility of satellite radar altimetry to measure general sea surface topography to an accuracy of 0.5 meters, as well as determine wave height. It will also provide data to refine the geodetic and geophysical results of the National Geodetic Satellite program. Further, it will be used in providing data to investigate solid earth dynamic phenomena such as polar motion and earth rotation variations; earth tides; and continental drift theory, employing 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 to determine precise locations on the earth's surface, and (4) intercomparisons of new and established techniques. The major FY 1975 efforts include the launch operations at the Western Test Range early in FY 1975, mission support during the year for data collection, and the start of data analysis.

Laser Geodynamic Satellite (LAGEOS)

	1973	1974	1975
Spacecraft	---	$830,000	$1,455,000
Ground operations	---	470,000	845,000
Total	---	1,300,000	2,300,000
Delta (Launch Vehicle Procurement program)	---	(3,000,000)	(1,600,000)
Total (including launch vehicles)	---	($4,300,000)	($3,900,000)

The LAGEOS program will provide the capability for making extremely accurate determinations of the earth's crustal and rotational motions by means of laser tracking techniques. It will be a major advance over GEOS-C and other current capabilities in this respect. LAGEOS will be employed to observe a number of phenomena associated with earthquakes, including fault motion; regional strain fields; dilatancy; tectonic plate motion; polar motion; earth rotation; and solid earth tides, as well as to determine accurate station locations for use in other efforts such as the EOPAP ocean dynamics program.

The LAGEOS program includes the building and launching of a very accurate reference satellite incorporating precision retroreflectors, the development and use of accurate laser ground tracking stations, and the application of the laser data in connection with the generating of models of the earth's crustal and dynamical motions.

The satellite will be a dense sphere covered with approximately 500 laser retroreflectors. Having a diameter of about 0.6 meters (2 feet), its high density will result in a weight of approximately 400 kg (880 pounds). Its array of corner reflectors will be especially designed to minimize errors associated with the reflection of the sharp laser pulses. It will be launched into a high circular orbit at a high inclination. Its altitude will be great enough to lessen the effect of orbital uncertainties due to imperfect knowledge of the earth's gravitational field, and it will be dense enough to markedly diminish the errors in its position caused by variations in the pressure of radiation from the sun and the earth. The high orbit is also well suited to the problem of measuring large scale motions of the earth's crustal plates and the dynamical motions of the earth as a whole as it rotates about its polar axis.

This will be the first time that both a total satellite system and its orbit have been designed especially for the purpose of making the kind of accurate measurements of the earth's crustal and dynamic motions which are needed to develop a better understanding of earthquake mechanisms.

A feasibility study dealing with all the major aspects of the spacecraft and its relationship to the laser ground tracking system has been completed, and a detailed preliminary design is being carried out in FY 1974. Final design and actual construction of the spacecraft will begin in FY 1975.

The development of accurate laser ground systems especially designed to track LAGEOS will be continued in FY 1975, as will the key preparations for analyzing the highly accurate data, which will be generated by the overall LAGEOS system.

Ocean Dynamics Satellite (SEASAT-A)

	1973	1974	1975
Spacecraft design, development and test	---	---	$3,200,000
Sensor development	---	---	4,800,000
Total	---	---	$8,000,000

The monitoring of the oceans from space will provide oceanographers for the first time with the kind of global, synoptic coverage for scientific analyses which have already been supplied by TIROS and NIMBUS satellites to meteorologists investigating the atmosphere, and by the ERTS spacecraft to scientists studying the land. A sound foundation of scientific knowledge of the oceans as global systems, based on the SEASAT-A data, will constitute an indispensable base upon which to build new ocean dynamics forecasting capabilities having major scientific and economic potential.

NASA and user organizations (DOD, DOT, DOC, and Research Institutions), have mutually defined a program plan for oceanographic research and ocean dynamics forecasting; the next major step in this plan is the SEASAT-A project. The sensor characteristics required to measure the parameters needed for SEASAT have been defined jointly by NASA and the users in the concept studies. During the definition phase in FY 1974, the preliminary design of the instrument subsystems as well as the spacecraft will be established. Instruments being tested under the Advanced Application Flight Experiments program will provide the basis for most of the instrument subsystem design. The development phase design effort to begin in 1975 will entail final design and engineering evaluation and testing of the experiment subsystems and the spacecraft.

The satellite will weigh about 1,000 Kg and will be launched into a high inclination orbit by a Delta launch vehicle in 1978. It will utilize spacecraft subsystem designs proven in other NASA programs, and will carry a mutually supporting ocean dynamics instrumentation complement. Candidate instruments currently include a precision radar altimeter, an imaging radar, a microwave radiometer, a scatterometer, and a visible and infrared imager. These instruments will provide the capability to monitor the world's oceans every three days and detect sea state (wave height); wind speed; wind and wave direction; ocean temperature; and ocean surface topography, from which current and geoid parameters can be derived. These data will be furnished by NASA to oceanographers for scientific studies. They will also be used as inputs to user models, which will generate forecasts of ocean surface conditions such as sea state, wave height and winds.

Existing NASA systems will be used to demonstrate the data processing and dissemination capabilities needed for the forecasting systems. Investigators of the polar regions will see extensive areas of the polar ice cap as dynamical, evolving systems in the images provided by SEASAT.

SEASAT will make a major contribution to the study of air-sea interactions, which is perhaps the most significant "interface" science involving our planet. Oceanographers, meteorologists, and climatologists will be able to use SEASAT information on wave height and direction, surface winds and ocean temperatures obtained globally in virtually all weather conditions. They will have a global view, but will also be able to scrutinize local systems, such as hurricanes, in detail. Targets of opportunity, such as tsunamis, will also be watched for and analyzed as they cross SEASAT's path.

Geodesists are also among the scientists who will take a major step forward by analyzing SEASAT data. The fine structure of the geoid which they will determine with much greater accuracy in the SEASAT data will be studied keenly by the tectonic physicists as they search for clues about the structure of the earth's crust. The science of orbit determination will also benefit from the use of the new type of satellite position data provided by the SEASAT altimeter.

This SEASAT-A instrument complement will enable the monitoring of ocean surface conditions to be accomplished with the precision and repetition necessary to make major advances toward the forecasting capability. SEASAT-A will in this way provide data for user applications including predictions of wave height and direction and wind fields for ship routing, ship design, storm-damage avoidance, coastal protection and development, and deep water port development.

Based on the results of the SEASAT-A data analyses and the improvements they will allow in ocean and weather forecasting models, it should be possible to define and develop forecasting systems which will provide ocean conditions, as well as ocean influence inputs, necessary for 14-day worldwide weather forecasting.

Tectonic Plate Motion

	1973	1974	1975
Tectonic plate motion.....	---	---	$2,000,000
Total.....	---	---	$2,000,000

One of the keys to understanding and predicting earthquakes is the ability to measure the movement of the giant tectonic plates which make up the earth's crust. If two adjoining plates are moving at certain places, but are locked elsewhere, then strain is building up. When this strain is released an earthquake occurs. During the past two years, experimental data have been collected and major progress has been made in measurement systems, as well as modeling capabilities, opening up new possibilities for gaining an understanding of the physics involved. During FY 1974 these experiments will be continued and the definition of three demonstration projects will be completed. As a result of the analysis of these specific preliminary field experiments and feasibility demonstrations, the Tectonic Plate Motion project as described below will be implemented in FY 1975.

San Andreas Fault Experiment (SAFE): The San Andreas Fault in California has been selected as an ideal testing ground for a demonstration. We will obtain the technical data which is needed for this area of the applications program and will also start toward the provision of potential future benefits to the people of California, who are particulary vulnerable to earthquake hazards. The San Andreas Fault Experiment will demonstrate the feasibility of using satellite-tracking lasers to determine surface motions along an active fault over a period of several years. Mobile lasers placed at least 100 km (62 mile) from the fault line on opposite sides and separated by 850 km (528 miles), will be used to measure interstation changes in baseline length that can be related to tectonic and crustal motion. The initial two sites will be in California at Quincy (on the North American Plate) and near San Diego (on the Pacific Plate). This demonstration project is being done in concert with ground-based activities being conducted by U.S. Geological Survey and others. Co-investigators from the USGS and Lamont-Doherty Geophysical Observatory of Columbia University are participating with NASA personnel on this project.

Astronomic Radio Interferometric Earth Surveying (ARIES): The objective of this project is to demonstrate the use of a Very Long Baseline Interferometry (VLBI) station for the measurement of regional crustal motion. This technique, using distant stars as a reference, is an alternative to laser tracking of satellites and should be carefully evaluated. A surplus U.S. Army antenna station transferred to NASA at no cost is being modified to make VLBI observations. The station will be calibrated against the two main JPL Goldstone stations so as to encompass a critical closure experiment. The portable station will then be located near various benchmarks in the first order precision geodetic survey grid in the Los Angeles basin, in order to validate the accuracy of the VLBI measurement technique.

Pacific Plate Motion Experiment (PPME): The primary objective of this project is to conduct a very large spatial scale experiment to determine the relative motions of the Pacific Plate, the North American Plate, and the Eurasian Plate. These motions will then be used to develop a tectonic plate motion model on a global scale. A number of existing stations in the continental U.S. will be furnished with equipment in order to enable them to be used for VLBI measurements from which the motions of these tectonic plates will be determined. In addition, an existing station in Alaska, one in Japan, and one in Hawaii will also be equipped for VLBI measurements.

Measurement Systems and Forecasting Techniques/Advanced Studies

	1973	1974	1975
Measurement systems and forecasting techniques.....	$1,859,000	$3,000,000	$2,600,000
Total.....	$1,859,000	$3,000,000	$2,600,000

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

This effort consists of an integrated series of interconnected tasks including: systems studies for the Earth and Ocean Physics Applications program; design studies of advanced satellite and ground systems; analytical design of Earth and Ocean Physics Applications program missions; preliminary design of experiments (ground-based, aircraft, ships, buoys, and satellites); establishment of measurement requirements; design of sensors and subsystems; feasibility experiments on new techniques; intercomparison experiments; analytical models for earthquake hazard assessment and alleviation, ocean currents, ocean dynamics effects, circulation and transport; and development and testing of forecasting techniques. Universities, institutions, and other Government agencies will be funded to perform scientific studies of fundamental phenomena in earth and ocean dynamics as a basis for the detailed requirements for experimental and analytical techniques.

Efforts will include studies utilizing space techniques which will lead to a better understanding of the mechanisms governing the dynamics of the solid earth and the world's oceans. In this way both improvement in models, instruments and techniques development will proceed in an orderly fashion.

Experiment Data Analysis

	1973	1974	1975
Experiment data analysis.....	---	$2,700,000	$2,700,000
Total.....	---	$2,700,000	$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 mapping and modeling ocean currents; monitoring and forecasting sea state, other ocean dynamics effects, and the interactions between ocean and atmosphere; and assessing earthquake hazards.

FY 1975 funds for data analysis will provide for the analysis of experiments currently in process to demonstrate the application of precision laser ranging to satellites for the measurement of fault motions. Included in this effort are the analysis and evaluation of new methods of making precision measurements of crustal deformations and earth motions, as well as intercomparisons of basic measurement and analytical techniques, and the analysis and evaluation of related earth dynamics experiments.

Further, in FY 1975 the analysis of data from GEOS-C experiments involving radar altimetry, laser ranging, satellite-to-satellite tracking, and other techniques will be initiated.

Data from such experiments, both earth-based and earth/satellite experiments, will be analyzed to determine applicability to particular problems, and feasibility and limitations in providing solutions to these problems. Data from intercomparison experiments will be analyzed to establish the relative merits of alternate techniques and the applications of acquired data to the development and assessment of analytical models for ocean currents, transport and circulation, and other earth and ocean dynamic effects.

Space Processing

	1973	1974	1975
Ground-based investigations analyses and studies.....	($3,100,000)*	$3,000,000	$3,100,000
Space processing sounding rocket missions.....	---	---	400,000
Total.....	($3,100,000)	$3,000,000	$3,500,000

* Funded under Space Flight Operations.

The NASA space processing program is designed to investigate the utility of space flight for work in materials science and technology and ultimately for commercial manufacturing of unique new high-technology products in space for use on earth. In FY 1974, other than the significant Skylab work carried forth by Manned Space Flight, the program is limited to ground-based investigations of prospective space processes and products. In FY 1975 we will initiate sounding rocket missions to accomplish preliminary tests of promising processes and techniques. Ground-based investigations will emphasize materials and processes that appear to have potential for early applications, as determined by previous studies and experimentation. These investigations will include: ultrapurification of metals and ceramics; preparation of medical products, such as specific types of blood cells and pure cell cultures; growth of semi-conductor materials by space-based methods; and production of new types of optical glass. The economics of space processing will be studied concurrently, using these products and processes as references, and exploratory work will continue in a variety of other areas of metallurgy, electronic materials, ceramics and glass, and biological products.

Sounding rocket flights in FY 1975 will be initiated to perform experiments on processes and techniques that can be tested in flight durations of five to ten minutes. These flights will provide opportunities for repetitive experiments under weightless conditions before Shuttle operations begin. Experiments will be acquired through an open Announcement of Flight Opportunity and will permit potential users of the Shuttle/Spacelab system to gain early results and experience at relatively low cost.

The space processing program will also provide reference information in support of the Shuttle Experiment Definition program and the flight experiments planned for the Apollo Soyuz Test Project to take place in mid-1975.

Ground-Based Investigations, Analyses and Studies

	1973	1974	1975
Ground-based investigations, analyses and studies.....	($3,100,000)*	$3,000,000	$3,100,000
Total.....	($3,100,000)*	$3,000,000	$3,100,000

* Funded under Space Flight Operations.

The primary emphasis in Space Processing Ground-Based Investigations and Analyses is on research and development concerning materials and processes. In previous years this work has been largely exploratory, seeking to identify promising prospects and test them to the extent possible through use of ground-based facilities, including free-fall tests in drop towers of a few seconds duration and during aircraft flights. Work will now be conducted to provide more practical feasibility demonstrations for promising products

identified thus far. In FY 1975 the program will begin to shift its effort from exploratory activities, including the results obtained from the experiments performed during the Skylab missions, to a set of projects focused on specific products and processes that appear to have the potential for early applications. Candidates for such focused projects include: electrophoretic separation of cells and establishment of cell cultures; growth of single crystal silicon ribbon; production of ultrahomogeneous simiconductors; vapor and solution growth of semiconductor and oxide crystals; refractory metal purification by vacuum/levitation processing; production of new types of optical glass from oxides; and controlled eutectic solidification for optical, electronic, and specialty structural parts.

Such experiments will be timely in the 1970's since they can provide early results to guide Shuttle payload development and evaluate space processes on a small scale with minimum resource commitments.

Effort is being applied in FY 1974 to define low-cost means of controlling acceleration levels on sounding rockets in free flight, so that experimental payloads can be developed and flown on these sounding rockets beginning in FY 1975.

In addition to experimental work, the FY 1975 program will study the economics of future space manufacturing operations.

Sounding Rocket Missions

	1973	1974	1975
Sounding rocket missions.....	---	---	$400,000
Total.....	---	---	$400,000

Work accomplished to date in the space processing program has identified areas of promise in the fields of metallurgy, electronic materials, glass and ceramic technology, and biological materials processing. Besides experiments performed during the Apollo and Skylab missions, the program has conducted extensive tests in ground-based drop towers and aircraft flights, which provide free-fall times of a few seconds' duration. However, long duration missions where the payload is retrieved are restricted, and it has been found that preliminary tests exceeding the durations of aircraft and drop tower tests are desirable for many processes.

Areas in which such tests are needed include levitation techniques, containerless melting, dynamics of levitated liquids, directional solidification of metals and semiconductors, and performance characteristics of electrophoresis apparatus.

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Through analysis and surveys of scientific consultants, the Space Processing program has determined that feasibility tests of a relatively wide range of space processes and processing techniques can be accomplished in the 5 to 10 minute periods of weightlessness that can be obtained in sounding rocket flights. For example, containerless melting and quenching can be done on a small scale, other manipulations of melts can be simulated, and the operation of certain types of electrophoresis apparatus can be demonstrated.

It is expected that this program of mutually supporting ground investigations and rocket flight tests will lead to a Shuttle/Spacelab experiment program allowing early implementation of economically viable processes and space manufacturing operations.

A program of sounding rocket experiment flights can serve as a useful "managment laboratory" to develop effective procedures to assure easy user access to space or repetitive low-cost flights. Thus, such a program can serve as a small-scale simulator of the shuttle experiment program, as well as a means for modeling substantial progress in process development.

Four rocket flights carrying experiment payloads are planned for FY 1975.

Energy Applications Program

	1973	1974	1975
Energy applications program.....	---	$2,000,000	$2,000,000
Total.....	---	$2,000,000	$2,000,000

During FY 1974 NASA initiated an energy applications program which included studies of solar power conversion and delivery systems, hydrogen production and utilization systems, and energy and environment conservation systems. In FY 1975 these activities will be continued, or in a few cases completed, and the most promising activities will be pursued in more detail, including additional experimentation and a limited amount of additional engineering demonstration performed. More specifically, the planned work in these areas is as follows:

Solar Power Conversion and Delivery Systems: A microwave receiver/rectifier array ("rectenna") engineering demonstration will be performed and the plans for an energy transmission test range will be established. The field demonstation will deliver 5 kw over a 1.6 km range with existing NASA equipment. Engineering and economic analyses will be made of large orbital power generation and transmission systems, and comparisons will be made with terrestrial systems, to determine performance, technology, and cost targets as well as identify critical activities which require work in the immediate future.

An earth-based central station-type powerplant concept for converting solar thermal energy to electricity will be defined, based on existing or near term technology, and this system will then be assessed for performance, economic viability and technical adequacy. On this basis, a plan for advanced technology and applicable system development will be developed.

Hydrogen Production and Utilization Systems: Studies will be initiated to identify new industrial applications and cost targets for hydrogen as an energy source and to evaluate the technology and system concepts of solar thermochemical reactions for producing hydrogen. Technology evaluation and a system conceptual design will be accomplished and performance and cost targets will be established.

Energy and Environment Conservation Systems: The engineering demonstration of residential solar heating and cooling at the Marshall Space Flight Center will be evaluated in terms of the applicability of the technology to commercially developed housing and office buildings. Studies will be made of a pyrolysis unit for disposal of waste and production of clean fuels, as well as studies of this unit as it might be integrated into overall utility systems, such as the Modular Integrated Utility System. A pyrolysis system will be designed, performance and cost targets identified, and fabrication of a breadboard test unit initiated.

Communications

	1973	1974	1975
Canadian cooperative satellite (CAS-C)	$2,686,000	$2,760,000	$1,550,000
Experiments coordination and operations support	---	800,000	3,700,000
Technical consultation and support studies	---	2,540,000	1,650,000
Advanced communications research	---	---	1,400,000
Applications technology satellite (ATS 1-5)	1,333,000	---	---
Multi-user communication experimental satellite (ATS-F)	51,854,000	16,000,000	---
Systems technology and techniques	2,033,000	---	---
Traffic management studies	154,000	---	---
Cooperative applications satellite (CAS-A)	46,000	---	---
Total	$58,106,000	$22,100,000	$8,300,000

NASA objectives in satellite communications have been refocussed towards meeting longer-term national needs. These needs, as expressed by legislative and executive agencies, including NASA, and the private sector, require that the unique, in-government, satellite communications technical capability developed over the past decade be maintained and made available to these agencies. These needs are in technical studies; consultation and advice (e.g., for U.S. Maritime Administration on maritime communications); studies conducted for specialized government services (e.g., for NOAA on a Disaster Warning Service); and maintenance of a capability for such support by conducting advanced research on technology in advance of that available or in the implementation stages. Advanced Communications Research is designed to go beyond that which will be developed by the commercial sector with risk capital. The phase-down of satellite communications research and development as related to early commercial utilization, announced by NASA in January 1973, is essentially completed. As already indicated, some effort is continuing because it has become apparent that all aspects of the planned termination of the NASA effort were not acceptable to several executive and legislative agencies that have traditionally relied on NASA to provide technical consultation and support for their needs in satellite communications. In some cases NASA has a statutory obligation to provide such services. Certain government agencies have requested continuing NASA support of their consultation needs and others have requested support of their special mission needs on a reimbursable basis. The FY 1975 funding required to meet these needs is presented in two line items: Technical Consultation and Support Studies, and Advanced Communications Research. No new flight projects are currently envisioned.

Two flight projects will be completed. These will demonstrate the basic technology for, and provide initial investigations into, community broadcast satellites and will in part form the basis for maintaining the government's unique capability in satellite communications. The first is the multi-user communications experimental satellite (ATS-F) scheduled for launch in 1974, and the second is the Canadian Cooperative Applications Satellite (CAS-C) scheduled for launch in 1975. The ATS-F satellite will support 23 of its planned 24 experiments, covering various disciplines during its first year. The 24th experiment will be initiated at the beginning of the second year after launch, when the spacecraft is moved to 35° E longitude where it can relay instructional material via its TV link over the Indian subcontinent. This is provided for under the US/India experiment agreement. The FY 1975 funding requirements for operation, coordination and scheduling of ATS-F experiments in the post-launch period are included in the Experiments Coordination and Operations Support line, along with the requirements for continued operation of ATS 1, 3 and 5.

The principal components in the CAS-C for which NASA funding is required are a 200 watt, 12 GHz, super-efficiency Traveling Wave Tube (TWT) and its power supply to be provided by NASA to the joint US/Canada flight mission. Preliminary transmitter development has been completed and the laboratory tests show that the specifications have been exceeded. The flight-qualified version of the TWT and its accompanying power-conditioning subsystem are under development. FY 1975 funding is required to continue this development. A core group of CAS user experiments by U.S. investigators is being selected to utilize the 50% U.S. share of CAS-C operating time. These experiments will be conducted at no cost to NASA.

Canadian Cooperative Satellite (CAS-C)

	1973	1974	1975
Spacecraft testing.....	$339,000	$460,000	$790,000
Experiments.....	2,247,000	2,200,000	560,000
Mission analysis and operations....	100,000	100,000	200,000
Total.....	$2,686,000	$2,760,000	$1,550,000
Delta (Launch Vehicle Procurement program).....	(---)	(1,000,000)	(3,600,000)
Total (including launch vehicles).....	$2,686,000	($3,760,000)	($5,150,000)

In April 1971 the Canadian Department of Communications (DoC) and NASA entered into agreement, formalized by a Memorandum of Understanding, to launch a Cooperative Applications Satellite (CAS-C, also referred to as Communications Technology Satellite or CTS) in late 1974. Launch readiness is currently assessed for late 1975. The overall objective of this project is to develop a technical capability for satellite communications with small ground stations in the newly allocated 12 GHz frequency band. The investigation of the use of frequencies above 10 GHz is considered urgent in view of forthcoming domestic satellite systems further crowding the spectrum below 10 GHz.

Principal objectives of this mission that are of interest to the United States are to: (1) flight test a super-efficiency power tube having greater than 50% efficiency at a minimum output power of 200 watts and operating at approximately 12 GHz; (2) flight test unfurlable solar power arrays of approximately 1.0 kw initial capability; (3) demonstrate accurate stabilization of spacecraft with flexible appendages for satellite communications experiments with 12 GHz terminals; and (4) conduct joint U.S.-Canada communications applications experiments, sharing the spacecraft time equally after the satellite

is successfully placed into geostationary orbit. User experiment proposals have been received by NASA and by Canada and are being selected.

NASA is responsible for the 200 watt transmitter tube and its power supply, for the Delta launch vehicle, and for launch of the satellite into geostationary orbit. Canada is responsible for the development and testing of the spacecraft, and for controlling the satellite after launch. Joint responsibility is assumed for the conduct and evaluation of the technological experiments.

During FY 1973, an experimental model of the super-efficiency power tube demonstrated 237 watts output at an efficiency of 56%, thus exceeding specifications by more than 10%. The FY 1974 funds are being used for further development of the power tube and its power supply, and for integration of these units into a Transmitter Experiment Package (TEP). A ground station, which will test the performance of the TEP during ground testing and later during orbital operation, is being built at Lewis Research Center. FY 1975 funds are required to fabricate and test the qualification and flight models of the TEP; to conduct environmental tests of the spacecraft engineering model; and to finish mission operations software required for launching the spacecraft. Canada is responsible for funding design, development and fabrication of the spacecraft.

Experiments Coordination and Operations Support

	1973	1974	1975
Experiments coordination and operations support.....	---	$800,000	$3,700,000
Total.....	---	$800,000	$3,700,000

In 1969 NASA made a public offer to afford potential users of communications satellites the opportunity to use Application Technology Satellite (ATS) 1, 3, and 5 in orbit for experimental use after the NASA experiments are completed. This offer has received substantial response. Under the procedures established for such use, the experimenter provides funding for support of his experiment. In like manner, many experiments have been approved for use on ATS-F and CAS-C (CTS) after launch under these user experiment procedures.

In FY 1975 support will continue for the operation, coordination, and scheduling of ATS 1, 3 and 5 for cooperative user experiments. NASA is cooperating with international, federal, regional and state agencies and industrial organizations in the conduct of these experiments covering a broad range of telecommunications objectives. These satellites are being

utilized to conduct educational and health care experiments in many parts of the United States, including Alaska and Hawaii, and in the Pacific Basin. In addition, aeronautical and maritime communication experiments are being implemented. In conjunction with the Federal Aviation Agency, Maritime Administration, Coast Guard, Canada and European Space Research Organization (ESRO), trilateration experiments will be conducted, using ATS-5 to augment the ATS-F Position Location and Aircraft Communications Experiment (PLACE). The data will be used to assess the practicability and accuracy of an air traffic control satellite system in the aeronautical L-band frequency region. NASA does fund for the continued operation of the satellites, as well as for the coordination effort to match the experiment to the technical capabilities of the satellites and coordination of the scheduling time on the satellite.

In FY 1975 support will be provided for continuing experiments for ATS-F (to be launched in 1974), including operation and scheduling of experiments, coordination with experimenters and operations planning, data analysis, continued reporting, continuing operation, and analysis of spacecraft performance. This activity will include cooperative experiments in Health and Educational Television (HET) services via satellite with the Department of Health, Education and Welfare; Satellite Instructional Television Experiment (SITE) with India; air and sea traffic control using the Position Location and Aircraft Communication Experiment (PLACE) with the Department of Transportation and Maritime Administration; technology experiments in meteorology using the Very High Resolution Radiometer (VHRR); and in propagation, radio interference, and spacecraft technology. Similar experimental support will also be provided to U.S. experimenters on the CAS-C satellite to be launched in 1975.

Technical Consultation and Support Studies

	1973	1974	1975
Technical consultation and support studies.....	---	$2,540,000	$1,650,000
Total.....	---	$2,540,000	$1,650,000

This program consists of special studies, measurements and consultation services providing support in spacecraft technology and telecommunications. The support is for NASA itself, in connection with its own communications needs; the Federal Communications Commission (FCC); and others at their request, and where appropriate, on a reimbursable or cost-shared basis. NASA's technology base is vital to carrying out this program.

In FY 1974 studies and measurements are being performed to improve and update NASA's specialized data base required to support special studies on frequency sharing, satellite space and positioning, radio interference predictions, and satellite system technology assessments and evaluations. These activities will be continued in FY 1975.

The sharing and interference study efforts are concerned with preventing radio frequency interference among satellite telecommunications systems and between space and terrestrial telecommunications systems. The results of the sharing and spacing studies will also be used by the FCC in establishing guidelines and regulations for the use of assigned frequency bands and orbits.

Radio interference has been experienced by space systems at an increasing rate and the future use of data collection systems, with their thousands of radio transmitters, could cause this problem to escalate. The increased use of the radio frequency spectrum for early resources sensing and for specialized government services will require detailed knowledge of both natural and man-made noise effects for satellite system design purposes. To offset this potential problem, studies will be conducted in FY 1975 to determine if a space measurement and monitoring program of radio emissions will be required.

Advanced Communications Research

	1973	1974	1975
Advanced communications research...	---	---	$1,400,000
Total.....	---	---	$1,400,000

The objective of this program is to develop technology and concepts in advance of current and planned state of the art communications technology. The effort is designed to maintain NASA's expertise in non-defense oriented spacecraft technology and space telecommunications. It will provide an advanced technology base for NASA's own needs in space telecommunications and will aid NASA in meeting statutory responsibilities to provide technical consultation services. The effort is intended to create an environment for new ideas and concepts. The Space Shuttle will provide the means to demonstrate the worth of many of the concepts and technologies that will be developed.

Work emphasized in FY 1974, and which will be continued in FY 1975, includes investigations to improve and expand the use of the microwave frequency spectrum; exploration of bandwidth compression and conservation techniques; antenna design studies; and certain special studies. At the

microwave frequency band between 12-30 GHz, low-cost, low-noise receiver preamplifiers and highly reliable medium-to-high power transmitters will be developed. At infrared and visible wavelengths, new communications technology will be explored and developed. The infrared and visible wavelength regions have the potential of providing communications bandwidths many times that presently available in the microwave frequency band. In the far infrared there is a potential of developing receiver preamplifiers with far less noise than those at infrared and visible wavelengths.

In order to better utilize the presently assigned frequency bands, we will explore technological advances in both on-board processing and bandwidth conservation techniques. Examples include the use of an advanced data rate reduction concept developed by NASA, and multiple-level modulation techniques and orthogonal polarization transmission for increasing the amount of data a given bandwidth can contain. Bandwidth utilization improvements over twelve times might be achieved through an appropriate combination of these methods.

To meet the requirement of providing unique geographic coverage by communications satellites without mutual interference, an advanced computer program capable of providing complete antenna design details will be developed.

In satellite technology, emphasis is placed on weight conservation techniques, reduced spacecraft costs, and improvement in reliability in order to meet the long-life need in synchronous orbit. These efforts include development of new concepts to make more effective use of the impinging solar energy for power generation and of the solar pressure for orbital station keeping.

We will also continue our special study of "Communications as a Substitute for Transportation." An experiment will be planned to provide audio, video and data links between NASA Headquarters and various field centers. Analysis will provide information on the use, cost/effectiveness, and cost/benefit characteristics of such a technique and its applicability within NASA.

Data Management Program

	1973	1974	1975
Data management systems requirements studies	---	---	$500,000
Developing on-board processing techniques	---	---	1,000,000
Data transmission technology development	---	---	1,000,000
Improving ground data processing systems	---	---	1,500,000
Total	---	---	$4,000,000

The objective of this program is to first study, and then design, develop and demonstrate a data management system which provides a much better data flow from the sensing of data to its application by the user. Capabilities such as earth observation satellites introduce new dimensions to data systems because: (1) the large volume of data generated will overwhelm present capabilities; (2) the data will be at exceedingly high rates; (3) there is an urgency to reduce the time between the acquisition of the data and its transmission to the user in suitable form and necessary quantities; and (4) proper archiving methods which facilitate rapid access for information retrieval, and provisions for feed-back inputs from users to the data store, become important parts of the system for the first time.

A systems approach will be required which, as a minimum, supports the planned effort for: (1) studying and identifying systems requirement; (2) developing on-board processing techniques for collecting, processing, compressing and storing, most efficiently with respect to user needs for information, the sensor-collected data, and preparing the data for transmission to ground stations; (3) developing technology to improve data transmission from satellite-to-satellite, satellite-to-ground station, and ground station-to-data processing facility; and (4) improving ground data processing systems.

The planned approach is to study data needs and the techniques which will be necessary to satisfy them, followed by systems analysis efforts to generate a model of a functioning data management system. Once established, the data management system model will be functionally exercised to optimize its operation. Consideration will be given to programmatic requirements (both user and operational); capabilities of the space, ground, and information transfer elements; and sensor application and utilization techniques. Maximum application will be made of existing data systems technology, in both hardware and software. Needs for new developments will be identified in the context of systems models using applicable technology wherever possible to satisfy user needs.

FY 1975 funds are required to determine user needs and develop conceptual models for a first generation general purpose data and information system directed toward the characteristics of earth observation satellites. An overall program plan will be developed to avoid unnecessary fragmentation and proliferation of approaches to the total data and information system. Included in this plan and included in the FY 1975 efforts will be both hardware and software efforts such as feasibility studies of applying data-processing techniques to spaceborne vehicles and trade-off analyses to determine the effectiveness of on-board processing techniques. Related efforts include exploring bandwidth reduction technologies; digital multiplexing and switching techniques to determine optimum approaches to compressing large amounts of data into pre-allocated transmission technology; and acceptable techniques for improving ground data processing systems.

Earth Observatory Satellite (EOS) System Definition

	1973	1974	1975
EOS system definition studies.....	$900,000	$3,000,000	$1,000,000
Total.....	$900,000	$3,000,000	$1,000,000

This program will continue the Systems Definition Phase studies for an Earth Observatory Satellite (EOS) to conduct earth observations research in the late 1970's and 1980's with a system that is compatible with the Shuttle and designed for low cost. Sufficient flexibility is to be provided in the spacecraft and ground system design to accommodate different missions and their sensors, for such purposes as land use management and sea surface and environmental surveys. The contracted system definition studies that are to be awarded in late FY 1974 and continued into the first half of FY 1975 will define a system that has this flexibility. Major emphasis to date has been placed on meeting the requirements of users who are concerned with improved techniques for land resources management and land use inventory. The ability to classify and monitor the changes in the use of land will be extended from categorizations of interest to state and county planners, to those of value to urban and city planners. Agriculture yield prediction accuracy will be increased by the ability to recognize more subtle differences in crop type and vigor, and by the extension of accurate identification from 20 acre fields down to those as small as an acre.

Basic feasibility and design concept studies for the long lead time sensors were conducted in FY 1973 and FY 1974. Some instrument breadboards are scheduled for completion in FY 1974. FY 1975 will emphasize the proof-test of selected instrument models to assure the adequacy of the instrument design concept and the adequacy of the spacecraft, ground system and data management concepts to accommodate the instruments.

Shuttle Experiment Definition

	1973	1974	1975
Shuttle experiment definition.....	---	$4,500,000	$4,500,000
Total.....	---	$4,500,000	$4,500,000

The objectives of the Shuttle Experiment Definition program are to identify and define the applications experiments to be conducted during the period when the Space Shuttle will be the principal Space Transportation System (STS). In addition to providing important information relating to the long-range planning and execution of the Applications Program, the

data stemming from these activities will be utilized both to influence the total STS design and to determine the STS impact on the comprehensive Applications Program envisioned for the 1980's. Other factors which will receive attention in the program include:

a. The feasibility of developing larger, multi-use instruments,

b. The availability of the zero gravity environment for the conduct of sophisticated manned and automated gravity-limited experiments,

c. The impact of man on the requirement for redundant systems to reduce spacecraft mortality, and

d. The utilization of man to enhance spacecraft data return and to effectively operate and maintain applications systems and components in flight.

The program content for FY 1975 includes experiments in the disciplines of weather and climate, environmental quality, earth resources survey, earth physics (i.e., geodesy), ocean dynamics, communications/navigation, and space processing. The variety of instruments that will be involved in these experiments will be extensive, and will afford the potential for multiple range across the Applications Program. The emphasis will be to conduct: (1) experiment definition and feasibility studies; (2) experiment preliminary design and breadboarding; (3) ground-based and aircraft concept verification tests and; (4) planning activities associated with the detailed design, development and testing of related flight instruments and ancilliary equipment. Included in this effort will be the continuation of work to define experiments recommended by our advisory committees and by the discipline panels of the Summer Study conducted by the National Academy of Engineering.

Advanced Applications Flight Experiments

	1973	1974	1975
Design and development of advanced experimental instruments.....	$4,694,000	$4,700,000	$4,700,000
Total.....	$4,694,000	$4,700,000	$4,700,000

The Advanced Applications Flight Experiments (AAFE) program plays a very important role in developing instrumentation for future missions in earth resources survey, pollution monitoring, weather and climate, earth and ocean physics, and space processing. During the past four years, the AAFE program has developed a number of experiments which provide improvements in user data and new types of instruments for missions such as the NIMBUS G pollution

monitoring satellites; the SEASAT A Ocean Dynamics Satellite; the Shuttle Sortie missions and future Earth Observation Spacecraft. Many AAFE instruments have become payloads in applications missions. The ability to develop instruments closely approaching their flight configuration, but not yet committed to flight, as is done in the AFFE program, is an effective way to provide for low cost development of such instruments.

For FY 1975, a portion of the AAFE funds will be used to continue experiments initiated in FY 1974. The work will include programs for a 200 megabit per second tape recorder, a high resolution pointable imager, an imaging radar, and an active/passive multifrequency microwave system. Other work will be directed toward the development of an advanced atmospheric sounder and imaging radiometer for geostationary missions, a long life technique for monitoring earth energy budgets, and space processing experiments for Shuttle missions. The remaining FY 1975 resources are divided between completing FY 1974 and prior experiments and initiating the FY 1975 experiments to be solicited in early 1974.

The experiments in the AAFE program are pursued until their feasibility has been established through testing of an engineering model or some other equivalent testing procedure. When the experiments are selected for incorporation on an approved mission, the construction of the appropriate instrumentation will be funded by the flight mission or the instrumentation program. On-going AAFE experiments include the Lower Atmospheric Composition and Temperature Experiment (LACATE) and the Measurement of Air Pollution from Satellites (MAPS), which have been selected for the payload on NIMBUS G; the Pulse Compression Radar Altimeter for SEASAT; a Microwave Temperature Sounder, a candidate for an EOS mission; a Hadamard Imaging Spectrometer for meteorology applications; on-board equipment, such as a Precision Attitude Determination System; and a fast multispectral processor which will make classification decisions in real time.

Applications Systems Analyses

	1973	1974	1975
Applications studies.....	---	$1,000,000	$5,000,000
Total.....	---	$1,000,000	$5,000,000

The Applications Systems Analyses program has two primary objectives; (a) user oriented systems and economic analysis and assessment of the applications programs and (b) the identification of systems feasibility analysis of new applications initiatives.

An important activity of the Applications program is the determination that the programs being carried out and proposed have real potential for

economic and social return to the public. The special characteristics of NASA's application activity places a great deal of importance on systems economic analysis and assessment. Studies initiated in FY 1974, directed to providing an assessment and appraisal of the Applications programs, will be expanded in FY 1975. Examples of the elements to be included in these assessments are as follows:

(1) User analyses with particular emphasis on establishing specific needs and requirements of the users.

(2) Determination of users information/data product requirements, service requirements and product requirements (e.g., data handling and processing equipment).

(3) Economic trade-offs and analyses including cost benefits, cost effectiveness.

(4) Technology appraisal and assessment.

(5) Selected user demonstration projects to evaluate applications effectiveness.

A primary objective of these activities will be to establish need and economic or other practical benefit justification as early in the life of a program as possible and to up-date the analysis through follow-on studies as more detailed information and data is developed.

An important consideration in the Applications Systems Analyses program is the assessment of how and when applications should be transitioned to operational status, and transferred to operating agencies or the private sector. Criteria must be established for determining when this transition is technically, economically and institutionally appropriate.

Systems Analyses includes advanced studies of new directions in current Applications programs and the study of entirely new applications. An early technical assessment of new application ideas as they are developed will serve to establish preliminary feasibility and key technical requirements. These early advanced studies also provide a basis for determining which new ideas justify further consideration and effort. Illustrative examples of studies that would be undertaken in FY 1975 include: investigation of techniques for data interpretation; monitoring and control of reuseable water treatment systems; identification of biological signatures detectable by advanced sensing techniques; and new techniques for obtaining ground truth.

Applications Explorer Heat Capacity Mapping Mission

	1973	1974	1975
Applications explorer heat capacity mapping mission.....	---	---	$2,600,000
Total.....	---	---	$2,600,000

The Heat Capacity Mapping Mission will make thermal inertia measurements of the earth's surface which will lead to the identification of surface rock types, the monitoring of ocean currents and aid in the development of a capability to inventory potential geothermal sources.

The identification of rock types is of major value in locating oil and gas fields since the exploration for these resources relies substantially on the identification of reservoir rock and local structure which might provide a trap for petroleum. Major civil works like highway and canal construction are critically dependent upon the type of surface rock that will be encountered along alternative routes.

Thermal anomalies have been found that correspond to surface and subsurface water. Thermal images are also of use in monitoring the location of the ocean currents and the temperature variations of water along the coasts. Thermal imagery has been demonstrated to be effective in detecting and monitoring river pollution plumes, sea ice, soil moisture, crop stress and disease. In order to accomplish these objectives, the thermal sensor will be placed in a specialized pre-dawn orbit for sensing day and night surface temperatures, near the maximum and minimum values, in a twenty-four hour period. This condition produces the greatest differentiation of materials with different thermal properties. Such an orbit is incompatible with the orbit required for other investigations, such as those associated with ERTS.

The instrument to be used on this mission is a spare flight unit and its performance has already been verified in an orbital test radiometer developed and tested on NIMBUS-5; however, it was not in our optimum orbit on NIMBUS-5 because of incompatibility with other instruments on the spacecraft. The chosen orbit and the ground swath of the instrument will provide repetitive coverage of a given area within no more than two days. The ground stations to be used for real time read-out of the data will provide coverage of virtually all of North America and Australia and most of Europe and North Africa.

The satellite subsystems will be common with the International Ultraviolet Explorer and the International Magnetospheric Explorer satellites where possible. The satellite will be 3-axis stabilized and will be launched by a Scout launch vehicle. FY 1975 effort covers satellite subsystem design and engineering testing, initiation of instrument modifications, and procurement of long lead items.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1975 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR

AERONAUTICS AND SPACE TECHNOLOGY PROGRAMS

Programs	Budget Plan		
	FY 1973	FY 1974	FY 1975
Aeronautical research and technology.....	$150,640,000	$168,000,000	$166,400,000
Space and nuclear research and technology.....	81,860,000	69,000,000	74,800,000
Total.....	$232,500,000	$237,000,000	$241,200,000

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1975 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY — AERONAUTICAL RESEARCH AND TECHNOLOGY

SUMMARY OF RESOURCES REQUIREMENTS

	1973	1974	1975
Research and technology base.....	$74,803,000	$81,426,000	$83,900,000
Systems and design studies.....	5,486,000	6,073,000	5,000,000
Systems and experimental programs..	70,351,000	80,501,000	77,500,000
Total.....	$150,640,000	$168,000,000	$166,400,000
Distribution of Program Amount by Installation:			
Johnson Space Center.....	$205,000	$164,000	$164,000
Marshall Space Flight Center...	910,000	647,000	647,000
Jet Propulsion Laboratory.....	1,282,000	620,000	620,000
Wallops Station.....	91,000	124,000	124,000
Ames Research Center.....	33,196,000	43,526,000	44,153,000
Flight Research Center.....	12,300,000	12,898,000	12,898,000
Langley Research Center.....	46,970,000	49,605,000	60,428,000
Lewis Research Center.....	53,330,000	58,786,000	45,736,000
Headquarters.....	2,356,000	1,630,000	1,630,000
Total.....	$150,640,000	$168,000,000	$166,400,000

HIGHLIGHTS OF BUDGET PLAN

Research and Technology Base

Materials - Basic research and development studies on metals, ceramics, ploymers and composites of those materials that will lead to improved high temperature properties and reliability.....	$4,474,000	$6,600,000	$6,900,000

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	1973	1974	1975
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.....	$5,659,000	$6,400,000	$7,000,000
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.....	2,946,000	3,200,000	3,800,000
Propulsion Environment Impact Minimization - Programs to establish technology for major reductions of noise and exhaust emission pollution in aircraft engines and propulsion systems while minimizing fuel consumption.....	9,400,000	11,700,000	10,400,000
Propulsion Components - Supports achievement of highly efficient, light weight propulsion systems through research efforts to improve inlets and nozzles, fans, compressors and turbines, combustors and augmentation system, and mechanical components.....	9,000,000	8,700,000	9,000,000
Air Breathing Engine Systems - Provide technology to reduce costs and time required for new engine development programs through improved engine systems design and analysis techniques and to investigate new system concepts.....	8,191,000	8,000,000	8,000,000

	1973	1974	1975
Fluid and Flight Dynamics - Programs to increase understanding and predictability of complicated aerodynamic and flight dynamic phenomena to provide improved vehicle design criteria.....	$9,087,000	$8,926,000	$9,400,000
Low-Speed Vehicle Systems - Research and technology programs to improve the levels of aerodynamic performance, noise, and handling qualities in general aviation, powered lift, jet-VTOL, and rotary wing aircraft.....	11,314,000	11,600,000	11,600,000
High-Speed Vehicle Systems - Supports efforts to establish technological superiority in civil and military aeronautics for medium and long haul cruise aircraft, hypersonic aircraft, and combat vehicles through improved aerodynamic configuration design.....	7,900,000	9,000,000	9,100,000
Man-Vehicle Technology - Provide the research and technology base for solutions to human problems in the areas of aircraft noise, ride quality, and flight management, that might impact the improved performance and safety of air transportation...	3,069,000	3,800,000	4,800,000
Aircraft Operations - Development of refined knowledge of the atmosphere (low level) 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.....	3,763,000	3,500,000	3,900,000
Total, Research and Technology Base.....	$74,803,000	$81,426,000	$83,900,000

	1973	1974	1975
Systems and Design Studies			
Systems Studies - Determine from mission, systems, and conceptual studies, the technology requirements, costs, benefits, and impacts, of advanced civil and military aeronautical systems. Included in FY 1975 is the assessment of alternate fuels for long-range subsonic aircraft.....	$4,295,000	$4,073,000	$4,500,000
Design Studies - Develop preliminary design data, system specifications, and resources requirements for configurations selected on the basis of systems studies as potential experimental vehicle candidates. Included in FY 1975 is the design study of a medium short haul aircraft.....	1,191,000	2,000,000	500,000
Total, Systems and Design Studies.....	$5,486,000	$6,073,000	$5,000,000
Advanced Systems Technology Programs			
Materials for Advanced Turbine Engines - Acceleration of development of advanced turbine engines by demonstrating validity of low-cost innovative materials.....	---	---	$900,000
Integrated Program for Aerospace Vehicle Design - A computerized technique to reduce design time with the simultaneous goal of reducing design, development, manufacturing and operational costs.....	---	---	1,000,000

	1973	1974	1975
Active Control Aircraft Flight Experiments - Confirmation of integrated active control concepts to achieve high performance at low cost in future aircraft.....	---	---	$1,600,000
Subtotal, Advanced Systems Technology Programs.....	---	---	$3,500,000
Systems Technology Programs			
Supersonic Cruise Aircraft Research - To provide the technology base for an economically and environmentally acceptable supersonic cruise aircraft and to assess the environmental impact of present and future foreign supersonic cruise aircraft.....	$11,700,000	$9,700,000	8,900,000
Quiet Propulsive-Lift Technology - To generate the integrated, total vehicle and operating systems technology to stimulate development of efficient quiet propulsive-lift, short haul transports.....	---	12,300,000	8,000,000
General Aviation Low Cost Avionics - Demonstration of advanced low cost avionics systems that enhance the safety and utility of general aviation aircraft.....	---	---	300,000
Subtotal, Systems Technology Programs.....	$11,700,000	$22,000,000	$17,200,000
Experimental Propulsion Programs			
Refan Program - Investigation and demonstration of noise reduction modifications that are retrofittable to current jet aircraft.....	24,000,000	19,000,000	1,000,000

	1973	1974	1975
Quiet, Clean, Short Haul Experimental Engine Program - Develop and demonstrate the technology to achieve a powered-lift aircraft noise goal of 95 EPNdB at 500 feet sideline distance.....	$1,868,000	$6,000,000	$10,000,000
Advanced Multi-Stage Compressor Program - Develop and demonstrate very high pressure ratio compressor technology for advanced high performance turbine engines.....	---	---	500,000
Experimental Quiet Engine for Conventional Take Off and Landing Aircraft - Test program of this engine completed in FY 1973.....	949,000	---	---
Subtotal, Experimental Propulsion Programs.....	$26,817,000	$25,000,000	$11,500,000
Flight Experiments			
C-8 Augmentor Wing Flight Experiment - Proof-of-concept flight tests of augmentor wing, powered-lift concepts.....	1,350,000	529,000	350,000
YF-12 Flight Experiments - A program of flight, laboratory and wind tunnel tests to validate or identify deficiencies in prediction techniques relative to structural, propulsion and aerodynamic performance in supersonic flight.....	5,847,000	5,399,000	5,300,000
Transonic Aircraft Technology Experiments - A joint NASA/AF program to determine the applicability of supercritical airfoil technology to variable sweep wing aircraft in transonic and supersonic flight.....	794,000	1,172,000	800,000

	1973	1974	1975
Fly-by-Wire Flight Experiment - Demonstration of digital fly-by-wire flight control technology via flight test and experience to provide the data for development of advanced aircraft.....	$2,514,000	$1,180,000	$2,200,000
Rotor Systems for Rotor Systems Research Aircraft - A joint Army/NASA program to develop and demonstrate improved helicopter rotor systems for next generation civil and military helicopters.....	---	---	1,800,000
Wake Vortex Minimization Flight Research - Validation of practical aerodynamic means to eliminate trailing vortices which constrain airspace/airport operations.....	---	---	1,200,000
Composite Primary Structures Flight Experiments - To establish confidence in composite materials for primary structures of commercial aircraft and demonstrate economic fabrication techniques and certification procedures.....	---	---	1,500,000
Advanced Acoustic Composite Nacelle Flight Program - Operational demonstration on a modern wide-body transport of economical advanced composite materials applied to the engine nacelle that will reduce the noise footprint.....	---	---	500,000
Composite Structures Flight Experiment - Operational experience of fatigue behavior, maintenance requirements and inspectability of selective composite reinforcement of metal aircraft structures. Completed in FY 1974.....	2,029,000	1,000,000	---

	1973	1974	1975
F-8 Transport Technology Flight Experiment - Flight verification of high-speed supercritical wing. Terminated in FY 1973.....	$2,059,000	---	---
Subtotal, Flight Experiments...	$14,593,000	$9,280,000	$13,650,000
Research/Experimental Vehicle Programs			
Rotor Systems Research Aircraft - A joint Army/NASA program to develop a unique flight test capability for advanced rotor research.....	1,614,000	5,266,000	7,100,000
Tilt Rotor Research Aircraft - A joint Army/NASA program to provide proof-of-concept evaluation of a tilt-rotor aircraft combining the best traits of the helicopter with the desirable cruise qualities of fixed-wing aircraft.....	1,637,000	5,345,000	11,300,000
Highly Maneuverable Aircraft Technology Flight Research Program - To provide low-cost flight research vehicles based on the application of new technology in a multi-disciplinary manner to exploit the synergistic potential for the design of advanced aircraft.....	---	---	1,500,000
Quiet Experimental STOL Transport Research Airplane - Cancelled in FY 1973. A research and technology effort is continuing under the quiet propulsive-lift program.....	2,968,000	---	---
Subtotal, Research/Experimental Vehicles Programs.....	$6,219,000	$10,611,000	$19,900,000

	1973	1974	1975
Operating Systems Experiments			
Noise Reduction Flight Procedures Experiments - Demonstration of reduced approach noise footprint via pilot and passenger acceptable, innovative noise abatement flight procedures.....	$2,924,000	$3,143,000	$1,200,000
Terminal Configured Vehicle Operating Systems Experiments - To provide improvements in airborne systems and flight procedures to reduce noise, improve fuel economy, improve terminal area productivity and improve approach and landing flight safety.....	4,753,000	5,000,000	6,300,000
Short Take Off and Landing (STOL) Operating Systems Experiments - A joint DOT/NASA effort to provide the technology base to stimulate development of all-weather STOL short haul systems.....	2,702,000	4,667,000	2,700,000
Vertical Take Off and Landing (VTOL) Operating Systems Experiments - Improved VTOL operation via extensive automation allowing operation under poor visibility conditions and in a manner to minimize noise, pilot workload and fuel consumption.....	643,000	800,000	1,550,000
Subtotal, Operating Systems Experiments.....	$11,022,000	$13,610,000	$11,750,000
Total, Systems and Experimental Programs.....	$70,351,000	$80,501,000	$77,500,000

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

AERONAUTICAL RESEARCH AND TECHNOLOGY PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The FY 1975 Aeronautics program is directed at improving the performance and reducing the energy requirements and undesirable environmental effects of civil and military aircraft. Maintaining the Nation's superiority in civil and military aviation is essential to the economic well-being and military security of the United States. NASA's role is the development of advanced technology to address specific areas of concern such as noise and pollution, and the general advancement of aeronautical technology to ensure the superiority of our military aircraft and a strong competitive position for the U. S. civil aviation industry in the international marketplace.

In civil aviation the program is aimed at removing or reducing the current growth restraints to civil air transportation by addressing the problems of congestion, safety, noise, pollution, and fuel consumption. NASA is actively cooperating with the Department of Transportation (DOT) and other appropriate organizations in finding solutions to most of these problem areas. A technology program is being conducted to reduce terminal area congestion and noise and to increase operating safety in the airport environment through the development of improved propulsion systems, avionics, guidance and control systems, and operating procedures. The technology to reduce pollution and fuel consumption and to utilize fuels other than those based on petroleum is being developed. Work is in progress on clean, quiet, efficient propulsion applicable to short take off and landing (STOL) and conventional take off and landing (CTOL) aircraft including propulsion system technology which could be applied to current narrow-body civil jet transports. Technology is being developed to provide superior short-haul, high-density, STOL and vertical take off and landing (VTOL) service in the future.

The development of advanced technology suitable for future military systems remains a key NASA objective. NASA is supporting joint development with the Department of Defense (DOD) of appropriate research, experimental, and prototype aircraft, to exploit technologies recently developed but not yet sufficiently verified for use in future production aircraft, and to determine whether attractive mission applications exist. NASA is also providing direct support to specific military aircraft to enhance the success of their development.

To enable long-term development of advanced aircraft, a continued fundamental research effort will be carried out in such areas as aerodynamics, propulsion, structures and materials, avionics, man-vehicle interactions, and safety and operational procedures. The basic objective is to improve performance, lower investment costs, lower operating costs, increase safety, and provide competitive aircraft in the world market.

The Supersonic Cruise Aircraft Research program represents a significantly reduced but vital continuing research effort in the area of supersonic technology. The program's objectives are the development of an expanded technology base for future military or civil supersonic cruise aircraft and to provide the data required to assess environmental impacts of present and future foreign supersonic cruise aircraft. The Quiet Propulsive-Lift Technology program has been expanded in scope to include flight research utilizing the Air Force Advanced Medium STOL Transport and an existing aircraft modified into a swept-wing quiet propulsive-lift research airplane.

Planned new activities include flight test confirmation of integrated design guidelines required for the implementation of active control concepts in future commercial and military aircraft designs, the demonstration of the use of advanced materials in primary aircraft structures and advanced turbine engines, the development of low cost avionics for general aviation, and the demonstration of highly maneuvering aircraft technology utilizing remotely piloted research vehicles.

BASIS OF FUND REQUIREMENTS:

Research and Technology Base

	1973	1974	1975
Materials research and technology..	$4,474,000	$6,600,000	$6,900,000
Structures research and technology.	5,659,000	6,400,000	7,000,000
Avionics research and technology...	2,946,000	3,200,000	3,800,000
Propulsion environmental impact minimization research and technology.....	9,400,000	11,700,000	10,400,000
Propulsion components research and technology.....	9,000,000	8,700,000	9,000,000
Air breathing engine systems research and technology.....	8,191,000	8,000,000	8,000,000
Fluid and flight dynamics research and technology.....	9,087,000	8,926,000	9,400,000
Low-speed vehicle systems research and technology.....	11,314,000	11,600,000	11,600,000
High-speed vehicle systems research and technology.....	7,900,000	9,000,000	9,100,000

	1973	1974	1975
Man-vehicle technology.....	$3,069,000	$3,800,000	$4,800,000
Aircraft operations research and technology.....	3,763,000	3,500,000	3,900,000
Total.....	$74,803,000	$81,426,000	$83,900,000

Materials Research and Technology

The aeronautical materials research and technology program is focused on the improvement of materials to reduce fuel consumption and the weight of aircraft, increase their longevity, safety, and reliability, and increase their cost-effectiveness and profitability.

In the area of high temperature engine materials, the research ranges from studies of the mechanisms by which materials maintain their strength at high temperatures to demonstrations of the behavior of materials under laboratory simulation of engine operating conditions. In FY 1975 laboratory proved candidate materials will be provided for inclusion into the "Materials for Advanced Turbine Engines" (MATE) experimental program. Prealloyed powders will be used in an attempt to reduce the materials cost of a typical turbine disk by one-third while increasing strength at 1,400°F by over 30 percent.

In the area of safer lightweight airframe materials, the focus is on the syntheses of new and improved polymers, composites, lightweight metals, and more efficient joining methods. The syntheses of polymers, foams, and window materials which do not ignite or emit toxic fumes when heated will be emphasized. In FY 1975 an evaluation of the toxicity of gases emitted by burning aircraft interior materials will be conducted, and substitute materials will be synthesized for the safety of passengers. A fire-retardant, nontoxic polyphosphazine composite matrix for use in aircraft interiors will also be synthesized. The joining studies will be aimed at increasing the use of adhesives in aircraft construction. In FY 1974 a process was developed which combines the advantages of brazing and spot welding for joining heavily stressed parts. In FY 1975 emphasis will be on synthesizing an adhesive for advanced high speed aircraft with a 50,000 hours lifetime at 600°F, 150°F over the current state of the art.

In the area of fatigue, fracture, and life prediction, the failure behavior of steel, titanium, and aluminum alloys and composite materials will be investigated analytically and experimentally. During FY 1975 corrosion inhibitors for high strength steels will be identified, and the "strain range partitioning" procedure for accurate prediction of material cyclic life in a jet engine will be applied to a variety of materials to establish its range of applicability. The fracture mechanics approach to fatigue crack initiation and crack growth will also be pursued in FY 1975. Emphasis will be put on the establishment of standard test methods that will provide accurate fracture indices thus reducing the cost and testing time involved in characterizing new materials.

Structures Research and Technology

The objectives of the aeronautical structures research and technology program are to provide significant technology advances in computer-aided design methods; loads, aeroelasticity, and structural dynamics; structural integrity; composite structures; and advanced structural concepts.

Benefits from these technology advances should result in improved fuel economy, operational economics, and reliability of future aircraft systems. In computer-aided design, research on automated methods for analysis and design of complex structures will reduce computer time and cost and extend capabilities. For example, a new level of NASTRAN will be released during FY 1975 which will decrease computer run-time by an order of magnitude and add the capability for automated, multilevel substructuring.

The objective in loads, aeroelasticity, and structural dynamics is to improve methods for predicting structural behavior in order to increase aircraft performance, extend service life, and improve safety and ride quality. Specific targets for FY 1975 include completion of a computerized subsonic flutter prediction capability for NASTRAN and methods for predicting the oscillating loads in turbulent airflows. Efforts will continue leading to improved understanding and more accurate and comprehensive panel flutter prediction methods. Research will also continue to improve aeroelastic load prediction techniques, including verification by wind tunnel data, and to provide analytical techniques which will predict more accurately the dynamic response of flexible aircraft.

Improvement in aircraft structural integrity by advancing the understanding of the factors that control crack initiation, crack growth, and fracture will be sought. Substantial improvement of analytical procedures for predicting the residual strength of reinforced sheet structures containing flaws is projected for FY 1975. Current methods underpredict strength by as much as 50 percent. Research in crack propagation and test techniques, which will lead to methods by FY 1978 for compressing the time required for life cycle testing of hot structures, will be conducted during FY 1975.

In composite structures, research to better understand and predict the behavior of filamentary composites will be continued to provide the basis for weight reduction of more than 25 percent and cost savings over current metallic structures in commercial aircraft. Ongoing demonstrations of secondary structures in commercial airline service will continue in FY 1975, including fairings on L-1011 aircraft and spoilers on B-737 aircraft. Additional components include rudders planned for installation on DC-10 aircraft in FY 1976. The 800,000 flight hours to be accumulated with these components, backed by ground tests and technology advances, will provide confidence for industry and the airlines to select composites for secondary structure of future aircraft.

Studies of advanced structural concepts seek to provide innovative concepts for improving the efficiency and reliability of aircraft structures and to explore structural concepts which will make possible future development of hypersonic aircraft. In FY 1975 various concepts for lightly loaded structures will be evaluated, and testing of actively cooled panel concepts for hypersonic aircraft will be initiated in the unique high temperature structures tunnels leading to the verification of these concepts.

Avionics Research and Technology

The focus of the avionics program is to develop technology for aircraft guidance, control, navigation, display and communications systems which will improve performance and reliability at reduced cost.

In the area of advanced avionics systems, modern guidance, control and navigation theory will be applied to the development of advanced avionics systems for STOL and general aviation classes of aircraft to provide improved maneuverability, timing and dependability in terminal area aircraft operations, increase landing rates up to 100 percent, and insure compatibility with future air traffic control requirements. In FY 1975 the performance benefits obtainable with optimal 4-D guidance and autoland software for STOL applications will be demonstrated by means of flight tests on a STOL aircraft using the STOLAND system. The design of a full-flight-envelope autopilot for augmentor wing aircraft and a preliminary design of tilt rotor aircraft will be completed. Analytical studies which define the preferred receiver configuration for very low frequency (VLF) navigation of general aviation aircraft will be completed.

In the area of innovative avionics, advances in solid state electronic components and system concepts will be applied to develop avionics system concepts which offer 60-70 percent reductions in the cost of control and display systems or significant improvements in operating efficiency and safety. In FY 1975 a low cost flight director (30 percent of the cost of current flight directors) for general aviation aircraft will be flight tested. Analytical studies of individual microstrip antennas will be completed.

In the area of automated VTOL avionics, digital circuit technology and real-time data processing techniques will be applied to the development of automated avionics systems and components for VTOL aircraft to reduce system costs and improve efficiency and safety in terminal operations. In FY 1974 navigation and guidance requirements for commercial VTOL operations were defined. In FY 1975 flight tests of a three-axis, low velocity, high accuracy airspeed sensor and the design of an acoustic altimeter will be completed.

In the area of active controls technology, highly reliable computer technology will be demonstrated, and design criteria developed for actively controlled aircraft concepts. In FY 1975 the conceptual design and analysis of high payoff active control system configurations will be completed, and a fault-tolerant computer organization concept applicable to flight management and control of civil aircraft will be defined.

Propulsion Environmental Impact Minimization Research and Technology

The objective of the environmental impact minimization program is to establish technology for major reductions of noise and exhaust emission pollution in aircraft engines and propulsion systems, while minimizing economic, operations, and fuel consumption penalties.

Propulsion noise reduction activities are aimed at providing the technology base for the understanding and reduction of aircraft propulsion component and system generated noise with minimum weight, performance and economic penalties. During FY 1975 fundamental studies will be continued to examine noise generating and propagation mechanisms associated with turbomachinery, inlets, nozzles, and jet interactions with the atmosphere and with aircraft surfaces. Experimental activities will include investigations of high mach number inlets, low noise fans and exhaust nozzles, and wind tunnel and F-106 aircraft tests to determine forward velocity effects on noise.

The noise footprint prediction program initiated in FY 1974 will evolve computational techniques for accurate prediction of ground noise levels from operating aircraft to establish acoustic characteristics, identify parameter sensitivities and guide research efforts. During FY 1975 an interim aircraft noise footprint prediction program will be established.

The exhaust emission pollution reduction activities are to establish technology to meet future environmental quality standards with minimum adverse effects on engine performance, weight, and system complexity. Research to be conducted in FY 1975 emphasizes reductions of emissions to extremely low levels for nitric oxide at takeoff and cruise conditions, and for unburned hydrocarbons and carbon monoxide at low power conditions. Most approaches to be investigated also result in reduced fuel consumption.

A major contracted effort (clean combustor program) with Pratt and Whitney and General Electric is underway to demonstrate a 75 percent reduction in emissions from a modern high pressure ratio aircraft gas turbine engine. Promising combustor concepts will be included in an engine demonstration phase using CF-6 and/or JT9D engines.

Recent research has shown that injection of small amounts of hydrogen into internal combustion engines permits stable, high efficiency operation with reduced fuel consumption and low nitric oxide emission levels. During FY 1975 this technique will be tested on aircraft piston engines and small aircraft gas turbine combustors.

Research associated with the interaction of exhaust emissions with the atmosphere is aimed at determining the aerothermochemical processes involved in exhaust gases and particulates mixing with the atmosphere. During FY 1975 two Boeing 747 aircraft equipped with instrumented packages to automatically record gaseous and particulate distribution along the airways of the world will go into operation. Research will continue on atmospheric reactions and kinetic rate measurements of selected reactions for use in wake and dispersion modeling.

Propulsion Components Research and Technology

The aeronautical propulsion components program objective is to provide the technology which supports achievement of highly efficient, light weight propulsion systems of broad operating range. Meeting this objective can result in system weight reductions and lower fuel consumption, with associated performance improvements, up to 30 percent for specific missions in the 1980's. Investigations will center on achieving improvements in the following components: inlets and nozzles; fans, compressors and turbines; combustors and augmentation systems; and subsidiary components.

Inlet and nozzle research will continue to concentrate on development of accurate analytical techniques for calculating complex external and internal flow fields associated with high speed inlets. In addition, experimental investigations of total system interactions between the inlet, engine and exhaust nozzle will be conducted in order to better define flow interactions between the various components of the total propulsion system. The inlet and exhaust nozzle research activity provides a technology base supporting military high speed aircraft designs, and contributes to the advancement of knowledge in the field of high speed internal aerodynamics.

Fan and compressor technology activity is aimed at achieving an understanding of flow dynamics, and demonstrating this understanding by increasing component efficiency, operating range, life, and reliability. Specifically, the fan and compressor technology in FY 1974 centered on determining stall margin and distortion tolerance improvement achievable by design techniques such as casing treatment, as well as demonstrated techniques for stage matching of high performance compressors and fans. In FY 1975 continuing effort is planned on multi-stage compressors designed for a high degree of stability under adverse operating conditions. Advanced turbine technology activity concentrates on achieving efficient cooling with minimum adverse effect on aerodynamic performance. Projects are also

underway to extract maximum work output from a given turbine stage, thereby reducing the number of turbine stages in an engine. Work of this nature is continuing in FY 1975. For both fans/compressors, and turbines, overall engine weight can be reduced by as much as 20 percent through successful achievement of the technology goals established. The reductions in engine weight will also result in lower aircraft fuel consumption.

Research and technology effort on combustors, searches for optimum means of providing the high exit temperatures and efficiencies required by advanced engines. Augmentor research is directed to achieving high combustion efficiency and lighter weight by reducing afterburner chamber length. The combustor and augmentor research will be continued in FY 1975.

Mechanical components provide the backbone supporting the major thrust producing devices, and includes bearings, shafts, seals, and lubrication systems. Long life, high reliability, minimum vibration systems are the targets of research on mechanical components. This activity is of a continuing nature, and in FY 1974 work focused on demonstrating long life high-speed bearings, and very low leakage engine seals. This work is continuing in FY 1975 with the ultimate objective of improving rolling element bearing life by a factor of 20 over current service bearings, and by reducing seal leakage rates by 90 percent compared to current values. The activity in the field of mechanical components is relevant to the entire spectrum of propulsion systems, and is a direct factor in reducing fuel consumption, and costs of present and future engines.

Air Breathing Engine Systems Research and Technology

The objective of the air breathing engine systems program is to provide technology to reduce costs and time required for new engine development programs through improved engine systems design and analysis techniques, and to investigate new system concepts.

Research on propulsion system dynamic behavior and control is directed toward the increased understanding of aerothermomechanical dynamic characteristics of gas turbine engine systems and component interactions, particularly in response to transient flow conditions. Laboratory tests of complete propulsion systems will be utilized to demonstrate the applicability of new on line digital computerized control system theories and system design concepts. A joint USAF/NASA program has been initiated to investigate the improvements attainable by integration of the control functions of the inlet and engine, and to demonstrate in flight on an F-111E airplane a new control technology that is responsive to the sensing, computation, and actuation requirements of the integrated inlet, engine, and exhaust nozzle system.

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Engines and complete propulsion systems will be investigated so that their basic performance characteristics and stability limits and responses to dynamic disturbances and distortions can be evaluated. Devices such as the pressure jet distortion system, temperature distortion system, choked inlet duct, screens, etc., will be employed to produce the desired engine inlet environment required for this work. Stability limited dynamic disturbances and distortions will be compared to those expected (from inlet tests) for preliminary evaluation of inlet-engine compatibility. Basic aeroelastic characteristics and response of an experimental, modern, high performance, military-type, turbo-fan engine will be determined in FY 1975 in a continuing joint NASA/USAF engine research program.

The low cost engine systems technology continues with its objective of establishing the feasibility of selected design characteristics and fabrication techniques to reduce the cost of gas turbine engines in the size range of interest for general aviation applications. Earlier engines tested under this project were in the 500-600 pound thrust class, intended for expendable missile applications. This phase of activity has drawn to a close with delivery of a test engine to the Navy. FY 1974 research activities will focus on low cost engine component technology. By the end of FY 1975 performance tests of a stamped and coined compressor rotor will be conducted in a demonstration engine.

Hypersonic propulsion research will establish the feasibility of propulsion systems for use in hypersonic vehicles for potential commercial and military applications. Complete small-scale, hypersonic propulsion systems incorporating thermal compression, and wall and strut hydrogen fuel injection will be demonstrated. These concepts show promise of significantly reducing engine cooling requirements. System effectiveness of scramjet propulsion system concepts having the potential of providing static sea level thrust will also be determined. Procedures will be established for prediction of internal shock-boundary layer interactions in hypersonic inlets, diffusers, and combustors needed for efficient and stable scramjet engine system designs.

The reduction of fuel consumption for energy conservation, and achievement of increased performance will be supported by investigations of feasibility of new or unusual propulsion system concepts for potential future applications in both the commercial and military aviation sectors. System characteristics of regenerator/recuperator engine cycles capable of achieving reductions of at least 30 percent in specific fuel consumption relative to current engines will be defined during FY 1975. The influence of hydrogen or methane fuels on aircraft engine designs will be determined during FY 1975. Propulsion system characteristics will be defined which will enable existing and new aircraft engine types to operate satisfactorily on synthetic jet fuels obtained from raw materials other than crude oil.

Fluid and Flight Dynamics Research and Technology

The thrust of this program is to advance our understanding and predictive capability of aerodynamic phenomena to permit increased performance optimization for more efficient, fuel conserving advanced aircraft and to ensure reduced environmental effects of advanced aircraft.

In the area of prediction of aerodynamic phenomena, theoretical prediction techniques are being developed to predict complete aerodynamic characteristics of complex three-dimensional aircraft configurations, so that preliminary design concepts can be evaluated with marked reduction in costly, energy consuming, wind tunnel tests. In FY 1974 calculation schemes were developed to predict the inviscid flow field over wing-body configurations, including viscous effects for the simpler two-dimensional case. For FY 1975 this limited predictive capability of inviscid and viscous flow fields will be extended to configurations of increased complexity using the Ames Research Center ILLIAC IV and the Langley Research Center STAR computers.

In the area of minimization of undesirable aerodynamic phenomena, extensive experimental, theoretical, and preliminary flight evaluations are underway to minimize such phenomena as wake vortex turbulence, airframe aerodynamic noise, and aircraft buffet which currently are severe aircraft operational constraints or hazards. In FY 1974 aerodynamic devices for reducing the wake vortex strength were developed in ground facilities and preliminary flight validation tests were performed. Preliminary measurements of noise radiated from airframe configurations were made in wind tunnels and in flight. In FY 1975 efforts will be made to further refine and develop the most effective aerodynamic devices for minimizing the wake vortex strength in both ground facilities and in flight tests.

In the area of experimental methods and facilities technology, innovative facilities such as the cryogenic tunnel concept for achieving high Reynolds numbers and the "quiet" (low disturbance level) supersonic tunnel are being developed to improve ground facility simulation of flight characteristics. In addition, improvements will be made in test techniques, scaling of tunnel results to flight conditions, and minimizing undesirable tunnel interference effects. In FY 1974 pilot models of the cryogenic tunnel and "quiet" tunnel concepts were evaluated to prove their feasibility. In FY 1975 model testing in the pilot cryogenic and "quiet" tunnels will continue and development of technology for large, high Reynolds number, transonic tunnels will be accelerated.

In the area of airfoil and configuration aerodynamics, experimental and analytical studies focus on the design of improved, highly efficient, lower drag (thus, lower fuel consuming) airfoils, with emphasis on the supercritical wing, as well as complete configurations for rotating and fixed-wing aircraft over the speed range. In FY 1974 considerable effort

was expended to document the supercritical wing aerodynamic characteristics over the entire speed range thereby providing a solid data base for advanced supercritical wing design. In FY 1975 experimental procedures for ensuring the validity of two-dimensional data will be established and verified. Also, innovative concepts such as the oblique wing and high aspect ratio swept-wing will be studied.

In the area of stall/spin, a parallel coordinated effort between NASA and DOD is being directed at specific studies aimed at defining the aerodynamic and inertial factors that are significant in preventing divergence and loss of control at high angles of attack. Analytical studies, high Reynolds number wind tunnel testing, and both small and large scale radio controlled models will be used to generate design data for improved flight characteristics at and beyond the conventional stall.

In the area of handling qualities, during FY 1975 efforts will continue to be directed toward the definition of specific handling qualities criteria for both aircraft and system design and for use by the FAA in determining certification requirements. Specific emphasis will be placed on those areas least understood, such as STOL, VTOL, and aircraft utilizing high levels of stability and control augmentation. Initial steps will be taken in the implementation of a broad based, manned flight simulation technology program during FY 1975.

Low-Speed Vehicle Systems Research and Technology

The low-speed vehicle systems research and technology program involves investigations to improve the integrated aerodynamic performance, noise, stability, control, handling qualities and vehicle dynamics of four aircraft categories--general aviation, powered-lift, jet-VTOL, and rotary-wing aircraft.

The general aviation technology efforts initiated in FY 1973 and 1974 directed toward safer and more productive aircraft will be continued. Significant improvements in aerodynamic performance have been predicted by wind tunnel tests of a new low-speed airfoil section. Flight verification of these predictions will be obtained during FY 1975. Models and full-scale aircraft will continue to provide data for improved spin characteristics. Efforts will also be devoted to aerodynamic means for improving the stall and low-speed flight characteristics. Approach and landing studies will examine new aerodynamic flight path control techniques. Technical consultation and design verification will be provided for the application of supercritical technology to the design of new business jets by the U.S. manufacturing industry.

Studies to provide the aerodynamic and flight dynamics technology to enable viable short haul powered-lift designs--from the standpoint of

performance, noise, and operating costs--will continue. Integrated aerodynamic performance, noise, stability, and control characteristics of advanced augmentor wing (AW) concepts will be verified in large-scale, low-speed tunnel tests. Similar studies will be completed for preliminary upper surface blowing (USB) designs. Small-scale tests to obtain first-order aerodynamic information on design improvements for several powered-lift concepts will be conducted, some of which will warrant large-scale verification in subsequent years. Definition of a preferred piloting control system for use during low-speed terminal area operation will be examined utilizing ground-based simulators and flight studies. In a joint effort with FAA, handling qualities and performance criteria for AW and USB powered-lift aircraft will be defined as a basis for establishing civil airworthiness standards.

In the area of jet VTOL aircraft, planned wind tunnel and static evaluations will examine the capability of a wing ejector-type propulsive system to provide an effective VTOL supersonic combat type aircraft. Tests will be continued to determine whether lift-fan transport models can be configured to achieve satisfactory terminal area operation, and if nozzle systems can efficiently vector the hot exhaust of the lift/cruise fans from the cruise mode to hover and thrust reversal. Flight tests using the X-14 research airplane and related simulator investigations will define the lateral control power needed in hovering flight for several promising VTOL control augmentation systems. Ground-based simulator capabilities will be validated to permit investigation of VTOL operations from small sea control ships under adverse conditions, in order to establish acceptable design and handling qualities criteria in subsequent years.

Rotorcraft studies will continue to validate and improve design predictive methods involving highly interactive flows, structural response, and control system factors. Particular attention will be given to main rotor/fuselage/tail rotor flow interference effects, to unsteady flow conditions on rotor blades and in the rotor wake, and to rotor blade and control system dynamics. Large-scale whirl tower and tunnel evaluations will develop the technology for advanced rotor systems having greater cruise and hover efficiency, reduced aerodynamic noise, reduced complexity/weight, and reduced vibration. Studies will be included on blade tip modifications, a variable-geometry concept, and a controllable twist rotor concept--all potential candidates for development as flight test articles for the rotor systems research aircraft. A variable stability helicopter will be used to evaluate handling qualities during curved decelerating approaches achievable with an advanced nonlinear control concept.

High-Speed Vehicle Systems Research and Technology

Aerodynamic technology, to achieve safe and reliable advanced civil aircraft and to establish technological superiority in military aeronautics, is being generated for medium and long haul cruise aircraft, hypersonic

aircraft, combat vehicles, and missiles. For each vehicle class substantial gains in aerodynamic flight efficiency will be sought to improve range/payload capability and/or to reduce substantially the fuel consumed such that the total energy of the system will be conserved. Technical assistance, consultive services, and facility support will also be provided by the NASA at the request of DOD for military aircraft and missile development programs to gain and maintain pre-eminence in military flight systems.

Aerodynamic design information, including improved prediction methods, for medium and long haul aircraft systems will be provided in the subsonic and near sonic cruise regimes so that next generation civil transports can offer a substantial competitive advancement over current technology transports and in the high supersonic speed regime so that an aerodynamic data base can be obtained for the design and assessment of generalized high supersonic speed aircraft configuration concepts. Langley will conduct parametric transonic wind tunnel studies to exploit the application of supercritical aerodynamics, to reduce airframe/pylon/nacelle interference penalties, and to update analytical prediction methods for optimizing transport configuration design. Transport models will be used to investigate the aerodynamic and control effectiveness and loadings of wing trailing and leading-edge controls which can meet vehicle design requirements for active control applications. Similarily, the feasibility of achieving the projected aerodynamic performance advantage of the oblique wing concept at cruise Mach numbers up to 1.4 in a practical overall transport design will be determined.

Representative configuration concepts potentially applicable to hypersonic transports and advanced military aircraft will be investigated in FY 1975 and later years to establish a technology base for defining aerodynamic, stability and control, and heating characteristics and to provide validation of analytic prediction methods of the total system performance. An investigation will be conducted to determine substitute gases for simulating engine exhaust flows. This technique will be verified experimentally using promising hypersonic aircraft configurations.

New aerodynamic technology for increasing air combat effectiveness of fighter aircraft over threat aircraft will be investigated and evaluated. In the joint U.K./NASA vectoring in forward flight program, flight tests will be initiated in FY 1975 using a modified Harrier aircraft which allows the thrust vector to be rotated 90° from full aft at speeds up to M=1.2 with no altitude restriction. Langley will conduct studies to delay flow separation on wings to obtain higher usable lift while maintaining control effectiveness which represents increased maneuverability. Aerodynamic studies of advanced fighter aircraft will be continued. Ames, Langley, and Lewis will continue studies in FY 1975 to integrate the propulsion system with the airframe to predict total system installed performance.

Technology will be provided by Langley in FY 1975 for advanced missiles with increased mission performance which will enable the DOD to select from a number of options, a required mission vehicle at minimum cost. Technology for air-to-air missiles with increased maneuver capability and for standoff missiles with increased aerodynamic lift over drag ratio (L/D) efficiency will be provided.

Experimental investigations, consultative services, and technical assistance will be continued in FY 1975, augmented with theorectical analyses when required, on major military development programs such as the F-15, YF-16, YF-17, B-1, Advanced Medium STOL Transport (AMST), and others as identified by the DOD in future requests.

Man-Vehicle Technology

The aeronautical man-vehicle technology program is concerned with providing the research and technology base for solutions to the human problems impeding the growth or the safety of air transportation. The program has four major elements; human response to noise; ride quality; flight management; and simulation technology.

The human response to noise program has as its objective the provision of the understanding of the relationships between aircraft noise exposure and annoyance. The objective is accomplished through investigation of such factors as effects number of aircraft operations, sleep interference, and low frequency content effects. Also social research is conducted to determine the effects of aircraft noise and operations on communities. During 1975 we will complete studies to determine the effects of take off and landing sounds on annoyance.

The ride quality program provides criteria for assuring passenger acceptance of an aircraft's motion environment. The focus of the program is to provide ride environment criteria that relates to advanced short haul air transportation systems. In FY 1975 we expect to establish multi-axis vibration criteria for enroute flight phases.

The objective of the flight management program is to provide the human factors research and technical data base that will permit the specification of crew roles, flight procedures, pilot training requirements, and control and display requirements for the National aviation environment of the 1980's-1990's. During FY 1974 the probable air traffic control environment of the 1980's and 1990's will be assessed so as to permit the conceptualization of required cockpit configurations, flight procedures, and pilot training requirements. A full mission, aircraft/air traffic control simulation is to be completed at Ames in FY 1975. Based on results derived from part-task and full mission simulations, the acquisition of an integrated cockpit flight

management system is planned. Flight test and verification of the system would occur during the period FY 1979-1980. Based on an analysis of the findings of a comprehensive study to define factors that contribute to pilot error in aircraft accidents, a program is being defined for implementation in FY 1975 that would potentially permit a substantial reduction in the number of approach and landing accidents.

The objective of the simulation technology program is to establish technology to permit effective and economical application of simulators to pilot training, proficiency maintenance, and aeronautical research and development. Simulators have become indispensible to some segments of the aviation community for reasons of cost effectiveness and safety. An impetus for even greater application now is the benefit to be derived in fuel conservation if simulators could be more widely used. Wider application is being restricted due to the unavailability of low cost systems and due to limitations in (1) visual scene generation technology, (2) understanding acceleration cue requirements, and (3) measuring pilot performance. In FY 1975 we will establish the system requirements where low cost simulation capability would result in the most fuel savings.

Aircraft Operations Research and Technology

The overall objective of the aircraft operations research and technology (R&T) program is to provide basic research and systems technology for solving the great variety of problems encountered in aircraft operations. The program has three essential elements which provide the organizational foundation from which individual research efforts develop. These three key elements are expansion of basic knowledge of the atmosphere, aircraft safety R&T, and improvement of the operational efficiency of aircraft systems.

Expansion of basic knowledge of atmospheric processes has as its objective the improvement of understanding of atmospheric processes as they affect the safe and efficient operation of aircraft. In FY 1974 an improved wind shear model was derived and applied to the aircraft landing problem. FY 1975 effort will refine this model in its relation to aircraft operations in the terminal area. Research will continue on understanding storm outflow turbulence, clear air turbulence generation, high altitude thermal and turbulence gradients, fog formation, and cosmic radiation hazards.

Safety research and technology has as its objective the development of a base of technology by which accident opportunities can be reduced and accident fatalities, injuries, and damage can be minimized. These efforts cover a wide spectrum of activity, including in-flight and aircraft fire prevention technology control of aircraft on the runway, wake vortex detection,

warning, and flight test, engine rotor disk integrity and lightning strike hazards. In FY 1974 information and data were gathered concerning factors present in the most hazardous phase of aircraft operation, approach and landing. This information supports a systems analysis of approach and landing which is being conducted to determine specific areas in this phase of operation where accident potential is high. This will identify research which has the highest impact on accident reduction. Progress has also been made in understanding the mechanics of aircraft interior fire propagation so that counter measures can be taken. FY 1975 will see the further development and operation of the approach and landing systems analysis, expanded fire technology, and expanded flight test activities to verify ground based facility research in wake turbulence. The control of aircraft on the runway will receive continuing attention, with explorations of unconventional landing gear concepts.

Aircraft systems operational efficiency improvement has as its objective the development of technologies which will permit increases in the service life and efficiencies of aircraft subsystems, through the application of new materials, designs, and operating techniques. In FY 1974 progress was made on improved brake and tire materials promising increases of as much as 20 percent in wear and durability, with consequent improvements in safety. Extending crosswind landing limitations of aircraft has begun by examining flight, touchdown, and rollout characteristics of a typical small STOL aircraft. Evaluations of control augmentation and crosswind landing gear configurations will be made in FY 1975 with a view toward increasing crosswind landing tolerance by 15 percent over present limits. Improvements will be sought in specialized flight test instrumentation for NASA flight research purposes.

Systems and Design Studies

	1973	1974	1975
System studies	$4,295,000	$4,073,000	$4,500,000
Design studies	1,191,000	2,000,000	500,000
Total	$5,486,000	$6,073,000	$5,000,000

System Studies

The overall purpose of aeronautical systems studies is to determine the technology requirements, costs, benefits and impacts of advanced civil and military aeronautical systems based on mission, systems and conceptual studies. Advanced aeronautical concepts are identified, analyzed and evaluated.

In the area of advanced transport technology system studies, the identification of significant technology advances and the R&T needed to support air transport development in the 1980's will be continued. In FY 1974 a study of design concepts to respond to future terminal area requirements without cruise performance penalties was made along with an initial feasibility study examining the potential use of liquid hydrogen as an alternate fuel. In FY 1975 studies of concepts to optimize fuel conservation will be conducted and the assessment of alternate fuels for long range subsonic aircraft will be continued. Results of R&T base programs will be integrated into updated transport economic studies.

Inexpensive alternatives for flight research will be pursued in studies of low cost options for flight research. In FY 1975 we expect to complete evaluation of costs and benefits of remotely piloted versus piloted research vehicles and also identify potential civil uses of remotely piloted vehicles.

Studies will be made to assess the potential of air transport technology advances for improvement of terminal ground operations. In FY 1975 this study program will determine the design and technology impacts on ground operations including intermodal transfer, cargo handling, loading and servicing, and recommend R&T activity in high payoff areas.

The FY 1975 activity in studies of traveler acceptance factors in low density short haul systems will include: a critique by airlines of university study results; and the identification of R&T requirements for improved ride quality, reduced noise and vibration.

Critical R&T needs toward reduction of civil aviation approach and landing accidents will be identified. In FY 1975 accident statistics will be analyzed to identify and rank specific factors contributing to accidents. A multiyear plan for aircraft safety research and technology programs will be prepared.

In the short haul transport system studies, previous investigations will be evaluated in terms of projected technology advances. In FY 1975 we expect to assess the impact of technology on system acceptance and determine the effects of improved terminal maneuverability on noise reduction and congestion relief.

Design Studies

Aeronautical design studies are made to develop preliminary design data, system specifications and resource requirements for configurations selected as candidate experimental vehicles or aircraft requiring more detailed design study.

In medium density short haul aircraft, a design study will be performed to determine the most useful and economic characteristics of aircraft to serve the medium density, short haul market, and identify associated research and technology needs. In FY 1975 we expect to complete a design study of a candidate economical, medium density, short haul aircraft which emphasizes creativity and innovation, together with a socio-economic analysis of the impact of such a vehicle in the short haul air system.

Systems and Experimental Programs

	1973	1974	1975
Advanced Systems Technology Programs	---	---	$3,500,000
Materials for advanced turbine engines	---	---	900,000
Integrated programs for aero-space vehicle design	---	---	1,000,000
Active control aircraft flight experiments	---	---	1,600,000
Systems Technology Programs	$11,700,000	$22,000,000	17,200,000
Supersonic cruise aircraft research	11,700,000	9,700,000	8,900,000
Quiet propulsive-lift technology	---	12,300,000	8,000,000
General aviation low cost avionics	---	---	300,000
Experimental Propulsion Programs	26,817,000	25,000,000	11,500,000
Refan program	24,000,000	19,000,000	1,000,000
Quiet, clean, short haul experimental engine program	1,868,000	6,000,000	10,000,000
Advanced multi-stage compressor program	---	---	500,000
Experimental quiet engine for conventional take off and landing aircraft	949,000	---	---
Flight Experiments	14,593,000	9,280,000	13,650,000
C-8 augmentor wing flight experiment	1,350,000	529,000	350,000
YF-12 flight experiments	5,847,000	5,399,000	5,300,000
Transonic aircraft technology experiments	794,000	1,172,000	800,000

	1973	1974	1975
Flight Experiments (Cont'd)			
Fly-by-wire flight experiment.....	$2,514,000	$1,180,000	$2,200,000
Rotor systems for rotor systems research aircraft.....	---	---	1,800,000
Wake vortex minimization flight research.....	---	---	1,200,000
Composite primary structures flight experiments.....	---	---	1,500,000
Advanced acoustic composite nacelle flight program.....	---	---	500,000
Composite structures flight experiment.....	2,029,000	1,000,000	---
F-8 transport technology flight experiment.....	2,059,000	---	---
Research/Experimental Vehicle Programs.....	6,219,000	10,611,000	19,900,000
Rotor systems research aircraft...	1,614,000	5,266,000	7,100,000
Tilt rotor research aircraft.....	1,637,000	5,345,000	11,300,000
Highly maneuverable aircraft technology flight research program.....	---	---	1,500,000
Quiet experimental STOL transport research airplane.....	2,968,000	---	---
Operating Systems Experiments.....	11,022,000	13,610,000	11,750,000
Noise reduction flight procedures experiments.....	2,924,000	3,143,000	1,200,000
Terminal configured vehicle operating systems experiments...	4,753,000	5,000,000	6,300,000
Short take off and landing (STOL) operating systems experiments...	2,702,000	4,667,000	2,700,000
Vertical take off and landing (VTOL) operating systems experiments.....	643,000	800,000	1,550,000
Total.....	$70,351,000	$80,501,000	$77,500,000

Materials for Advanced Turbine Engines (MATE)

The objective of the MATE program is to accelerate the development of advanced turbine engines by advancing the technology of new materials. The data and capabilities provided by MATE will allow advance materials to be used with confidence in fans, compressors, turbines, combustors and other demanding components of production engines.

A variety of promising and innovative engine materials are available at the laboratory level as a result of research. Approximately seven of these will be selected sequentially during 1975-1978, using systems cost-benefit studies and technology readiness as the bases for selection. The goal of MATE is to demonstrate such improved components as (a) dispersion strengthened alloy turbine vanes with a service lifetime of more than 1,000 hours at 1,100°C (compared to 980°C for present vanes) by 1977, (b) eutectic alloy turbine blades with a 1,050°C capability (100°C beyond the state of the art) by 1977, (c) powder metallurgy turbine disks with a 650°C capability (100°C beyond the state of the art) by 1978, and (d) ceramic turbine vanes with a further increase in capability to 1,350°C by 1980.

Research advances of this nature require engine tests to verify the laboratory scale prediction and to assure economic maintenance free service performance. NASA will contract with engine companies to produce the materials on a pilot scale, characterize them, manufacture experimental engine parts and test them in engine rigs. Final and full-scale testing in experimental engines will then be performed at engine company expense.

Integrated Programs for Aerospace Vehicle Design (IPAD)

The objective of IPAD is to reduce the time required for vehicle design by 50 percent and design costs by 25 percent. Improved performance of future vehicles, which can be translated into fuel economy, will also result because of improved design.

IPAD will be applicable to the design of future commercial and military aircraft and to the design of space vehicles. It will also be useful in system studies to determine where technology improvements will provide the greatest benefits. It is expected that IPAD will find broad use outside the aerospace industry in the design of various types of structures.

The approach is to develop a computer program that will automate most of the design process and integrate the many technical disciplines during design to meet system performance requirements within the constraints imposed by manufacturing, operations, schedules, etc. IPAD will provide the necessary continuity and rapid exchange of engineering information that is required as the design progresses from conceptual design to preliminary design to detail design and into manufacturing. Today's

design engineers spend much of their time preparing and exchanging information. IPAD will automate these functions freeing the engineering staff for technical evaluation and decision making tasks.

Two contracted definition studies for an IPAD system have been completed and are being evaluated by NASA and the aerospace industry during FY 1974. A contract for the development of IPAD will be initiated during FY 1975. The first phase of the program will be completed in December 1977 with delivery of the major components of the system - the executive, the data base manager, and utility programs. The second phase of the program will be a check out of the IPAD system by NASA and major aerospace companies leading to formal release of the program in January 1980.

Active Control Aircraft Flight Experiments

The objective of this new advanced systems technology program is to provide, through flight test, confirmation of integrated design guidelines required for the implementation of active control concepts in future commercial and military aircraft designs. These concepts can permit the design of economically superior aircraft configurations having lower structural weights (up to 20 percent reduction in gross take-off weight) and greater performance capabilities through stability augmentation, maneuver load alleviation, ride quality control, and flutter suppression.

During FY 1975 conceptual design and systems studies will be conducted to definitize quantitative values for the cost of implementation and the realizable payoffs of the various active control concepts. These studies will address conventional aircraft which may be modified to demonstrate the integrated design approach. The results of these studies will be analyzed and the most promising will be advanced to preliminary and final designs in the future. This will be followed by the modification and flight test of a conventional aircraft, demonstrating the resulting high payoffs. High risk concepts which could endanger the pilot and/or aircraft will be evaluated on a scaled, remotely piloted, active control designed research aircraft.

Supersonic Cruise Aircraft Research

The objectives of this program are to provide: (1) an expanded technology base for future military or civil supersonic cruise aircraft, and (2) data required to assess environmental impacts of present and future foreign supersonic cruise aircraft.

Efficient supersonic cruise aircraft require reduced structural weight fractions attainable through the application of advanced concepts, design tools, and relatively new materials. In-depth studies will be continued through FY 1975 to determine the best structural approaches to the aerodynamically efficient arrow-wing configurations. Titanium panel tests

will be continued on the YF-12 in FY 1975 and composite panels will be installed and flight tested on the YF-12 in subsequent years. Ten thousand hours cumulative exposure laboratory tests on sample fiber matrix composites under simulated supersonic flight conditions will be achieved in FY 1975.

The propulsion technology portion of the research program is directed at a reduction of noise levels for take off and landing, a reduction in nitric oxide emissions for high altitude cruise conditions and a reduction in fuel consumption rates to improve the efficiency of supersonic military aircraft and to determine the possibilities for an economically viable supersonic transport. In FY 1975 the noise reduction potential of suppressors for coannular jets for application to duct turbofan cycle engines will be established. Wind tunnel techniques will be developed for the prediction of the effects of forward speed on noise characteristics. The technology for reducing NO_x emissions to 90 percent less than current engines at supersonic cruise altitudes will be verified in FY 1975. An inlet shock stabilization system, which provides improved inlet tolerance to flow disturbances, will be tested in the wind tunnel in 1975 and its operational suitability will be demonstrated by YF-12 flight tests in FY 1976.

In FY 1975 there will be a continuation in the improvement of methods for supersonic cruise aerodynamic design and analysis and for the prediction of critical wing and fuselage design loads. Low speed aerodynamic theories will be validated by FY 1976 and critical design load theory will be verified in subsequent years. Wind tunnel tests of supersonic cruise configuration concepts will be continued.

The stability and controls technology program will provide for the inclusion of major control system advances in supersonic cruise aircraft while at the same time assuring good handling qualities even for cases of partial failure of redundant systems. In FY 1975 YF-12 flight tests of a longitudinal cooperative control system will be conducted to verify and demonstrate the benefits of such systems in an operational environment.

The stratospheric emission impact program which combines laboratory tests, theory, and flight tests will be continued in FY 1975 to provide data to assist the DOT climatic impact assessment program in the assessment of the environmental impact of jet emissions on the stratosphere.

Quiet Propulsive-Lift Technology Program

The quiet propulsive-lift technology program will generate and verify through ground-based and flight research the integrated vehicle and operating systems technology data base for design and certification criteria for practical and efficient quiet propulsive-lift civil and future military short haul transports.

The program includes two major elements: (1) an effort directed to flight research utilizing the straight-wing propulsive-lift Air Force Advanced Medium STOL Transport (AMST) prototype aircraft; and (2) an effort directed to flight research utilizing an existing aircraft modified at low-cost into a swept-wing quiet propulsive-lift research airplane.

NASA will supplement its own flight research with flight research on the AMST military prototype aircraft in order to obtain flight verification of the detailed performance predicted by the ground-based research data generated by NASA. NASA is currently providing support to the AMST development activity and will participate in the Air Force phase of flight evaluation. A NASA Deputy Test Director has been assigned to the AMST program. In 1977 NASA will take the lead for extended flight research with the AMST vehicles. Stability, control, aerodynamic performance and handling qualities will be measured to the limit of the AMST capability.

The quiet propulsive-lift research airplane effort involves low-cost modification of an existing airplane into an aircraft which has greater flight research capability than the AMST aircraft. The aircraft will be modified to an advanced propulsive-lift configuration to obtain stability, control, aerodynamic performance, noise footprint, and handling qualities flight research data.

Parallel aircraft design studies conducted during FY 1974 by Lockheed-Georgia Company and the Boeing Company will provide design, schedule and cost information for selection of the aircraft to be modified. In FY 1975 final design and fabrication of the aircraft modifications including engines would be competitively procured. Flight research on the modified aircraft would begin in FY 1976. By FY 1978 NASA would provide industry and the FAA with data to establish certification criteria for handling qualities, operations, and noise footprint of civil propulsive-lift short haul aircraft.

General Aviation Low-Cost Avionics

Advances in avionic systems technology, properly integrated and applied, offer practical low-cost guidance, control and navigation systems for general aviation aircraft which can enhance the safety and utility of this mode of transportation. An effort to provide this capability will be initiated in FY 1975. Digital electronics stressing the use of integrated circuit technology will be applied to the design of selected control and display system concepts. Component and subsystem breadboards will be assembled and evaluated in laboratory simulations, and software required to integrate these system elements will be defined. In FY 1976 transponder, data link and navigation concepts will be selected and added to the overall laboratory system. In FY 1977, laboratory evaluation of the breadboard system will be completed and an optimized integrated system design initiated. In subsequent years, the breadboard system will be flight tested and results incorporated into the integrated system design to provide criteria and guidance to commercial system developments.

Refan Program

The objective of the refan program is to provide the technology for engine modifications and acoustic treatment to provide a 75 percent reduction in the noise footprint area of 727, 737 and DC-9 aircraft. These aircraft account for about 70 percent of domestic commercial fleet operations. Refanning, if adopted for retrofit use, would have a major impact on the airport community noise problem.

The approach is to develop the technology for engine kits to modify existing or new JT8D engines, to develop acoustic nacelles for the modified engines and to demonstrate the noise and performance levels of a DC-9 airplane in flight and a 727 propulsion system in ground tests.

The program is being conducted by Lewis Research Center through contracts with engine manufacturers, aircraft manufacturers, and airline operators. NASA in-house effort is used to manage the contracted efforts and to support the program through studies and tests in NASA facilities.

The first phase of the program, completed in June 1973, established the refanned engine and nacelle characteristics through analysis, design, and limited component testing. The second phase of the program, which started in July 1973, will include the detailed design and fabrication of the modified engine and acoustic nacelles and testing the complete propulsion systems on the ground and in actual flight. The major program milestones are: tests of the modified engine starting in February 1974, ground tests of the modified engine in a Boeing 727 nacelle in January 1975, and flight tests in a Douglas DC-9 airplane in February 1975. Final technological and cost data will be furnished to FAA and Environmental Protection Agency (EPA) by June 1975 for consideration of rulemaking on engine retrofit and new production aircraft.

Quiet, Clean, Short-Haul Experimental Engine (QCSEE)

The QCSEE program is aimed at consolidating and demonstrating the technology needed for very quiet, clean and efficient propulsion systems for economically viable and environmentally acceptable, powered-lift, short haul aircraft.

Future power-lift, short haul aircraft need quiet, clean, efficient and economical propulsion systems whose technology is not yet available. Demonstrations of component and system interactions in credible, full-scale engines and propulsion installations are needed to establish the data base to stimulate industry development with acceptable risk, and to help government establish environmental and operational requirements. The program is not directed to the development of an engine for flight nor are any flight tests planned as part of the program.

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Following a competitive procurement, the General Electric Company was awarded a contract to design, fabricate, test and deliver two QCSEE propulsion systems. The initial deliverable propulsion system will be an under-the-wing configuration for an externally blown flap powered-lift short haul aircraft. The second propulsion system will be a derivative of the first propulsion system but for an over-the-wing configuration.

The QCSEE design will utilize the existing F101 engine core being developed in the USAF B-1 aircraft development program. This engine core will be mated with specially designed low pressure ratio fans to produce a very high bypass ratio engine of greater than 12 to 1. By comparison, current engines in the wide body jets employ bypass ratios of five or six. The QCSEE design will also include other advanced technology features such as variable pitch gear driven fans, composite fan blades, lightweight integrated nacelle, and integrated electronic controls. The contract is expected to be completed in 56 months.

Preliminary design of the QCSEE propulsion systems has been initiated and will continue throughout the balance of FY 1974 with a layout review to be held at the end of the fiscal year. The contractor will phase into detailed design during FY 1975 and final design reviews for the QCSEE propulsion systems will be completed during FY 1975.

Advanced Multi-Stage Compressor

This program will provide the compressor technology required for advanced turbofan engines which will be required in the advanced subsonic transport of the 1980's. A major goal is demonstrating performance of a 20 to 1 compressor pressure ratio in six stages of a single spool compressor. Achievement of this goal would contribute to reductions of up to 20 percent in commercial aircraft gross weights with significant reductions in fuel consumption and operating costs. The advanced technology embodied in this project is also of benefit to the military sector.

The advanced multi-stage axial flow compressor experimental program is planned for initiation in FY 1975. By late FY 1975 two preliminary designs will be in hand from which a single design will be selected for further refinement. Completion of the final design will take place in early FY 1977 followed by fabrication/assembly late in FY 1977. A year's performance testing, ending in the third quarter of FY 1978, will then follow.

C-8 Augmentor Wing Flight Experiment

Analysis and documentation of the proof-of-concept flight tests of the C-8 augmentor wing research aircraft will be completed in FY 1975, including preliminary assessment of the aircraft's STOL operational characteristics by several U.S. and Canadian pilots. (The aircraft is a joint venture by NASA and the Canadian Government in a cooperative augmentor-wing research

program that has been underway since 1965.) The primary utilization of the aircraft during FY 1975, however, will be for handling qualities and STOL operating systems experiments. The handling qualities experiments, utilizing the aircraft as a representative powered-lift research tool, will define flight-dynamic properties characteristic of most powered-lift concepts. Results will be used to develop methods for simplifying the pilot's control task so as to reduce his workload, improve the precision with which he can perform the approach and landing of this class of aircraft, and minimize fuel utilization during this phase of operation.

YF-12 Flight Experiments

YF-12 aircraft, capable of sustained Mach 3 flight, are used to obtain structures, propulsion system, and aerodynamic flight measurements. When combined with analysis, laboratory tests, and wind tunnel tests, these measurements are used to validate or to identify and quantify deficiencies in current prediction techniques, to provide the basis for improved techniques, and to provide solutions for unknown problems uncovered in supersonic flight.

In the propulsion effort, the results of YF-12 flight tests will be used to compare and evaluate prediction techniques in the areas of supersonic inlet performance, inlet flow dynamics and interactions of engine, inlet, and aircraft control system. The engine has been instrumented to obtain inlet steady state performance measurements which were obtained in FY 1973, dynamic measurements at the compressor face which will be obtained in FY 1974 and FY 1975, and boundary layer measurements in the internal system which will be obtained in FY 1975. The flight and wind tunnel data and theoretical results will be correlated and reported in a propulsion symposium in FY 1976.

Emphasis in FY 1974 was placed on instrumenting a YF-12 aircraft to obtain high speed flight measurements in FY 1974 and FY 1975 of boundary layer transition, noise, heat transfer, and skin friction.

YF-12 aircraft will be used in FY 1975 to conduct flight research oriented directly to the supersonic cruise aircraft research program. Representative lightweight titanium and composite structural panels designed to achieve longtime structural integrity will be evaluated. Flight tests will be initiated to evaluate a longitudinal cooperative control system, part of an overall integrated airframe-propulsion control system designed to reduce the large cruise altitude fluctuations from $\pm$ 4,000 feet to several hundred feet.

Transonic Aircraft Technology (TACT) Experiments

This joint USAF/NASA research effort, initiated June 1971, provides proof-of-concept and design criteria of supercritical airfoil technology for variable wing sweep aircraft in the transonic and supersonic flight regimes. This is being accomplished by analytical studies, wind tunnel tests, and flight tests of an F-111A aircraft equipped with a new supercritical wing.

Supercritical airfoil research has been under way since 1964 with successive refinements in concept. The supercritical airfoil offers significant aerodynamic benefits in the transonic speed regime. Two earlier flight programs verified the benefits of supercritical airfoil technology applied to fixed-wing aircraft.

The TACT program will provide the necessary data to verify the benefits to be achieved at supersonic speeds through the combination of supercritical technology and variable sweep wings, and in particular, the improvements that can be obtained in combat aircraft maneuverability.

The flight test program will continue through FY 1975 and FY 1976 and will culminate with a Government/industry technical symposium.

Fly-By-Wire Flight Experiment

The objective of this continuing experimental program is to demonstrate digital fly-by-wire flight control technology and provide test data and experience required for civil and military applications. Comparative studies have shown that digital fly-by-wire flight control systems incorporating stability and command augmentation functions provide improved flexibility and significant reductions in cost (14 percent), weight (20-70 percent) and volume (44 percent) over conventional control systems having the same functional capabilities.

During FY 1974 the Phase I flight tests of a single channel fly-by-wire system using an Apollo digital computer have demonstrated conceptual feasibility. In Phase IIA, system configurations for a redundant digital fly-by-wire control system are being designed and advanced control laws are being defined and verified in laboratory simulations. This activity will continue in FY 1975 with modifications to the test aircraft and initial flight tests of a dual redundant system with analog backup. In subsequent years, the system will be reconfigured to a fully redundant digital fly-by-wire flight control system and completely tested to demonstrate reliability and the operational flexibility of this technology.

Rotor Systems for Rotor Systems Research Aircraft (RSRA)

The expanding role of the helicopter for a wide variety of military and civil applications has generated requirements which exceed the current rotary wing technological state of the art. The more promising of several advanced rotor system concepts must be flight tested to establish and demonstrate their technological improvements for enhancing the proven effectiveness of the helicopter. Recognizing the need, NASA and the U.S. Army in another program are jointly developing two rotor systems research aircraft (RSRA), scheduled for delivery to Langley in 1976. The RSRA will provide a generalized flight test facility with unique capability for investigating complete rotor systems in the real flight environment over much broader operational envelopes than now possible.

This program request beginning in FY 1975 is to provide for utilization of the RSRA by conducting the necessary study, selection, design, development, and flight evaluation of promising advanced rotor concepts on the RSRA. The initial two rotor concepts will be selected in FY 1975. Development of the first rotor system will be initiated during FY 1975 to be ready for flight test by mid FY 1977. The second research rotor system will be developed for flight test readiness by early FY 1978, and a third system by FY 1979.

New technology concepts which are promising candidates for development in experimental rotor system test articles for the RSRA include: (1) the areo/acoustic rotor having reduced external acoustic noise and increased cruise lift over drag ratio; (2) the variable geometry rotor having reduced external acoustic noise and rotor vibration and increased hover efficiency; (3) the composite structures rotor having reduced rotor system weight; (4) the variable diameter rotor having increased cruise speed; (5) and the controllable twist rotor having increased cruise lift over drag ratio cruise speed, hover efficiency and reduced rotor vibration. The performance potential of each concept developed for the RSRA will be thoroughly evaluated both in flight and analytically, with strong emphasis given also to energy efficiency, noise, vibration, dynamic loads, reliability, maintainability, and ultimate overall operating cost.

Wake Vortex Minimization Flight Research

The wake vortex flight research program involves the development of a flight research capability for demonstrating in flight aerodynamic methods which will reduce the landing and take off separation distance imposed by wake vortices generated by large jet transports on trailing aircraft from the present 3-5 miles to 2 miles without significant detrimental effects on aircraft performance. The DOT, the Air Transport Association, and other concerned professional groups have identified the wake turbulence hazard as the air transport industry's number one operational problem. Aside from the obvious

safety hazard, the reduced runway utilization rate due to the large separation distances imposed by the vortex hazard directly increases departure and arrival ground taxi times and arrival holding-at-altitude delays which significantly increases jet fuel consumption.

Candidate vortex minimization devices will be selected in late FY 1974 from among the most promising devices developed in the on-going ground facility experimental program. In early FY 1975 a suitable, moderate size, transport-like aircraft which can be economically modified to accommodate the dissipation devices will be selected for use as a wake vortex generator aircraft.

Initially, a currently available instrumented probe aircraft will be used to penetrate the vortex at various distances behind the generator aircraft and document the structure of the trailing vortices and the integrated upsetting forces with and without the modifications.

Modifications of the transport-like generator aircraft and instrumentation of the probe aircraft are scheduled for completion August-September 1974. Initial flight tests will begin subsequently and continue through mid-FY 1976. As promising dissipating devices suitable for commercial application are developed in these flight tests, they will be further refined and consideration given to later installation on a commercial wide-body jet transport for final evaluation.

Composite Primary Structures Flight Experiments

The major goals of the composite primary structures technology program are to demonstrate weight savings in aircraft structures and to develop confidence in the future use of composite materials by flight service experience. These goals will be achieved through a current flight program aimed at demonstrating the advantages of selective composite reinforcement of metal structures, and a program to be initiated in FY 1975 to develop and demonstrate all-composite construction applied to primary aircraft structures.

Advanced transport technology studies have projected significant performance and economic benefits from the use of composite materials in primary structure of commercial airline aircraft. An overall weight saving of more than 25 percent is predicted which would increase return on investment (ROI) by 20 percent. Similar benefits could be achieved in STOL and supersonic cruise aircraft. At present, designers and manufacturers lack the confidence required to depart from conventional metallic structures and commit to extensive use of composites in primary structures. These composite primary structure, flight experience programs will be a major extension of the existing all-composite secondary structures program. It will establish the confidence through demonstrated performance necessary to achieve full benefit of composite structures in future aircraft.

Selective composite reinforcement is currently being applied to the center wing box of the C-130 Air Force transport airplane. Two current production aircraft are being modified to incorporate reinforced boxes with a weight saving of 11 percent. Regular military flight service and evaluation of the boxes is scheduled to begin during FY 1975 and will be conducted for a minimum of three years.

An added program to incorporate all-composite construction in aircraft primary structures and demonstrate a 25 percent weight saving will be initiated in FY 1975.

Two different primary structural components will be selected from existing commercial transport aircraft for redesign and fabrication using composites instead of metal. These will include a vertical fin and a large component such as a wing panel. The components will be tested, certified, and placed in flight service for a period of three years, accumulating approximately 9,000 hours of service experience per installation.

Advanced Acoustic Composite Nacelle Program

The objective of the advanced acoustic composite nacelle program is to provide technology for future production wide-body transports that can either reduce their fuel consumption at current noise levels, or can achieve a reduction in noise footprint area of about 30 percent with no increase in operating cost or fuel consumption. The program will demonstrate the application of advanced interwoven acoustic absorbent and composite structural materials to a wide-body transport nacelle. Application of this technology to future advanced technology transports can either reduce aircraft weight and fuel consumption simultaneously with some noise reduction, or can result in noise reduction with no increase in operating cost or fuel consumption.

Current nacelle noise suppression technology involves the addition of non-load carrying acoustic absorbent materials to the nacelle structure. The advanced acoustic composite technology involves interweaving of acoustic absorbent and composite materials to form an acoustic absorbent structural material. In this manner the structural material provides noise suppression. Laboratory studies of the interwoven technique indicate about 15db reduction in sound intensity as compared to an equivalent weight current technology quieted structure.

Conceptual design studies for the nacelle were initiated in FY 1974 and preliminary design will be completed in FY 1975. Ground tests will be completed in FY 1979 leading to possible later flight demonstration.

Rotor Systems Research Aircraft

This joint Army/NASA program will provide a unique flight test capability for advanced rotor research to expedite and improve rotorcraft research through the use of a specially designed flight test vehicle.

Extensive onboard instrumentation will provide better research data, and repeated use of the test vehicle will enable timely and economical completion of rotor research projects.

Currently, flight tests of promising advanced rotor concepts are conducted by modifying existing aircraft or by building a new aircraft for each concept. This approach is time consuming, costly, and often gives less than good results.

NASA and Army in-house and contractor predesign studies were conducted in early FY 1973 to establish the feasibility of an advanced research vehicle capable of testing a wide variety of advanced rotor systems concepts, and to define the characteristics of and requirements for the flight vehicle, the flight test control system, and the research instrumentation systems. A request for proposals was issued in March 1973 and following the evaluation of competing proposals, the Sikorsky Aircraft Company was selected to perform the design and fabrication of two research aircraft. A contract was awarded to Sikorsky on November 6, 1973. The first sixty days of the contract is a fixed-cost planning effort. Detail design and component fabrication began in January 1974. Design and fabrication will continue through FY 1975. First flight is scheduled for mid-FY 1976.

Tilt Rotor Research Aircraft

This joint Army/NASA program will demonstrate and provide proof-of-concept evaluation of the tilt rotor concept. Conceptually, the tilt rotor combines the best characteristics of the helicopter with the good cruise characteristics of fixed-wing aircraft.

The low downwash and low noise inherent in rotors provide valuable benefits for military rescue missions and ground attack missions where short detection time is important to survival in a hostile arena. For civil applications, the efficient VTOL capability will permit operations at small airfields and close-in populated areas to provide an efficient transportation system. The tilt rotor VTOL capability eliminates the need for taxiing and maneuvering on the ground and the attendant use of valuable fuel. The inherent efficiency of the rotors acting as propellers in cruise can provide an effective, fuel saving, public transport system for short and intermediate ranges.

The tilt rotor research aircraft will have twice the cruise speed of the helicopter while retaining its efficient hover capability.

Based on in-house studies and analyses by NASA/Army engineers, it has been concluded that the tilt rotor concept shows the greatest promise for a capability to meet military and civil V/STOL needs anticipated in the future.

For the past twenty years, the Army, Air Force, NASA, and industry have been pursuing the establishment of a tilt rotor technology base. The next step requires flight test in the real and dynamic environment of flight.

A preliminary design competition was conducted in early FY 1973 and proposals for the design and fabrication of two research aircraft were received in January 1973. Following evaluation of the competing proposals, Bell Helicopter Company was selected and awarded a contract for the design and fabrication of two tilt rotor research aircraft on July 30, 1973. A fixed cost 60-day planning effort was completed on September 26, 1973, at which time initiation of detail design and component fabrication was approved. The principal design effort will be completed in the first quarter of FY 1975. Material procurement and manufacturing will be carried on through FY 1975. First flight is scheduled for late FY 1976.

Highly Maneuverable Aircraft Technology (HiMAT) Flight Research

The objective of this program is to provide low-cost flight research vehicles by 1978 to promote and stimulate the application of new high risk (laboratory) technology in a multidisciplinary manner to exploit the potential of new technology for the design of future military combat vehicles. Reductions in the cost of the experimental flight tests to explore the new technology of approximately 50 percent over comparable manned test vehicles will be realized through flight test of subscale vehicles utilizing the relatively new remotely piloted research vehicle (RPRV) test technique.

In a recent study conducted under the auspices of the Aeronautics Panel of the DOD/NASA Aeronautics and Astronautics Coordinating Board (AACB), it was concluded that "substantial improvements will be needed for advanced fighters in the 1980's." The NASA HiMAT program is designed to respond to the identified needs by maturing through testing in the real and dynamic environment of flight, the most promising high risk advanced technology concepts to an application readiness state for potential incorporation in fighter aircraft in the 1980's. Also, the interaction of the various advanced technology concepts will be investigated so the synergistic potential inherent in a multidisciplinary design approach can be exploited to the highest practicable degree.

Design feasibility studies were completed in August 1973 in which nine contractors explored the potential for achieving significant improvements in maneuvering capability using the above described design approach. Based on the encouraging results of the feasibility studies, follow-on conceptual design studies are being conducted in FY 1974 by three firms.

In FY 1975, one of the three firms participating in the conceptual design studies will be selected to carry his configuration into final design and then to fabricate two subscale RPRV's which will be tested at NASA's Flight Research Center.

Noise Reduction Flight Procedures Experiments

The program objective is to reduce the approach noise footprint (by at least 60 percent) through scheduled airline demonstrations of avionic systems for noise abatement flight procedures.

In FY 1974 a successful in-service evaluation of the two seqment approach with a B-727 was completed by United Air Lines. Over 40,000 passengers were carried, 555 two segment approaches were made, and 38 United flight crews participated. The two segment approaches were accepted by the pilots and air traffic controllers, and unnoticed by the passengers. Test data confirmed the expected approach path noise reduction. In addition to reducing the approach noise footprint of aircraft, the flight procedures developed may well result in fuel savings from the reduced fuel flow during the steeper segment of the two segment approach. Fuel flow is reduced by approximately 1,000 pounds/hour per engine. Thus in a three engine aircraft there is a savings of 67 pounds (10 gallons) per approach. Assuming approximately five million air carrier landings per year, this represents an annual fuel savings of 50 million gallons.

An in-service evaluation of the two segment approach with a DC-8 will commence late in FY 1974 and will be completed in FY 1975. The DC-8 is a more challenging aircraft than the B-727 because of its cleaner aerodynamic characteristics, and different equipment will be used for providing guidance on the upper segment of the two segment approach.

Analysis of the applicability of the two segment approach to other aircraft in the fleet will be completed in FY 1974 for the DC-9, DC-10, B-707, B-737, and B-747. Analysis of the L-1011 will be completed in FY 1975. There is no plan to conduct flight evaluations beyond those with the B-727 and DC-8.

The potential of other operating techniques for reducing aerodynamic and propulsion noise on approach and landing will be investigated, starting in FY 1975. Limited tests with the CV-990 will provide noise and operating procedures data for a simulation program and noise impact assessment. Promising operating procedures will be verified in flight during FY 1976.

Terminal Configured Vehicle Operating Systems Experiments

The broad objectives of the program are to provide improvements in the airborne systems (avionics and air vehicle) and operational flight procedures in order to reduce noise, to improve terminal area productivity (with emphasis on energy conservation), and to improve approach and landing flight safety. This program is being conducted to be responsive to the national needs for an efficient, safe, and economical air transportation system which will meet with community acceptance.

To improve productivity and safety, a zero visibility landing capability will be provided by improved precision automatic control, primary displays, and an independent landing monitoring system. Increased airport acceptance rates will be made possible by improved arrival accuracy for close longitudinal spacing, improved flight path control for closer lateral spacing, and reduced runway occupancy time. Improved flight deck design, better understanding of crew coordination and individual tasks, and automation will reduce pilot workload.

To reduce adverse environmental impact, operational procedures, displays, and guidance equipment will be developed to reduce atmospheric pollution, permit fuel savings, and reduce noise.

The program is primarily concerned with airborne elements which will be needed for operations in high density terminal areas equipped with new landing systems and navigation aids under development by the FAA. Emphasis will be placed on the development of operational methods for the highly automated environment anticipated in the future. The program involves research analysis, simulation, and flight studies. In FY 1974 a Boeing 737 airplane is being equipped with highly flexibile display and control equipment and an aft flight deck for research purposes. Late in FY 1974 and in FY 1975 simulation and flight experiments will be conducted in precision flight path control with accurate arrival times and in very low visibility conditions. Later, operational feasibility demonstrations will be conducted to gain acceptance by flight crews and the airlines.

STOL Operating Systems Experiments

The broad objective of the program is to establish a technology base upon which operational STOL short haul systems can be based with confidence in the 1978-2000 time period. Benefits which will be demonstrated include a 90 EPNdB noise footprint within the airport boundary, a zero visibility landing capability, improved guidance accuracy, and pilot workload reduction of 30 percent through automation and displays.

In this joint DOT/NASA program, operating systems experiments will be conducted to provide information to aid in the choice of STOL terminal area guidance, navigation and control system concepts, and to define operational procedures. Steep ascents, descents, tight turns, and slow speed approaches and landings will be studied using analysis, simulation and flight tests. Flight paths for STOL operations independent of conventional aircraft operations will be synthesized in FY 1975. An integrated digital avionics research system (STOLAND) became available in FY 1974 for use in both simulation and flight experiments. This system will be installed in the DHC-6 Twin Otter for flight experiments commencing in July 1974 and in the C-8A augmentor wing research aircraft for flight experiments commencing in December 1974.

Introduction of the microwave landing system (MLS), now under development by the FAA, will provide improved terminal area landing guidance. The MLS will be used by CTOL, STOL, and VTOL aircraft. Consequently, one task to be accomplished in this program is to support the FAA in the development of the MLS to ensure its suitability for STOL applications. Analysis, field investigations, and flight experiments will be conducted to define realistic criteria for MLS proof-of-concept evaluation and prototype validations beginning in FY 1975. The field investigations will include ground and flight tests with the programmable STOLAND avionics system. These investigations will emphasize MLS performance for terminal area navigation and approach and landing guidance for low visibility operations. Flight validation of a prototype system will be completed in FY 1976.

VTOL Operating Systems Experiments

The broad objective of the program is to establish a technology base leading to improved VTOL operating efficiency, especially in low visibility conditions, and decreased environmental impact. Benefits which will be demonstrated include reduction of the 90 EPNdB footprint to less than 0.6 square mile, zero visibility landing capability in crosswinds up to 20 knots, improved guidance accuracy and a 50 percent reduction in pilot workload.

Effective use of VTOL aircraft in the National Air Transportation System will require extensive automation to permit operation under conditions of poor visibility and to permit operation along flight paths that minimize noise, airspace, pilot workload, and fuel usage. Studies will be conducted to define automation requirements and to develop satisfactory pilot/vehicle interfaces that allow the pilot to monitor, interact with, and take over from the automatic control in vehicles characterized by controlled degrees-of-freedom that are more complex than for STOL or CTOL aircraft. Also, in order to maximize the potential of VTOL aircraft for relieving air and ground congestion, an efficient and safe interface between VTOL and other traffic must be developed.

This program is being conducted jointly by Ames Research Center (ARC) and Langley Research Center (LaRC). Experiments conducted at ARC will focus on nonrotary wing VTOL aircraft, and experiments conducted at LaRC will focus primarily on rotary wing VTOL aircraft or helicopters. An integrated digital avionics system with the flexibility to be used for both simulation and flight experiments is being provided by ARC and will be completed in FY 1975. Piloting procedures and system performance characteristics will be investigated with simulations during FY 1975. Various automatic and manual control modes, and descent and landing flight paths including time constraints, noise considerations, winds and other disturbances when using the MLS terminal guidance will be evaluated. Installation of the avionics system in the tilt rotor research aircraft will be initiated in FY 1976. VTOL IFR approach paths in the presence of a realistic terminal area environment will be demonstrated in FY 1977. At LaRC, analysis, simulation, and flight experiments using helicopters are underway. The automatic approach studies which resulted in the automatic landings with the CH-46 in March 1972 will be expanded to include automated curved approaches in FY 1975, and automatic time sequenced control for minimization of airspace needs and optimization of aircraft spacing in FY 1977. Advanced integrated display concepts will be investigated commencing in FY 1975 resulting in an advanced automatic approach display in FY 1976. Investigation of helicopter/air traffic control interface requirements will be conducted in FY 1975.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1975 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

SPACE AND NUCLEAR RESEARCH AND TECHNOLOGY PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1973	1974	1975
Research and technology base....	$55,510,000	$60,907,000	$61,500,000
Systems and design studies.....	1,230,000	1,300,000	1,600,000
Systems and experimental program	8,020,000	3,693,000	6,700,000
Low cost systems program.....	---	3,100,000	5,000,000
Nuclear power and propulsion program.....	17,100,000 1/	---	---
Total.....	$81,860,000	$69,000,000	$74,800,000
Distribution of Program Amount by Installation:			
Johnson Space Center.....	$318,000	$565,000	$765,000
Marshall Space Flight Center..	2,655,000	2,890,000	3,401,000
Goddard Space Flight Center...	3,761,000	5,109,000	5,222,000
Jet Propulsion Laboratory.....	17,297,000	14,585,000	15,662,000
Ames Research Center.....	7,353,000	7,060,000	7,525,000
Flight Research Center.....	1,422,000	1,078,000	1,128,000
Langley Research Center.....	14,953,000	13,656,000	15,920,000
Lewis Research Center.....	29,321,000	22,146,000	23,266,000
Headquarters.....	4,780,000	1,911,000	1,911,000
Total.....	$81,860,000	$69,000,000	$74,800,000

HIGHLIGHTS OF BUDGET PLAN

Research and Technology Base

Materials - Basic and applied research studies aimed at increasing the long life performance and reliability of materials in the space environment. Thermal protection systems effort formerly under Entry Technology funded here in FY 1975.	$6,899,000	$6,200,000	$9,122,000

1/ Authorized in P.L. 92-304 as Nuclear Power and Propulsion.

	1973	1974	1975
Structures - Development of advanced structural concepts and structural dynamics technology, including thermal protection system and deployable space structures.....	$5,912,000	$5,400,000	$5,400,000
Fundamental Electronics - Basic technology for advanced information systems and electronic devices including fabrication techniques for reliable and economic electronic systems.....	4,465,000	4,800,000	4,800,000
Space Guidance and Control - Advance techniques and technology in guidance and navigation and control for low cost missions operations.....	2,232,000	1,900,000	1,900,000
Information Systems - Derivation of components, systems, and techniques needed for gathering, processing, transmitting and reducing data from planetary and earth orbiting spacecraft.....	6,589,000	6,736,000	6,800,000
Chemical Propulsion - Development of energy systems for long-life satellites, spacecraft, and difficult space missions by focusing on reusable hydrogen-oxygen systems, space storable and low cost solid stages.....	7,180,000	7,300,000	7,300,000
Electric Propulsion - Improve capability of long-life interplanetary and near earth space missions by developmental research in the areas of solar electric, ion, and plasma propulsion and related systems.....	2,848,000	4,900,000	4,900,000

	1973	1974	1975
Energy Systems - Reduce costs of power systems through technological advances as well as standardization and improved operating procedures involving solar cells and arrays, electrochemical cells and batteries, power processing parts and circuits, thermomechanical engines and new systems concepts.....	$8,558,000	$8,200,000	$8,200,000
Nuclear Energy - Development of reactor power systems technology applicable to space and terrestial power generation and space propulsion emphasizing practicality and cost effectiveness.....	---	2,200,000	2,200,000
High Power Lasers and Energetics - Basic research and experimental engineering in power generation, conversion and transmission to provide basis for future capabilities in space as well as support effort to meet long-range energy needs on earth.....	883,000	4,535,000	5,000,000
Entry - Aerothermodynamic effort for solutions to the problems of high-speed entry and flight of spacecraft in atmospheres of earth and other planets. Research in thermal protection systems included under Materials Research and Technology in FY 1975.....	9,944,000	8,736,000	5,878,000
Total, Research and Technology Base.....	$55,510,000	$60,907,000	$61,500,000
Systems and Design Studies			
Analysis and study to identify technology requirements for focusing technology programs and identification of new areas of opportunity.....	1,230,000	1,300,000	1,600,000
Total, Systems and Design Studies.....	$1,230,000	$1,300,000	$1,600,000

	1973	1974	1975
Systems and Experimental Program			
Advanced Systems Technology			
Energy and Environmental Systems Technology - The application of NASA research and technology capability to reduce the fuel consumption and pollution attributable to stationary and mobile power systems	$1,987,000	$2,528,000	$2,900,000
Solid State Data Storage System - To demonstrate the superior reliability and versatility of a solid state data recorder using magnetic bubble domain technology.....	---	---	800,000
Subtotal, Advanced Systems Technology.....	1,987,000	2,528,000	3,700,000
Flight Experiment Programs			
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.....	993,000	1,050,000	1,000,000
Subtotal, Flight Experiment Programs.....	993,000	1,050,000	1,000,000
Spacecraft/Payload Programs			
Space Technology Shuttle Payloads - To exploit the Shuttle-Spacelab opportunity to conduct innovative research and technology in the space environment...	---	---	2,000,000
Meteoroid Technology Satellite - Completed in FY 1974..	154,000	41,000	---
Space Plasma High Voltage Interaction Experiment - Completed in FY 1974.....	$593,000	$74,000	---

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	1973	1974	1975
Electric Auxiliary Propulsion - Ion thrusters and pulsed plasma thrusters, funded under the space propulsion program starting in FY 1974	690,000	---	---
Space Storable Propulsion - Space storable propulsion technology program funded under the space propulsion program starting in FY 1974	1,200,000	---	---
Subtotal, Spacecraft/Payload Programs	2,637,000	115,000	$2,000,000
Transportation Programs			
Solid Rocket Motors - Solid rocket motor technology program funded under the space propulsion program starting in FY 1974	1,572,000	---	---
Solar Electric Propulsion - Solar array-powered ion engine system funded under the space propulsion program starting in FY 1974	831,000	---	---
Subtotal, Transportation Programs	2,403,000	---	---
Total, Systems and Experimental Program	$8,020,000	$3,693,000	$6,700,000
Low Cost Systems Program			
Focuses on reducing the overall costs of space systems or a standardization of components and systems and improvement of business and programmatic practices	---	3,100,000	5,000,000
Total, Low Cost Systems Program	---	$3,100,000	$5,000,000
Nuclear Power and Propulsion Program	$17,100,000 1/	---	---

1/ Authorized in P.L. 92-304 as Nuclear Power and Propulsion.

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

SPACE AND NUCLEAR RESEARCH AND TECHNOLOGY PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The FY 1975 Space and Nuclear Research and Technology program is directed at providing a technology base which will adequately support current and future space activities and at the application of technology to civil energy needs. The program concentrates on advancements in the engineering sciences and technologies used in systems required to transport, protect, power, control and communicate with the spacecraft and scientific instruments needed to achieve the objectives of current and future NASA space missions.

The economical and efficient exploitation of space is the objective of several technology development efforts. The technology is being developed for low-cost, highly reliable, high performance electronic components and systems used for guidance and control, and for storing, transmitting, and analyzing massive amounts of data in the most economical manner. Materials and structures research is being conducted to develop highly efficient, low-cost structures for advanced spacecraft and for propulsion and power systems. The FY 1975 program includes a new initiative to define experiments and to integrate them into payloads to best exploit the opportunity offered by the Shuttle-Sortie Laboratory.

Whereas the advent of the shuttle transportation system allows a trade off to be made between performance, weight, and cost for operations in earth orbit, performance and weight of spacecraft systems are still at a premium in missions to the planets. The program is directed at providing the technology requirements for such missions. High performance, long duration, chemical and electric propulsion system technology is being developed. The technology is being developed for low cost, highly reliable, long-life nuclear and non-nuclear power systems for spacecraft. Research is being conducted to develop aerothermodynamics and heat protection technology to improve spacecraft design for both planetary and earth orbital missions.

Meeting civil energy needs through the application of technology in power and propulsion to the problems of energy conversion, conservation, storage, and transmission is an important objective of the program. Technology is also being applied to the problem of local pollution detection and monitoring.

The nuclear part of the Space and Nuclear Research and Technology program has been expanded from the nuclear effort proposed in FY 1974. The electrophysics program has been incorporated into the high power lasers and energetics program. An expanded program for reducing the cost of isotope power systems and increasing the efficiency of thermomechanical engines for nuclear power is

included in the energy systems program. The nuclear energy program is directed at developing reactor power systems technology applicable to space propulsion and to both space and terrestrial power generation while emphasizing practicality and cost effectiveness.

The low cost systems program initiated in FY 1974 addresses the reduction of overall systems cost through the standardization of space equipment and improvements of program and business practices.

BASIS OF FUND REQUIREMENTS:

Research and Technology Base

	1973	1974	1975
Materials research and technology	$6,899,000	$6,200,000	$9,122,000
Structures research and technology	5,912,000	5,400,000	5,400,000
Fundamental electronics research and technology	4,465,000	4,800,000	4,800,000
Space guidance and control research and technology	2,232,000	1,900,000	1,900,000
Information systems research and technology	6,589,000	6,736,000	6,800,000
Chemical propulsion research and technology	7,180,000	7,300,000	7,300,000
Electric propulsion research and technology	2,848,000	4,900,000	4,900,000
Energy systems research and technology	8,558,000	8,200,000	8,200,000
Nuclear energy research and technology	---	2,200,000	2,200,000
High power lasers and energetics research and technology	883,000	4,535,000	5,000,000
Entry research and technology	9,944,000	8,736,000	5,878,000
Total	$55,510,000	$60,907,000	$61,500,000

Amounts included for Nuclear Research and Technology by discipline:

Energy systems research and technology		$1,800,000	$1,800,000
Nuclear energy research and technology		2,200,000	2,200,000
High power laser and energetics research and technology		3,000,000	3,000,000
Total		$7,000,000	$7,000,000

Materials Research and Technology

Space materials research and technology spans a spectrum from basic materials science to more directed programs to provide efficient, stable, long-lived materials for the structures, propulsion systems, entry bodies, and electronic equipment for future advanced spacecraft.

The area of materials science is focused on understanding the relationships between chemical structure and physical properties of materials and applying this knowledge to the synthesis of new and improved materials. The mechanisms by which metals are embrittled by gases and liquids will be investigated so that failures can be controlled. The fundamental materials parameters which influence friction and wear will be established, thereby providing guidance for synthesizing new and improved bearings, seals, and lubricants. The basic relationships between the electronic and defect structures of semiconductors will be determined for such purposes as increasing the efficiency of Gallium Arsenide solar cells from 13 to 20 percent by 1976. Various theories for increasing superconducting temperatures from 20°K to above 40°K with the potential for revolutionary advances in power distribution and entirely new reentry concepts will be investigated.

Materials research and technology will continue to provide in FY 1975 improved, reliable, thermal protection systems (TPS) for the space shuttle, advanced earth orbital spacecraft and planetary probes. Reusable surface insulations and leading edge materials will be evaluated in unique arc-jet tunnels in support of the shuttle program. The effects of gaps, joints, and defects on these thermal protection systems will also be evaluated and solutions to any problems will be proposed. Lighter weight and lower cost TPS materials for advanced earth orbiting spacecraft will receive increased attention. Research will be carried out on heat shield materials and simulation facilities for planetary probe designs for missions to Venus, Saturn, Uranus, and Jupiter.

Materials technology in support of space transportation systems includes high temperature and cryogenic insulations, lubricants, and optical materials. In FY 1975 the use of improved graphitic materials in self-acting life-pad seals to extend the capability of 500 psi LOX sealing systems from single start to 100 starts for reusable spacecraft propulsion units will be evaluated. The degradation mechanisms in high energy window materials which are transparent to laser beams will be identified and a program to produce degradation resistant materials will be defined. The utility of a chemical vapor deposition technique for bonding aluminum to graphite fibers will also be evaluated for metal matrix composite applications.

The area on control of environmental effects is focused on thermal control, space debris, and optical contamination. During FY 1975 the synthesis of a

white thermal control coating having a three-fold increase over the current one-year space stable lifetime will be completed. Research will continue to demonstrate, through laboratory tests, second surface mirrors with a minimum three-year lifetime in interplanetary or synchronous orbit and a cost half of that of optical solar reflectors. Work to establish the performance capability of cryogenic heat pipes in zero G for infrared detector cooling in the range of 77 to 150°K will be initiated. The nature and extent of near-earth, man-made debris will be evaluated using ground-based facilities. Contamination of optical surfaces will continue to be of concern because of its effects on space experimentation. Contaminant sources and reactivities with surfaces will be determined and assessment of cleaning procedures will be made.

Structures Research and Technology

The objectives of the space structures R&T program embrace advanced space structures, space vehicle dynamics, and vehicle design methods. These objectives involve the enhancement of structural concepts, advances in analytical and experimental techniques, and expansion of design methods, all of which are needed for near-term and advanced space systems to improve efficiency and reliability, reduce cost, and demonstrate feasibility for design applications.

In advanced space structures, new approaches are being developed to improve the operational effectiveness of future space systems through the creation of new concepts for expandable structures. Investigations of concepts for large furlable antennas will culminate in FY 1975 with fabrication of a 15-foot diameter scale model for laboratory tests to confirm feasibility for potential application to much larger antennas. Concepts for other large erectables for energy collection and transmission will also be explored. Another important aspect involves the exploitation of composites for major structural systems. Composite pressure vessels are being investigated, and weight savings of more than 20% with overwrapped vessels will be demonstrated in FY 1975; efforts will continue on all-composite vessels with potential for much greater weight savings. Lightweight composite primary structures needed for future systems like the space tug will also be explored.

The objective in space vehicle dynamics is focused on verifying dynamic and aeroelastic technology needed by the shuttle development team for vehicle design and qualification and reducing the cost of future space systems through improvement of spacecraft payload acoustic and vibration analysis and test methods. Shuttle dynamics and aeroelasticity development will be supported in FY 1975 by wind tunnel investigations of buffet, flutter, aerodynamic noise, and other critical conditions. In addition, preliminary vibration characteristics of the shuttle will be determined by 1/8-scale model tests, response to TPS panels to thermal-acoustic environments will be investigated, and a flowmeter will be demonstrated for application to POGO

(a dynamic stability of the vehicle involving coupling of engine thrust perturbations with the structure and propellent system) suppression systems. The payload dynamics program will be expanded in FY 1975 leading to improved approaches for spacecraft vibration qualification programs which will permit lower development costs for future systems.

In vehicle design methods, shuttle thermal protection systems development will be supported in FY 1975 by tests in the 8-Foot High Temperature Structures Tunnel and the new Thermal Protection System Test Facility to provide critical data on the capability of these systems. Other vehicle design activities will focus on providing advanced automated analysis and design methods, fracture control and life prediction procedures, and experimental data to confirm the validity of the analytical techniques. The reliability and efficiency of future long-life, weight-critical space transportation systems, such as the Tug, will depend on the availability of these advanced methods for structural design and evaluation.

Fundamental Electronics Research and Technology

Research in fundamental electronics provides the basic technology in advanced information systems, electronic devices and fabrication techniques necessary to the design and synthesis of functional electronic systems with improved economy and reliability.

In the advanced information systems area, techniques for integrating sensors and control devices with problem-solving logic systems which approximate rudimentary cognitive processes are being established to circumvent time delays encountered in planetary surface exploration (45 minutes round trip to Mars) and extend man's capability to operate in hostile environments. During FY 1974, subsystems and integrating software for a robot roving vehicle are being developed and tested at Jet Propulsion Laboratory. In FY 1975 these hardware and software elements will be assembled and operated in a tethered, laboratory environment to evaluate performance and define characteristics of autonomous machine operations.

In the area of electronic devices, the electronic properties of materials are being exploited to provide more effective and economical devices for the detection, storage and processing of information. During FY 1974, liquid crystal and light emitting diode (LED) arrays are being developed to provide flat panel cockpit displays. In FY 1975, operating displays will be evaluated in laboratory and flight tests. Research on data storage devices includes studies of charge coupled devices (CCDs) for high speed memories, organic materials for 10^{12} bit optical mass memories and development of a 10^5 bit magnetic bubble chip for solid state data storage. In FY 1975, laboratory models of the CCD and optical memories will be fabricated and evaulated. Materials and infrared CCD imagers are being investigated in FY 1974 to permit design of a feasibility model in subsequent years. Participation with DOD in the Advisory Group on Electron Devices enhances coordination of these activities.

In the circuit fabrication area, techniques for achieving predictable long reliable operating lives are being developed. Research on processing parameters, failure mechanisms and construction characteristics is being pursued in FY 1974 to provide standards and specifications for the acquisition of cost effective, reliable integrated circuits. Automated techniques for the design, processing and testing of integrated circuits are being developed to increase yield and reliability. In FY 1975, this work will continue with emphasis on semiconductors-on-substrate (SOS) technology as the next family of circuits to be used in aerospace applications.

Space Guidance and Control Research and Technology

Location and orientation of space vehicles and experiments are critical to successful mission operations. The objective of this program is to provide guidance, navigation and control technology which will permit reductions in vehicle or mission costs up to 50% while maintaining or improving performance standards.

In the area of low cost guidance and control, novel concepts which offer improved performance, yet provide major cost saving potential receive primary emphasis. During FY 1974, a prototype all-sky pointing system using low cost sounding rocket hardware, which can aim instruments at any predetermined point in the sky using the positions of selected stars as a reference is being assembled for gound testing; modifications to laser gyro inertial navigation systems are being studied to increase their accuracy and operating life; long-lifetime motors and bearings are being developed to improve stabilization system lifetimes; and an extended life attitude control system for planetary spacecraft is being developed. In FY 1975, design guidelines for the all-sky pointer will be developed; flight test of a laser gyro inertial system will begin; and tests of subelements in the extended life attitude control system will be conducted.

Advanced navigation techniques using improved ground-computer position estimates and onboard measurements are needed to minimize propellent requirements, increase mission pointing accuracy and lower operational costs of planetary exploration. During FY 1974, advanced mathematical filtering and modeling techniques for predicting spacecraft position will be developed and evaluated. Onboard sensors will be tested and integrated models designed which combine onboard and ground-based tracking data. During FY 1975, data from the S-X band experiment on Mariner Venus/Mars 73 will be analyzed to verify filter and modeling techniques. Approach guidance concepts using in-flight measurements to provide 5 seconds of arc measurement accuracies on outer planet missions will be derived and validated.

Information Systems Research and Technology

Emphasis in the information systems program centers on the derivation of components, systems and techniques needed for gathering, processing, transmitting and reducing data from planetary and earth orbiting spacecraft.

Lasers and optical components are being developed to provide high rate data transfer and improve satellite tracking accuracy. During FY 1974, lasers and detectors to provide a 400 megabit transfer link are being developed; balloon flight tests to assess atmospheric turbulence effects on optical links have been conducted; and techniques for measuring the location of pulses in laser ranging systems evaluated. In FY 1975, laboratory evaluation of elements in the 400 megabit CO_2 laser data link will begin; a 1.2 meter ground telescope will be completed; and a high efficiency (5%) detector for laser tracking will be tested.

Microwave techniques and components are being developed for multiple missions, both planetary and earth orbital, to provide greater operational flexibility, reduce spacecraft development time and minimize cost. During FY 1974, a modular solid state transponder is being designed and breadboarded, Ku-band receivers and transmitters are being fabricated, and highly efficient power amplifiers for aerospace applications are being designed. These activities will continue in FY 1975. Efforts to effect improvements in the efficiency of high frequency transmitters will be pursued and optimized coding techniques studied for potential data rate increases.

Design data and techniques for reliable, high speed, high capacity data processing and handling systems are being developed for use in interactive information transfer. During FY 1974, breadboard holographic memory systems are being evaluated; design of a modular, fault-tolerant unified data system for planetary spacecraft was initiated; and development of elements of an optical parallel processor was started. In FY 1975, mating the holographic memory with an operating computer will be completed and testing initiated; conceptual design of the unified data system will be completed; and elements of the optical processor assembled to begin system tests.

Techniques to improve the resolution, sensitivity and reliability of sensing systems will be derived to support effective and economic acquisition of physical and scientific data. In FY 1974, development of low light level solid state imagers using charge-coupled device (CCD) technology has begun, operation of a tunable laser for pollutant detection was demonstrated, and field investigations of laser imagers to measure ocean characteristics were initiated. In FY 1975, this work will continue with emphasis on development of a breadboard CCD imager, extension of the dynamic range of the tunable laser, and design of a second generation Light Detection and Ranging (LIDAR) for more efficient operation.

Chemical Propulsion Research and Technology

The chemical propulsion program is designed to fill the need for long-life systems for satellites and spacecraft; the need for cost reduction; the need for high energy for difficult space missions; and the need to understand the distribution of rocket exhaust products in the atmosphere. The work to meet these broad requirements is focused on (a) reusable hydrogen-oxygen systems, (b) long-life space storable stages, (c) low cost solid stages, and (d) exhaust effects studies. These efforts are supported and nurtured by a broad research program which explores the sciences and processes common to all chemical propulsion systems: combustion, heat transfer, fluid flow, etc. In addition, research is carried on to discover new, potent sources of energy which can yield a large increase in propulsion capability.

Reusable H_2-O_2 systems: This research program on reusable H_2-O_2 propulsion systems, at the Lewis Research Center, will provide technology for the engine, feed system, insulation, and attitude control components for a stage that can be used at least 20 times. Through reuse, the effective cost of propulsion will be reduced by a factor of at least 10, and through high specific impulse of 470 seconds, mission capability will be increased. The engine must operate at high pressure to produce the high specific impulse. In FY 1975, the technology for seals and bearings for the small, high speed turbopumps needed for such an engine will be established. Work will continue on other parts of the turbopump, on the thrust chamber, on reusable insulation, feed lines and auxiliary thruster systems.

Long-life propulsion: Many missions of the late 1970's and beyond will last for years: for example, flight time to Jupiter is about 2 years; to Saturn almost 10 years; to Uranus more than 10 years. The Jet Propulsion Laboratory will provide the technology for high performance spacecraft propulsion systems to meet this requirement. In FY 1975, the Jet Propulsion Laboratory will establish techniques for predicting the life of propulsion elements through short duration tests. Selection will be made between bipropellent and dual mode engine concepts for long duration, high energy missions, and construction of an engine will be started. It will be tested in FY 1976. The technology for 10-year-life valves, regulators, and tanks will also be explored.

Low cost solid propulsion: Extended use of solid propellent rockets is desirable due to their generally lower cost than other propulsion systems. In FY 1975, a two-burn solid motor suitable for satellite orbit insertion will be fired and a sterilizable solid motor meeting planetary quarantine standards will be demonstrated on an advanced case concept to achieve very high stage mass fraction (.92 versus .88 current) through use of the combustion chamber of one motor for the nozzle of the succeeding motor.

Atmospheric effects: The solid propellent motors used for shuttle boost and for launch vehicle upper stages will put aluminum oxide and hydrogen chloride into the atmosphere. A multicenter program is in progress to determine the reaction of hydrogen chloride with water vapor, rain and other constituents of the mesosphere and stratosphere. A model of the exhaust cloud will be developed to allow prediction of the exhaust cloud shape, location, and concentration.

Basic research: Basic research tasks will be continued to provide the understanding of the chemical and physical processes of chemical propulsion, and to establish new concepts of energy storage and use. These include exploration of the influence of baffles and cavities on combustion stability; measurement of the backflow from rocket nozzles and determination of the damage to spacecraft surfaces and optics; determination of the burning process of materials at zero gravity; stabilization of active states of elements with specific impulse potential over 1,000 seconds; and evaluation of propulsion systems based on laser beam energy transmission.

Electric Propulsion Research and Technology

High specific impulse propulsion offers payload and performance advantages which, for difficult missions, can be translated into cost advantages. Electric propulsion currently offers the only practical approach to specific impulses greater than about 1,000 seconds. The present emphasis in electric propulsion is on two major areas of application; auxiliary propulsion for stationkeeping and attitude control of long-life application type satellites, and primary solar electric propulsion as a low cost extension of existing launch vehicle capability and later of shuttle capability for interplanetary and near-earth geocentric missions.

In the area of auxiliary electric propulsion, a small 1 millipound, 150 watt ion thruster will be flown aboard the ATS-F in FY 1974 as an experiment to demonstrate North-South stationkeeping capability. This is one of the most demanding propulsion requirements for long-life (greater than 5 years) geosynchronous three-axis stabilized satellites such as for communication applications. During FY 1975, operation and evaluation of the flight experiment will take place. However, because the spacecraft's experiment schedule precludes demonstration of the life capability of the ion thruster, a ground test program to demonstrate 5 year cycle life (1,800 cycles and 15,000 hours thrust time), initiated in FY 1974, will be continued in FY 1975 with completion scheduled by the end of FY 1976. Other investigations during FY 1975 will continue to study means of improving ion engine reliability which is essential for such long-life applications.

Additional efforts in this area involve the evaluation of small pulsed plasma thrusters which are ideally suited for very precise precession control

(2-3 arc seconds versus current 15 arc seconds) of spinning type satellites and resistojets capable of using hydrazine and low freezing point mono-propellents to simplify onboard satellite propulsion systems. In FY 1974, a small pulsed plasma thruster (25 micropound-sec./pulse) demonstrated the required 12 million pulses. During FY 1975, testing will be aimed at achieving repeatability and scaling to higher impulse bits (1 millipound-sec/pulse). Evaluation of the resistojet using such low freezing point propellents (222k to 217k) as monomethylhydrzine (MMH) and unsymmetrical dimethylhydrazine (UDMH) will also be carried out during FY 1975.

In the area of primary solar electric propulsion, the program is presently aimed at demonstrating by the end of FY 1978, the technology for a 3,000 second specific impulse modular thrust subsystem and the technology for large (25 kw), lightweight (15 kg/kw) solar arrays. The successful accomplishment of these two major tasks will allow application of solar electric propulsion for missions in the early 1980 time period.

A modular approach has evolved in the use of thrusters and power conditioners. This modular approach minimizes the resources required to carry out the technology and development inasmuch as many similar units take the place of a few larger and more specialized units. The modular approach also permits the technology to be applicable to a wider range of possible missions and mission modes.

During FY 1975, life testing of a 30-cm engineering model ion thruster (2.75 kw) will continue towards achieving a 10,000 hour goal. In addition, design and fabrication of an engineering model power conditioner for integration with a thruster will be initiated. Subsequently, the thruster/power conditioner module will be integrated into a complete thrust subsystem including propellent system, switching matrix, thruster assembly and a computer control system to demonstrate full performance capability and to evaluate subsystem interactions. During FY 1975, fabrication of other thrust subsystem elements will be continued. In addition, fabrication and initial testing of a lightweight (15 kg/kw) solar array (one 12.5 kw wing) will be completed in FY 1975. This technology effort is aimed at demonstrating the structural and dynamics suitability of such large, lightweight arrays.

Energy Systems Research and Technology

Energy systems R&T aims at major cost reductions through technological advances as well as standardization and improved operating procedures, while simultaneously increasing life, reliability, and power density of the system. Involved are solar cells and arrays, electrochemical cells and batteries, power processing parts and circuits, and thermomechanical engines.

In addition to these means, others (such as wind and photosynthesis) are being investigated for terrestrial applications for both mobile (motive) and stationary purposes. The program is carried out primarily at the Lewis Research Center and the Jet Propulsion Laboratory with small efforts at the Goddard and Marshall Centers and is directed by the Space Propulsion and Power Division at Headquarters.

The solar cell and array effort at the Jet Propulsion Laboratory is aimed at advancing the energy density of flexible arrays from 66 to 110 watts/Kg, feasibility of which has been shown as a first stage. New thin and highly efficient cells and solderless contacts are being developed for this purpose. A continuous ribbon technology for high quality, greatly-reduced cost cells will be at the point where solar cells made from it can be evaluated in FY 1975. New standard solar cells will be distributed, after having been flown at the user's request in FY 1974. Solar standard module design studies will be completed in FY 1975. At Lewis Research Center, equipment for continuous production of silicon web dendrites will be designed for an alternative source of low cost cells. Work on lowering the cost of plastic covered arrays will continue, as will work on improving cell efficiencies.

A virtually nongassing nickel-cadmium battery cell will be technology ready in FY 1975 at the Jet Propulsion Laboratory, thus considerably increasing safety and reliability of storage batteries not only for space but also for other critical uses as, e.g., heart pacers and body implants generally. Work by Goddard Space Flight Center will continue on developing a nondestructive test method for batteries, expected to be available by FY 1976, for selecting and matching cells with high confidence in their performance. Evaluation of the inorganic separator, developed for Lewis Research Center, will continue, especially in silver-zinc cells, the main purpose being to achieve at least 5-year life in synchronous orbit at 20-30 watt-hr/lb power density, some three times more than available from current nickel-cadmium systems. The search for a solid, low temperature electrolyte will be continued at the Lewis Research Center for an order-of-magnitude increase in power density (to 150 watt-hr/lb), indefinite shelf and very long cycle life. Such a discovery would also be very useful for energy storage in conjunction with electrically powered terrestrial devices, including vehicles.

The power processing program will continue to explore new concepts and to seek advances in component capability, equipment designs and circuit techniques which will meet future spacecraft needs for higher power, longer life, and lower cost equipments. In FY 1975 tests will be conducted to confirm design principles for modular DC regulators. Also, a new concept for simplified regulation of power from a high voltage, high power solar array will be tested.

The emphasis on thermomechanical energy conversion systems in FY 1975 will be placed on continued development of a .5-2.0 KWe, high efficiency gas turbine conversion system for use with isotope heat sources in space. This type of conversion system can reduce the cost of isotope power systems compared to thermoelectric conversion now being used by a factor of four and conserve scarce isotopic fuel. In FY 1975, tests of key component elements such as bearings and heat exchanger will be performed and fabrication of an experimental turbocompressor-alternator will begin.

Nuclear Energy Research and Technology

Research and technology investigations will be conducted in areas related to advanced applications of nuclear energy in space. Building upon the extensive space nuclear programs of the past decade, these activities will maintain a viable, long-range capability in nuclear research for space power and propulsion while providing important benefits to the Nation in its concerns for future energy sources.

Research is conducted in the field of thermionic energy conversion with a long-range goal of achieving efficiencies up to 30% with operating temperatures as low as 1,100 C. Diode performance of this character would make thermionic convertors extremely useful for topping cycles in both nuclear and fossil-fueled power plants. The research consists of fundamental investigations of emitter and collector materials, measurement of diode performance, and analyses of convertors and their uses.

Gas-core reactor research is continued to investigate the production of fission energy with the nuclear fuel in the gaseous or plasma state. Gas-core reactors may become important new sources of energy since they are efficient users of uranium fuels, may be effective breeder reactors, have inherent safety features, and may permit the efficient transformation of fission energy to other forms by thermo- or photo-chemical means. Low power, low temperature, self-critical experiments employing gaseous uranium-hexafluoride are planned for the FY 1974-75 period. In addition, high temperature uranium plasmas will be produced electrically and observed spectroscopically.

As a means to apply the vast technical knowledge on high temperature reactors provided the nuclear rocket program, studies will be conducted during FY 1974 and 1975 to determine the use of heat from high temperature reactors and industrial processes such as coal gasification, hydrogen production, iron ore reduction, etc. If these studies show economic and practical promise for nuclear industrial processes, experimental programs on enabling technologies will be identified and conducted.

High Power Lasers and Energetics Research and Technology

The high power laser and energetics program provides, through basic research and experimental engineering, major advances in power generation, conversion, and transmission which will be the basis for future capabilities in space and which will apply to the long-range energy need on earth.

Research is conducted in the area of plasmadynamic energy systems to establish the knowledge required to produce, confine and utilize plasmas for advanced power and propulsion systems of potential importance to space missions. By the end of FY 1974 experiments on a closed-loop MHD power generator will be completed, as will the initial phases of a project to investigate combustion-driven MHD generators for very high power densities. In this project, combustor experiments will be completed during FY 1975 to be followed by generator tests in subsequent years. Operation of the large superconducting magnetic mirror apparatus and the bumpy torus device will continue to explore the phsyics of D.C. plasma heating and other fundamental problems which are of major significance to fusion energy for terrestrial and space applications.

In magnetics and cryophysics, research is conducted to achieve stable, intense magnetic fields of minimum mass and power use and to understand the physics of materials and devices exposed to low temperatures and intense fields. In FY 1974 and 1975, novel magnet windings and materials will be tested and efficient magnetic refrigeration will be demonstrated.

Basic research is conducted to provide fundamental data and to investigate novel concepts in the emission and absorption of radiation from all states of matter in support of a broad range of possible applications in power generation, propulsion, lasers, space environment, and atmospheric physics. During 1975, studies of charge exchange reactors for noble gas ions and various lasting molecules will be completed, and research on fission pumping of iodine and xenon lasers will be conducted.

An integrated program of laser systems technology is being conducted to determine whether high power lasers can make a major impact on aerospace mission capabilities. To make this evaluation, continuous operation of a laser will be investigated to uncover technical barriers to long duration operation at high powers. Problems of laser optics, beam transmission, and laser energy conversion will also be studied as they apply to possible space applications. In this context, use will be made of the major laser programs in other agencies.

Entry Research and Technology

The entry technology program will provide aerothermodynamic technology to improve spacecraft design, safety, reliability, and to assure more efficient aerodynamic operation with maximum payloads for earth orbital missions and planetary exploration.

Planetary probe technology will be focused on spacecraft design for missions to Venus, Saturn, Uranus, and Jupiter. In FY 1974 high temperature properties of the shock-heated entry environment were evaluated to provide heat shield design data for Venus entry probes. Aerodynamic stability tests in support of Mars and Venus probes were also conducted. Laboratory experiments to define shock layer properties for the higher speed outer planet entry probes were started. In FY 1975, aerodynamic design studies for Venus probes will be continued. Laboratory experiments at the high velocities of outer planet entry will be continued with emphasis on determining critical high temperature radiative property data. The effects of gaseous products of heat shield ablation on the shock layer flow around entry probes will be examined.

In the area of space shuttle test and support, wind tunnel and analytical efforts will be continued to aid in aerothermodynamic design, development, and verification of the orbiter and launch vehicle configurations. Approximately 12,000 wind tunnel hours have been committed by NASA research centers in FY 1974 in support of required aerodynamic performance, stability and control, heat transfer, and specialized aerothermodynamic testing and in study of aerodynamic-related operational problems. These activities will be continued in FY 1975 at a reduced level of effort.

Advanced earth orbital spacecraft design will concentrate on aerothermodynamic design for reusable spacecraft concepts suitable for use in the late 1980 and 1990 period. In FY 1974 design studies of single-stage-to-orbit and two-stage vehicles examined the potential of lighter weight, lower cost structures and thermal protection systems, improved propulsion, and greater aerodynamic efficiency in increasing vehicle performance. In FY 1975 efforts will be continued to improve the data base in all areas, and to optimize vehicle aerodynamic shape through experimental wind tunnel investigation and use of recently developed aerodynamic design computer synthesis programs and flow field programs.

Systems and Design Studies

	1973	1974	1975
Systems and design studies.....	$1,230,000	$1,300,000	$1,600,000
Total.....	$1,230,000	$1,300,000	$1,600,000

Systems Studies

The overall purpose of space systems and design studies is to identify areas for future technology focus, including continuous examination of current technology objectives to ensure their appropriateness and payoff, and to provide the necessary technical and economic decision base to support this selection of future system and experimental programs.

The space systems studies are conducted to determine technology requirements, costs, benefits and impacts of advanced space systems based on mission, systems and conceptual design studies. Advanced spacecraft and vehicle concepts are identified, analyzed and evaluated.

In the area of high capability, cost effective systems for space exploration, mission and conceptual system studies will be continued to apply advanced technologies to space exploration. Studies are being conducted of proposed missions of the 1980's which consider advanced technology and cost reduction techniques as well as modifications and improvements to Pioneer and Viking. Examples in the FY 1974 program included Mars rover, Venus radar orbiter, ballistic Mercury orbiter, and outer planet orbiter/lander studies, both in-house and contract. In FY 1975, studies of outer planet satellite lander requirements will be continued, especially Titan (a satellite of Saturn with an atmosphere), preliminary design and a study of multipurpose space storable stages for planetary orbiters will be procured.

High capability, cost effective systems for space applications, mission and conceptual system studies will be continued to apply advanced technologies to space applications. Studies are being conducted on proposed missions for the 1980's which consider advanced technology and cost reduction techniques. Examples in the FY 1974 program included development of sensor cost modeling techniques, study of new uses of the space shuttle in research and technology areas, and evaluation of satellite communications for computer-to-computer data transfer. In FY 1975, studies of technology requirements for future missions planned for implementation during the 1980's, with emphasis on the use of Spacelab, will continue. Definitive studies of applications missions utilizing the data transfer and processing capabilities of space systems will continue as a means of targeting the OAST research and technology base program on specific future needs.

Systems and Experimental Programs

	1973	1974	1975
Advanced Systems Technology.....	$1,987,000	$2,528,000	$3,700,000
Energy and environmental systems technology.....	1,987,000	2,528,000	2,900,000
Solid state data storage system...	---	---	800,000
Flight Experiment Programs.....	993,000	1,050,000	1,000,000
Atmospheric flight experiments....	993,000	1,050,000	1,000,000

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	1973	1974	1975
Spacecraft/Payload Programs.....	$2,637,000	$115,000	$2,000,000
Space technology shuttle payloads.	---	---	2,000,000
Meteoroid technology satellite....	154,000	41,000	---
Space plasma high voltage interaction experiment.....	593,000	74,000	---
Electric auxiliary propulsion.....	690,000	---	---
Space storable propulsion.....	1,200,000	---	---
Transportation Programs.....	2,403,000	---	---
Solid rocket motors.....	1,572,000	---	---
Solar electric propulsion.....	831,000	---	---
Total.....	$8,020,000	$3,693,000	$6,700,000

Energy and Environmental Systems Technology

The objective of the energy and environmental systems technology program is to reduce the fuel consumption and pollution attributable to stationary and mobile power systems by the application of NASA research and technology capability.

In the area of stationary power, NASA has a joint effort with the Office of Coal Research, Department of Interior, to achieve a thermomechanical conversion efficiency of better than 50% while meeting Federal pollution standards for central station power plant operations. A comprehensive study is in process to define the system performance potential, plant capital/operating costs and technology development requirements for a liquid metal topping cycle operating in conjunction with a standard steam power plant. A significant broadening of the program is planned for FY 1975 to include additional advanced conversion cycles and experimental investigations will be initiated in the areas of advanced materials, combustion and conversion system technology.

In the area of mobile power, a joint Environmental Protection Agency/NASA program was initiated in FY 1974 to demonstrate an improved automobile gas turbine engine by October 1975, which meets pollution standards with reduced fuel consumption, size and cost. A series of studies is in progress for the Federal Railroad Administration of alternative engine cycles such as the Brayton, Stirling and advanced diesel for applications to trucks and trains. In addition, a program to evaluate the potential of hydrogen injection in internal combustion engines was initiated in FY 1974. This effort has the objective of demonstrating that a conventional automobile equipped with a hydrogen injection system can meet 1977 Environmental Protection Agency emission standards with at least a 25% reduction in fuel consumption compared to 1973 automobiles.

In the area of energy storage, analytical and experimental studies will be initiated in FY 1975 to survey existing technology and evaluate candidate approaches in terms of their potential overall demands on resources, environmental and social impacts in order to identify and define the most promising areas for increased emphasis. The development of more cost effective means for the storing of energy would facilitate the use of solar energy, increase the efficiency of central power stations and further reduce the demand on scarce petroleum reserves by permitting the wider use of electric vehicles in urban areas.

Solid State Data Storage System

Electromechanical tape recorders commonly used on aerospace vehicles exhibit unacceptably high failure rates with most failure attributable to moving parts. Recent advances in magnetic bubble domain technology indicate a no-moving-part data storage system with reliability 10 times better than current types and costs per bit about 1/10 that of comparable tape recorders is feasible. The purpose of this program is to demonstrate the improved reliability and versatility of a solid state data storage system using bubble domain technology in tape recorder applications.

During FY 1974, a 10^5 bit magnetic bubble domain memory chip is being developed as part of the fundamental electronics program. That chip will form the basic element in the solid state storage system. In FY 1975, design of a 10^8 bit solid state data storage system will be initiated. During FY 1976, a breadboard system will be fabricated for laboratory evaluation. In FY 1977, a prototype system will be fabricated and subsequently qualified to flight standards to demonstrate technology readiness.

Atmospheric Flight Experiments

Atmospheric flight experiments is a piloted flight test program conducted jointly by the U.S. Air Force and NASA at the Flight Research Center using the X-24B vehicle. The purpose of the program is to obtain information on terminal area piloting problems, vehicle handling qualities and aerodynamic performance at speeds from near Mach 1.5 to landing. The X-24B is characteristic of the double delta class of wingless aircraft with potential for use as future military hypersonic aircraft and also advanced earth orbital spacecraft. The program provides an opportunity to explore, at low cost, potential flight problems of this class of vehicle. Approximately 30 flights will be carried out over the span of the program.

The X-24B configuration is a rocket-powered test vehicle based on extensive research carried out by the Air Force Flight Dynamics Laboratory. The vehicle was fabricated by a low cost modification to the USAF X-24B previously

used in the lifting body flight research program. The first glide flight was accomplished in August 1973 using B-52 air launch techniques established in previous lifting body research. Following several more glide flights, the first rocket-powered flight was accomplished in November 1973.

Flight tests through the remainder of FY 1974 will concentrate on evaluation of vehicle performance, stability and control, and handling qualities at transonic speeds and below. During FY 1975, the flight envelope will be incrementally expanded to speeds near M = 1.5. Following completion of this phase of research, the vehicle will be used as a testbed for advanced control system study. Program completion is scheduled for the end of FY 1976.

Space Technology Shuttle Payloads Program

The thrust of the space technology shuttle payloads program is to exploit the Shuttle-Spacelab opportunity to conduct innovative research and technology programs in the space environment when cost effective use can be made of the characteristics of space including weightlessness, large vacuum sink, radiation, and/or the unique location.

The long duration exposure module (LDEM) will be used to transport passive low cost experiments to space for exposure for periods of 6 to 9 months. Experiments will be performed using materials, coatings, meteoroid-debris shields, components, and subsystems where benefits are derived from exposure to the total space environment. In FY 1974, experiments will be selected for the first LDEM flight and in FY 1975, the design of the module will be completed.

An advanced technology laboratory will make use of the Spacelab to utilize man's capability to conduct in the space environment multidiscipline research and technology focused on National technological needs. In FY 1974, experiment definition and development will be initiated for completion in FY 1978. Physics and chemistry investigations in superfluidity, gas chemistry, and gravity sensitive fluid physics phenomena will be defined and developed. In FY 1975 and 1976, a solicitation for experiment concepts will be conducted and experiment definition studies will be initiated.

Experiments to provide real time monitoring of contaminants in the vicinity of the shuttle and its payloads will be developed. In FY 1976, development of a real time contamination monitor will be initiated. Laser information/data transmission experiments will be developed to verify the technology of a laser relay satellite system, in conjunction with a laser system on a synchronous satellite by about 1982.

Entry technology experiments will be defined to provide vehicle aerodynamics/dynamics, pressure, and thermal data during ascent and reentry to understand vehicle/atmosphere interactions and to validate ground-based theoretical and experimental wind tunnel design data.

In the area of airborne support, a simulation Spacelab will be constructed and installed in an aircraft to provide capability to evaluate all aspects of experiment integration and operation in a real-life situation.

Low Cost Systems Program

	1973	1974	1975
Low cost systems program.....	---	$3,100,000	$5,000,000
Total.....	---	$3,100,000	$5,000,000

Standard Space Equipment Development

The Low Cost Systems program has been established to reduce the overall costs of space systems. The purpose is to maintain a vigorous program that can fulfill NASA's space goals within the resources available. The program is structured to develop standardized space equipment and components designed to satisfy a majority of anticipated mission requirements, and to search NASA's business and programmatic practices with a view to reducing overall costs.

For certain utility functions which are common to many space systems, this program will identify space equipment and component requirements, define their interfaces, and develop suitable standard subsystems, engineering components and/or software for use by the Program Offices.

Use of standardized capabilities will reduce the costs of designing and developing unique equipment for differnt missions. Cost per unit should decline with quantity production; reliability and assurance should improve; and delivery schedules should be shortened.

Standard equipment and components will be developed for spacecraft in four areas initially. These are Power, Communications and Data Handling, Auxiliary Propulsion, and Stabilization, Guidance, and Control.

The availability of these equipments and/or software will be made known to project teams through a catalog/inventory.

Program and Business Practices Studies

The objective of the program and business practice efforts is to identify opportunities for effecting cost savings within current and future projects. The studies pinpoint cost areas that can be and should be addressed. New techniques and methods for directing programs and transacting business in NASA should result from work in this area.

Specific items to be addressed include: assist in development of criteria and estimating factors for establishing low cost program targets; investigate methods for quantifying cost-risk trade offs in development, production, and support; identify and develop program management techniques that can be used in NASA program offices to limit costs; and survey cost effects of NASA's business practices with the aim of developing improved practices for NASA which obtain better overall cost results.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1975 ESTIMATES

BUDGET SUMMARY

OFFICE OF TRACKING AND DATA ACQUISITION

TRACKING AND DATA ACQUISITION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1973	1974	1975
Operations	$194,701,000	$195,200,000	$192,800,000
Systems implementation	45,130,000	39,600,000	48,000,000
Supporting research and technology	8,500,000	9,200,000	9,200,000
Total	$248,331,000	$244,000,000	$250,000,000

Distribution of Program Amounts by Installation:

Goddard Space Flight Center	$183,665,000	$177,180,000	$180,900,000
Jet Propulsion Laboratory	42,730,000	44,210,000	45,500,000
Wallops Station	6,522,000	6,100,000	6,900,000
Flight Research Center	1,520,000	1,700,000	1,800,000
Langley Research Center	580,000	300,000	---
Headquarters	13,314,000	14,510,000	14,900,000
Total	$248,331,000	$244,000,000	$250,000,000

HIGHLIGHTS OF BUDGET PLAN

Operations

Spaceflight Tracking and Data Network - Manned and unmanned mission support. FY 1975 workload will average 35-40 spacecraft in addition to preparation for Apollo Soyuz Test Project	$104,801,000	$102,000,000	$98,200,000

	1973	1974	1975
Deep Space Network - Planetary and interplanetary mission support. FY 1975 workload includes Pioneer 6-9, Mariner Venus/Mercury 1973, Pioneer 10 and 11, and Helios A. Preparation for Viking support.....	$31,500,000	$33,400,000	$34,600,000
Aeronautical and Sounding Rocket Support - Support for Wallops Station sounding rocket programs and Flight Research Center and Langley Research Center research aircraft flight..	5,010,000	5,000,000	5,500,000
Communications - NASA's global communications network (NASCOM) supporting all NASA and NASA supported projects. Apollo Soyuz Test Project, Helios, and Viking 1975 are major additions to FY 1975 requirements.....	31,390,000	31,800,000	30,900,000
Data Processing - Information processing for both spacecraft control and analysis. Includes funding for operation of image data processing facility to support Earth Resources Technology Satellite.....	22,000,000	23,000,000	23,600,000
Total, Operations.....	$194,701,000	$195,200,000	$192,800,000
Systems Implementation			
Spaceflight Tracking and Data Network - Procurement and implementation of systems for Spaceflight Tracking and Data Network, control centers, and special instrumentation in support of ongoing and new earth-orbiting projects requirements.....	20,970,000	18,600,000	25,600,000

	1973	1974	1975
Deep Space Network - Procurement and implementation of systems for Deep Space Network for support of ongoing and new planetary missions, including the Mariner Jupiter/Saturn 1977 and new Pioneer Venus missions.....	$11,100,000	$11,500,000	$12,000,000
Aeronautics and Sounding Rocket Support - Procurement and implementation of instrumentation for aeronautics and sounding rocket program support..	3,330,000	2,700,000	3,300,000
Communications - Procurement of NASA communications network equipment to meet new support requirements and maintain the high degree of reliability in communications between the tracking stations and control centers.....	2,400,000	2,300,000	3,200,000
Data Processing - Procurement and implementation of systems and equipment to maintain, integrate, and augment data processing capabilities in support of flight projects.....	7,330,000	4,500,000	3,900,000
Total, Systems Implementation.....	$45,130,000	$39,600,000	$48,000,000
Supporting Research and Technology			
Tracking, Orbit Determination, and Ground-Based Navigation - Improved techniques for ground-based navigation of planetary orbiters, landers, swingby, and earth orbiter missions.....	2,430,000	2,490,000	2,140,000

	1973	1974	1975
Spacecraft-to-Ground Communications, Telemetry, and Command - Study extension of capabilities to handle multiple spacecraft support and increasing data rates; development of solid state components and spacecraft transponder compatible with a Tracking and Data Relay Satellite System..	$2,860,000	$3,360,000	$3,190,000
Network Operations and Control Technology - Study automation techniques for improving real-time control techniques, and use of minicomputers for Deep Space Network.....	1,720,000	1,590,000	1,840,000
Data Handling and Processing - Development of processing systems for imaging data from earth resources satellites. Work on high data rate satellite problems.....	1,490,000	1,760,000	2,030,000
Total, Supporting Research and Technology.....	$8,500,000	$9,200,000	$9,200,000

OFFICE OF TRACKING AND DATA ACQUISITION

TRACKING AND DATA ACQUISITION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The purpose of this program is to provide vital tracking and data acquisition support to meet the requirements of all NASA flight projects. In addition to NASA flight projects, support is provided, as mutually agreed, for projects of the Department of Defense (DOD), 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, suplemented 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 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 hardware 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 hardware and techniques.

BASIS OF FUND REQUIREMENTS:

Operations

The FY 1975 request reflects a downward trend in funding requirements for network operations. With the completion of Skylab support, Spaceflight Tracking and Data Network staffing will be phased down and two stations, Corpus Christi, Texas, and Carnarvon, Australia, will be closed. In both the Spacelight Tracking and Data Network and the Deep Space Network the support workload will remain relatively high with preparations underway for the Apollo Soyuz Test Project and Viking support.

	1973	1974	1975
Spaceflight tracking and data network	$104,801,000	$102,000,000	$98,200,000
Deep space network	31,500,000	33,400,000	34,600,000
Aeronautics and sounding rocket support	5,010,000	5,000,000	5,500,000
Communications	31,390,000	31,800,000	30,900,000
Data processing	22,000,000	23,000,000	23,600,000
Total	$194,701,000	$195,200,000	$192,800,000

Spaceflight Tracking and Data Network (STDN) Operations

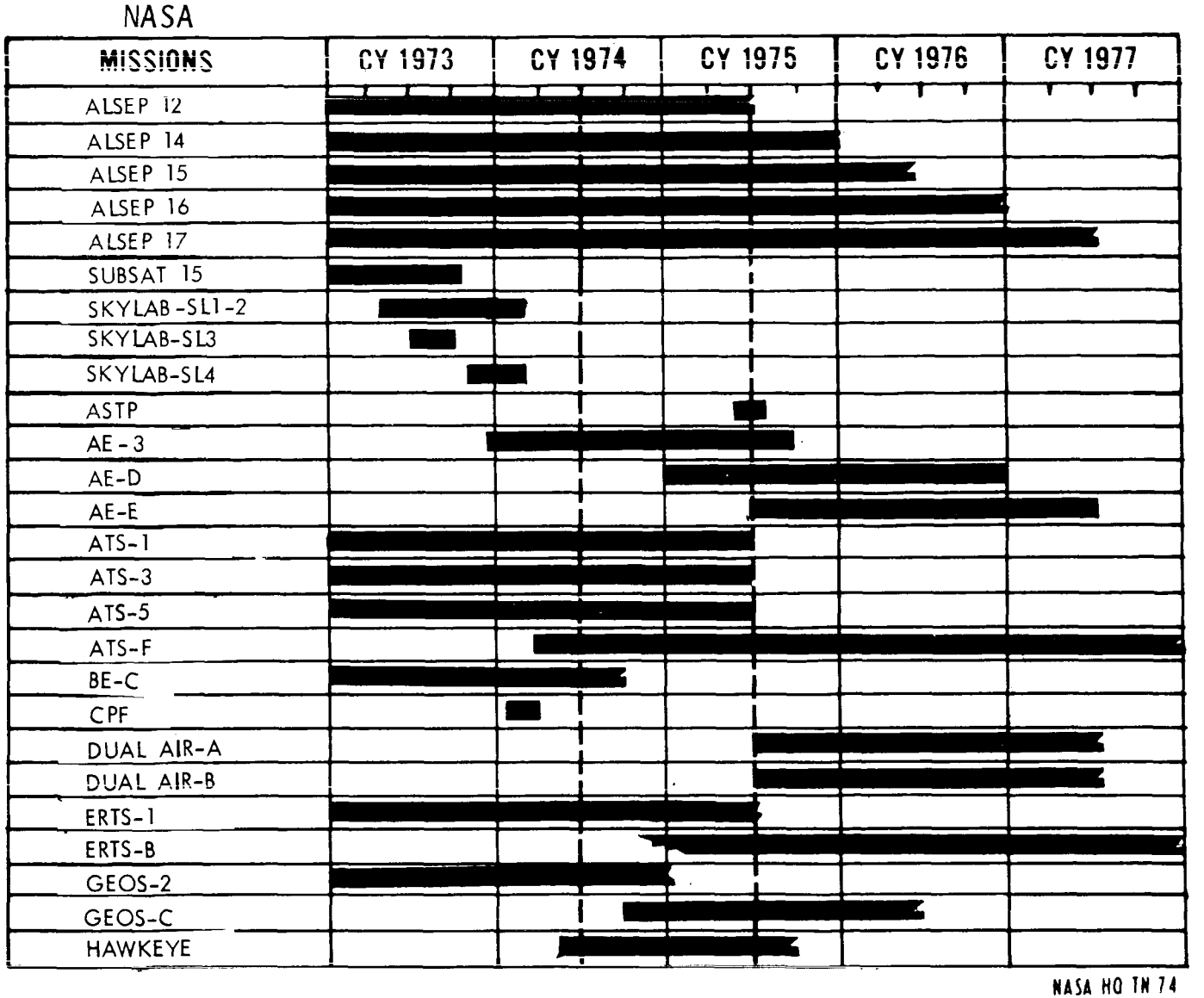
The primary function of the Spaceflight Tracking and Data Network is to support manned and unmanned spaceflight missions. The majority of these missions have near earth orbits; however, the network does support missions through lunar distances. In addition, the network provides launch support to the spaceflight missions of the Department of Defense (DOD) and other U.S. agencies.

The Spaceflight Tracking and Data Network must be responsive to the tracking and data acquisition requirements of a large variety of flight projects from the time of launch to the completion of flight project objectives. In some instances the period of support required by flight projects extends to several years.

The Spaceflight Tracking and Data Network presently consists of eighteen geographically dispersed land stations, two transportable facilities, two advanced instrumentation aircraft, one instrumented ship, and a control center complex at Goddard Space Flight Center. These facilities have the capability by electronic means to track the spacecraft, send commands for spacecraft and experiment control purposes, receive engineering and scientific data from the spacecraft, and in the case of the astronauts maintain voice communications for safety and other project related purposes. In addition to these electronic systems, the Spaceflight Tracking and Data Network is supplemented by a growing number of laser tracking systems to meet the extremely precise needs of NASA's geodetic investigations.

The eighteen land stations are located at Fairbanks, Alaska; Goldstone, California; Merritt Island, Florida; Hawaii; Rosman, North Carolina; Corpus Christi, Texas; Guam; Ascension Island; Canberra and Carnarvon, Australia; Bermuda; Canary Islands; Santigo, Chile; Quito, Ecuador; England; Madagascar; Johannesburg, South Africa; and Madrid, Spain. The transportable station located near St. John's, Newfoundland, for early Skylab support has been put in caretaker status and will be reactivated in FY 1975 for the Apollo Soyuz Test Project. A second transportable facility is being modified at Goldstone, California, prior to relocation to Madrid for Applications Technology Satellite F support.

SPACEFLIGHT TRACKING AND DATA NETWORK WORKLOAD



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SPACEFLIGHT TRACKING AND DATA NETWORK WORKLOAD

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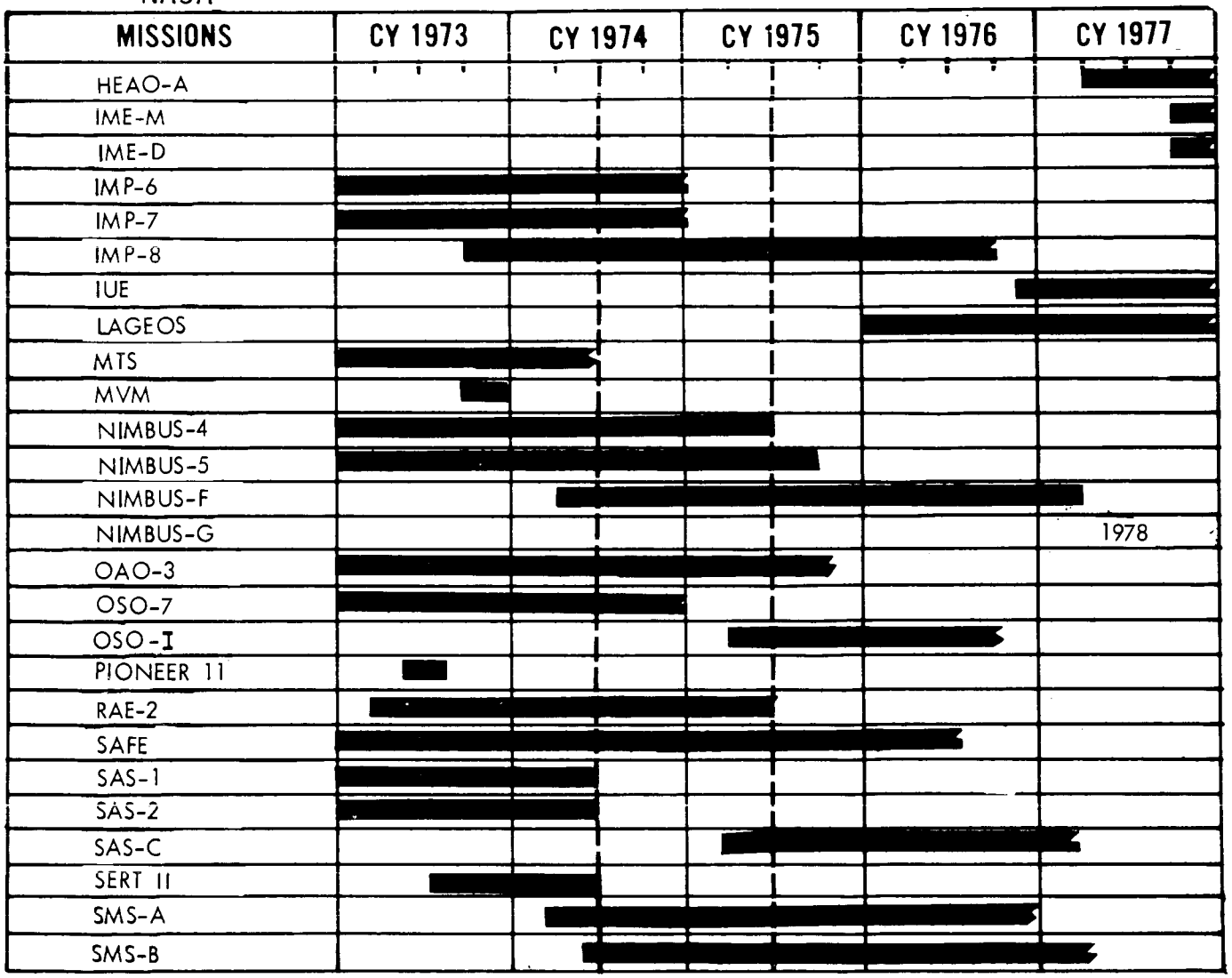

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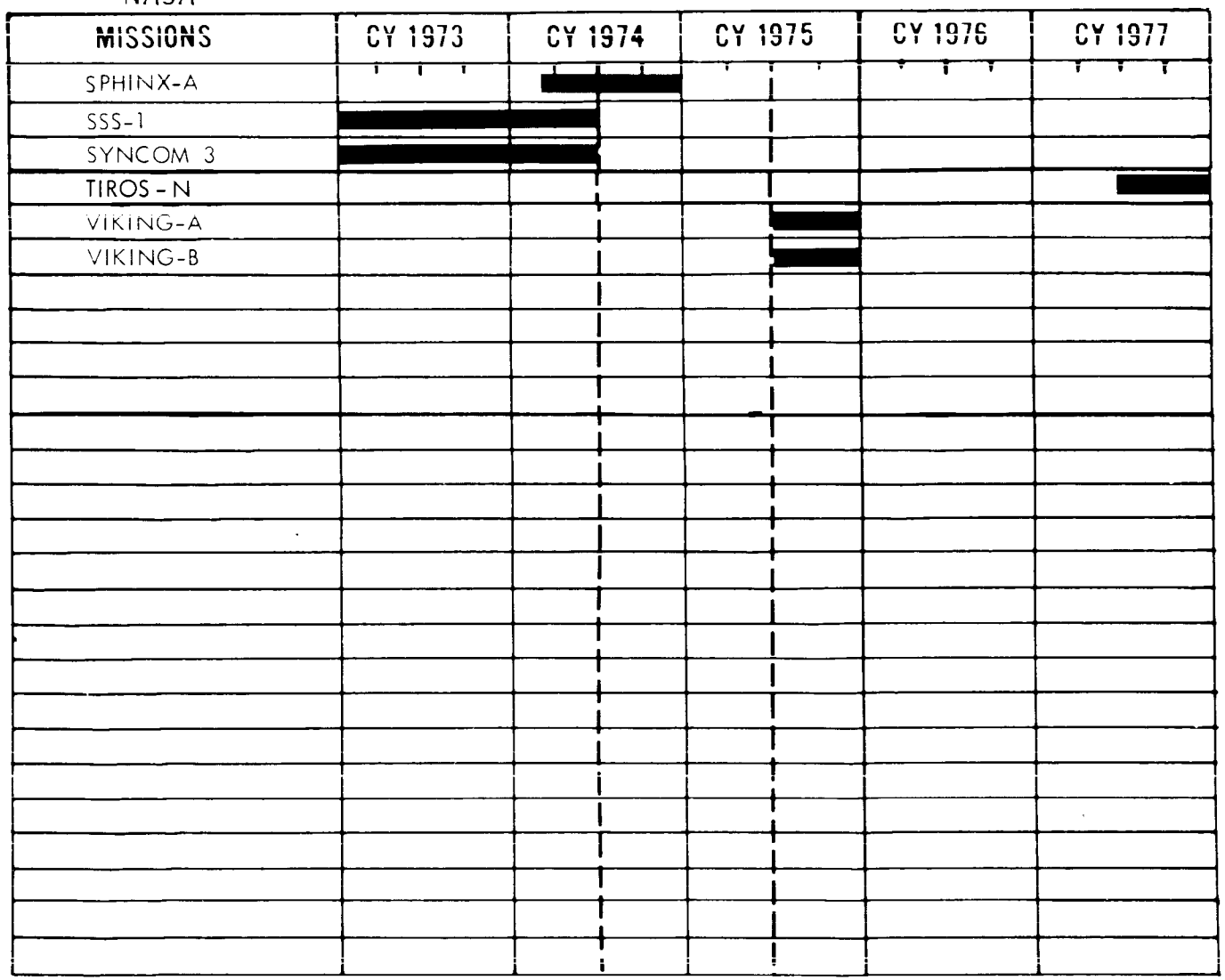

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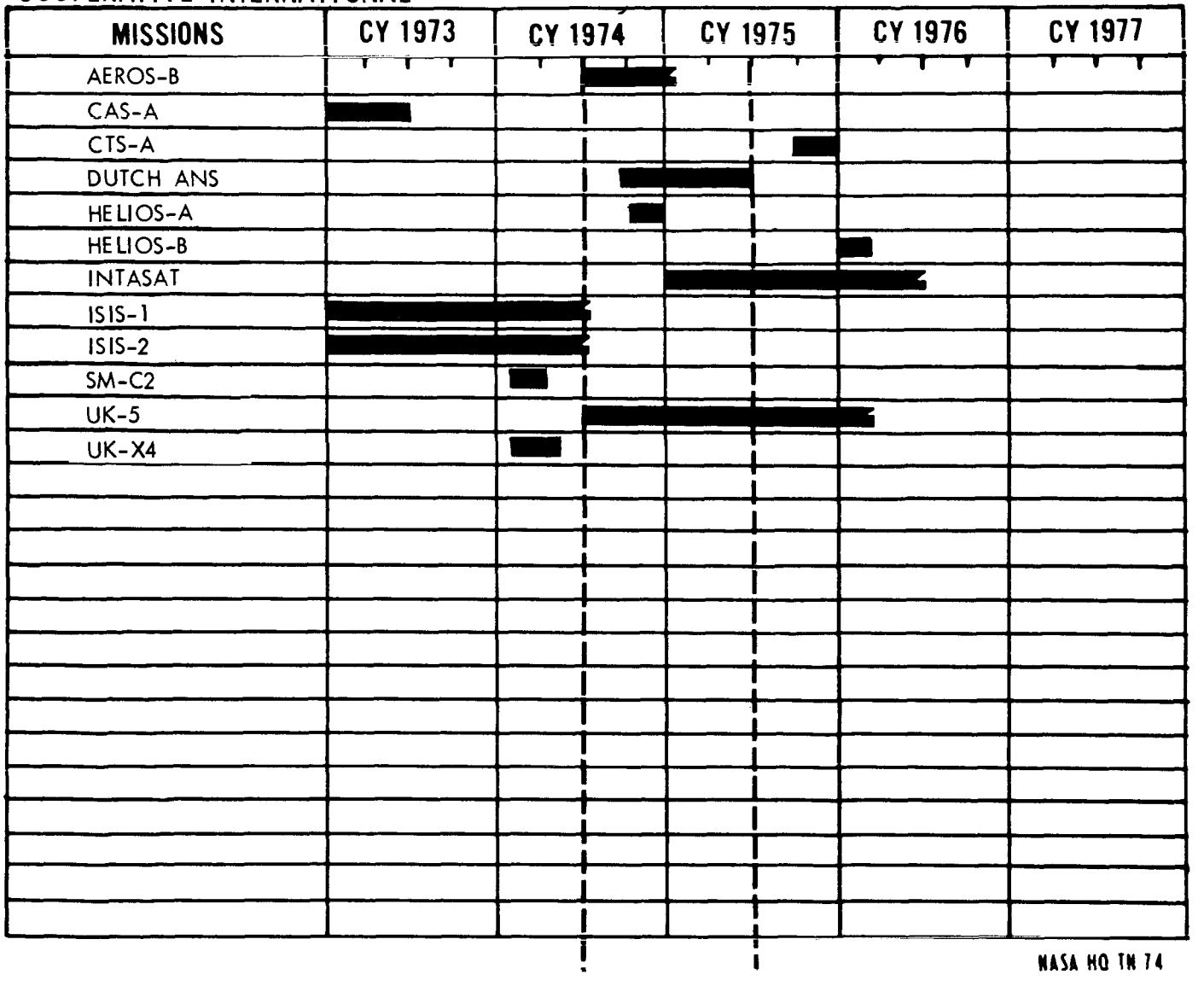

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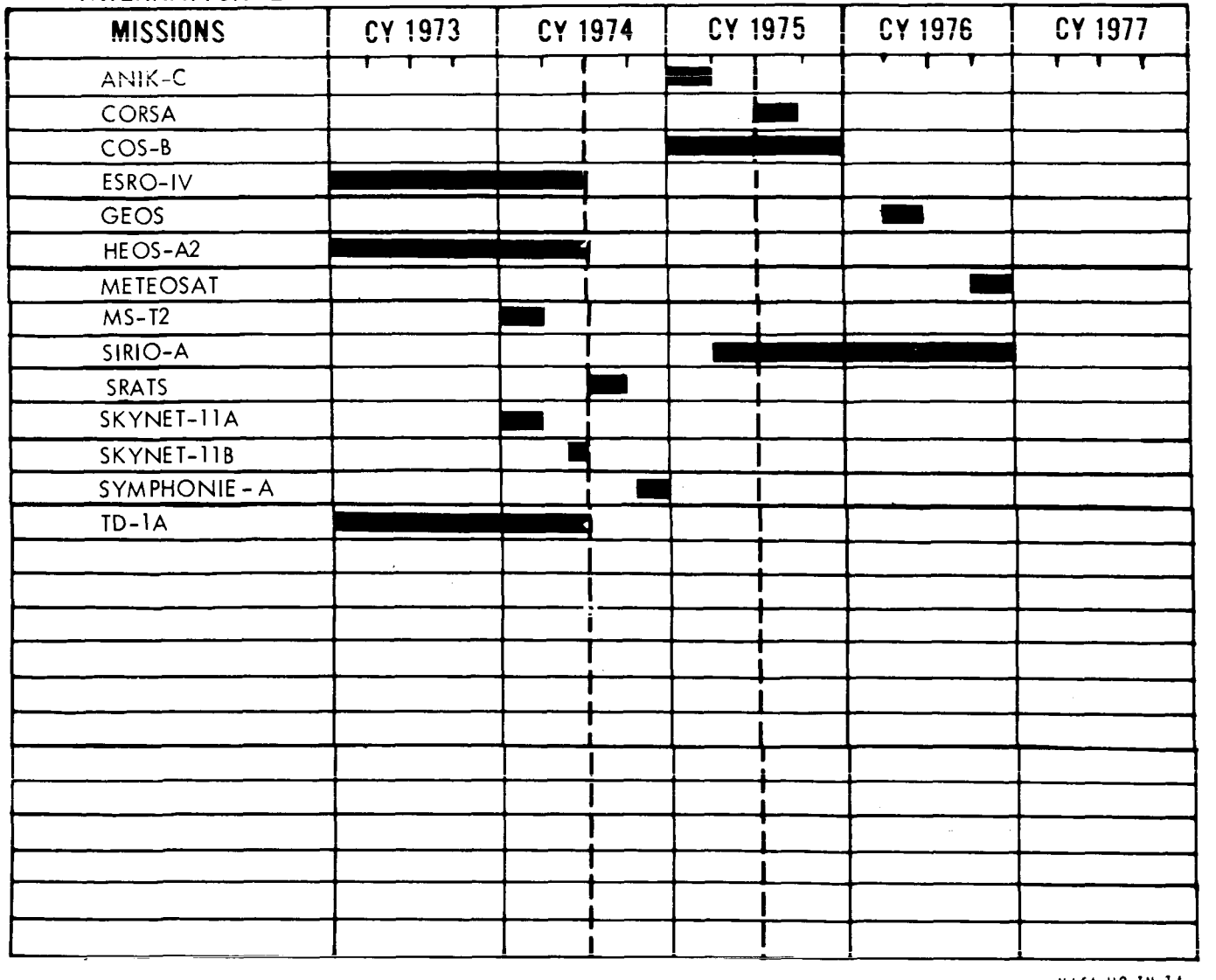

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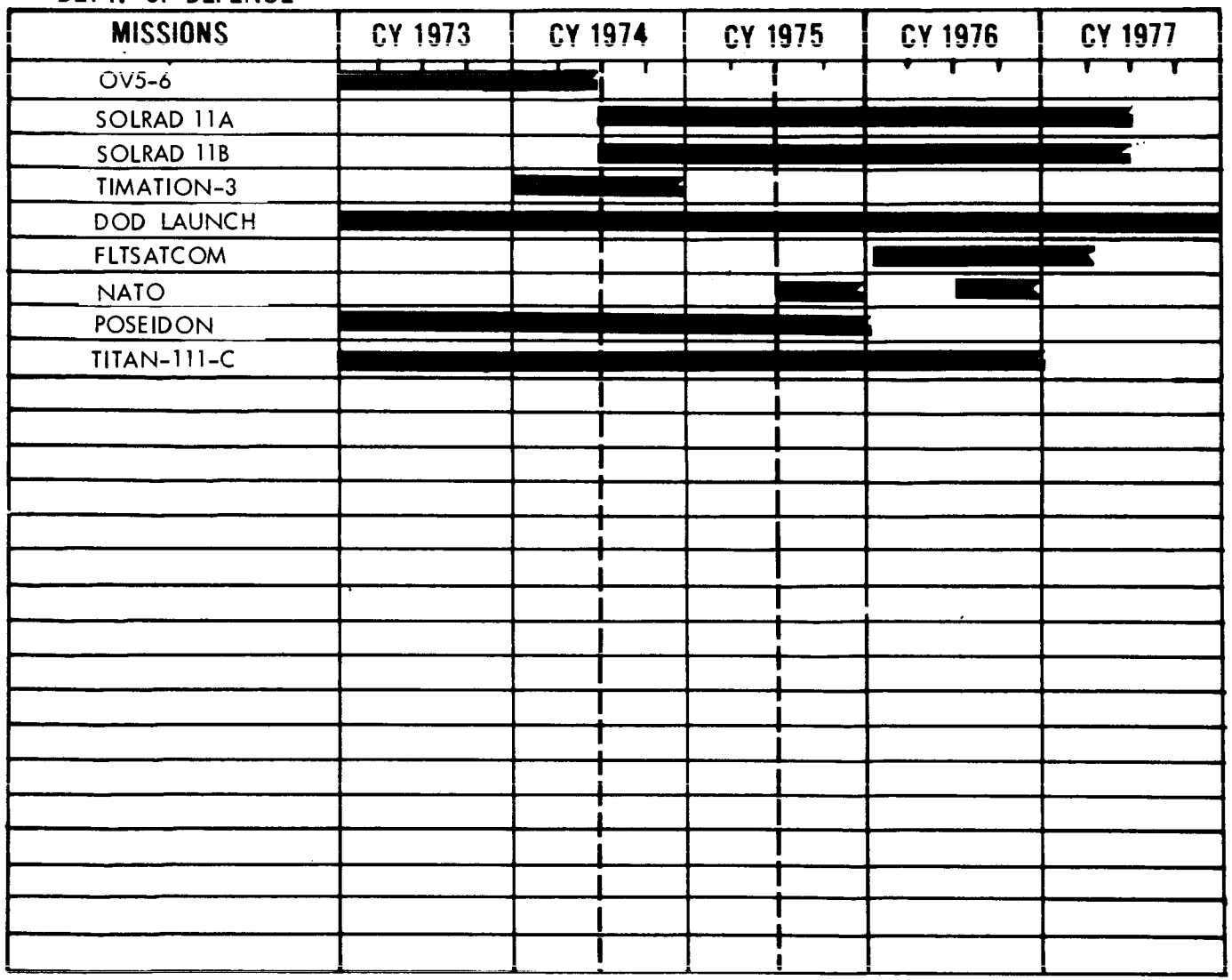

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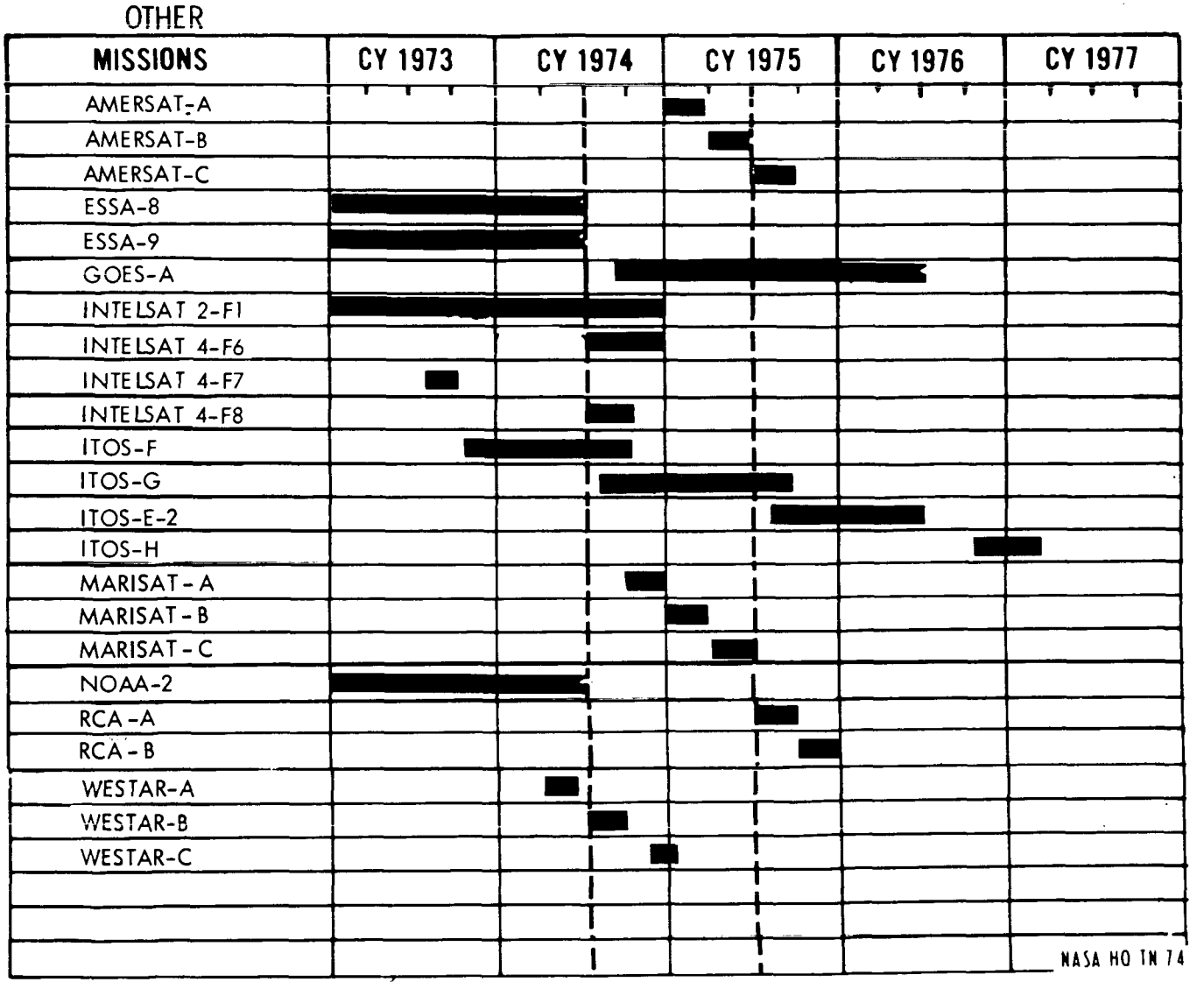


Due to reduced requirements the station at Corpus Christi, Texas, is scheduled for closure immediately after completion of Skylab and the station at Carnarvon, Australia, is scheduled for closure in December 1974, after support of Atmosphere Explorer 3. Reduced support effort at Bermuda and Canary Islands is also planned after completion of Skylab support.

The Spaceflight Tracking and Data Network is currently supporting on a continuing basis an average of approximately thirty-seven unmanned scientific spacecraft including such missions as Earth Resources Technology Satellite 1, several Applications Technology Satellites and Interplanetary Monitoring Platform satellites, Orbiting Solar Observatory 7, Radio Astronomy Explorer 2, Atmosphere Explorer 3, and Nimbus 4 and 5. In addition, the network is supporting Skylab and the Apollo Lunar Surface Experiment Packages left on the moon's surface by the Apollo 12, 14, 15, 16, and 17 missions. Upcoming missions to be supported include Synchronous Meteorological Satellites A and B, Nimbus F, Applications Technology Satellite F, Geodetic Earth Orbiting Satellite C, Orbiting Solar Observatory I, and Apollo Soyuz Test Project. The overall workload of the Spaceflight Tracking and Data Network, which is expected to continue to average 35 to 40 spacecraft during FY 1975, is indicated on the accompanying charts.

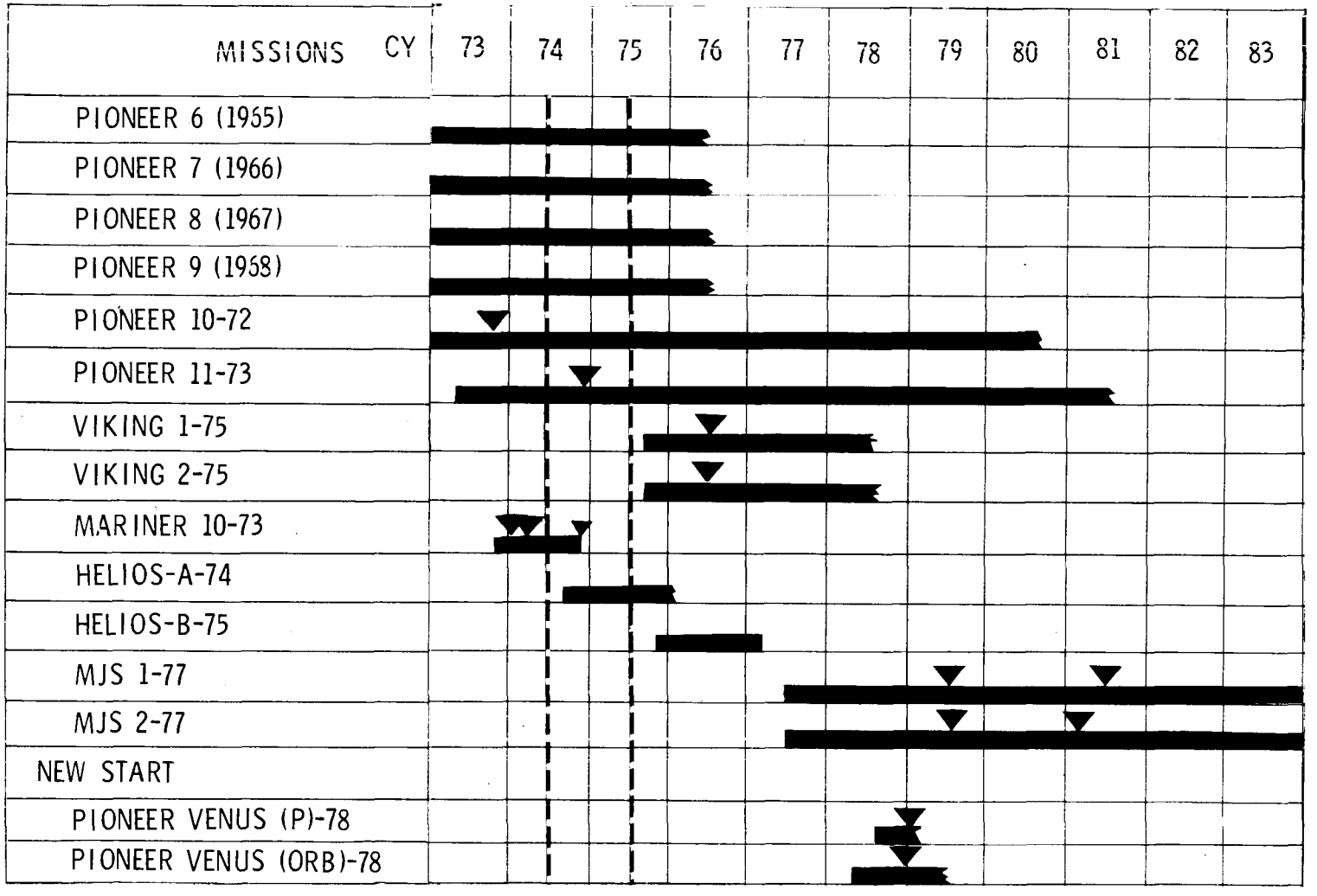
Because of their increasing complexity, the new spacecraft will place greater demands on the network and control centers. As an example, the data and command rates for the upcoming Orbiting Solar Observatory I have increased by approximately twenty-fold over those of the first Orbiting Solar Observatory. In addition, computer capacity has increased five times from a small computer to a large scale computer resulting from the requirement to display eight times more data in order to operate the spacecraft.

Funds requested for the Spaceflight Tracking and Data Network operations in FY 1975 are required for the maintenance and operation of the network facilities as well as the related logistics, network support and computer programming costs associated with the around-the-clock operation of the network. The FY 1975 request reflects the decreases associated with the station closures and the post-Skylab reductions noted above.

Deep Space Network Operations

The primary function of the Deep Space Network is to support planetary and interplanetary space flight missions. The current Pioneer 10 and 11 missions to Jupiter and beyond involve spacecraft traveling 600 million miles and more from earth. Future missions to Saturn and beyond will involve distances measured in billions of miles. 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 and requiring very large ground antennas. As flight distances continue to increase and the missions become more complex, equipment designs and

DEEP SPACE NETWORK WORKLOAD



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computer program techniques are required in this network which continue to push the state of the art in interplanetary communications. The Deep Space Network provides the vital two-way communications link to these distant spacecraft by which the spacecraft are controlled and the scientific information is obtained.

The Deep Space Network stations are located at Goldstone, California; Canberra, Australia; Madrid, Spain; and Johannesburg, South Africa. In addition there is a checkout facility at Cape Canaveral, Florida. The control center for the Deep Space Network is located at the Jet Propulsion Laboratory in Pasadena, California.

The two new 64-meter antenna facilities near Canberra, Australia, and Madrid, Spain, became operational in April and September 1973, respectively. The checkout facility at Cape Canaveral, Florida, is being consolidated with the Spaceflight Tracking and Data Network station on Merritt Island, Florida, during FY 1974. The Deep Space Network facility at Johannesburg, South Africa, is scheduled to be phased out in FY 1975. In FY 1975 the network will consist of stations at Goldstone, California; Canberra, Australia; and Madrid, Spain.

During FY 1974, the Deep Space Network workload consists of six on-going Pioneer spacecraft and the Mariner 10 mission. The major portion of this workload, reflected in the accompanying workload chart, will continue on into FY 1975. In addition, the Helios A mission will be launched in the first quarter of FY 1975 and will require support. The Helios is an extremely interesting mission which will investigate interplanetary space in the direction of and close to the sun. It is an international cooperative project between the Governments of the U.S. and West Germany and is expected to provide information about our nearest star which will lead to greater understanding of this source of life sustaining energy.

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 such as radar mapping of the surfaces of Venus and Mars, and measurements of the characteristics of pulsars and quasars. Support of these experiments will continue on a non-interference basis to the flight missions.

The FY 1975 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 Helios, Viking, Mariner Jupiter/Saturn 1977, and Pioneer Venus missions.

Aeronautical and Sounding Rocket Support Operations

Instrumentation systems are maintained and operated in support of the aeronautics and sounding rocket programs conducted by Wallops Station, Langley Research Center, and the Flight Research Center. These systems include general

purpose fixed tracking, telemetry, data handling, recording, timing, plotting, and communications systems, as well as special purpose optical equipment.

The sounding rocket program continues to be very active with close to 300 missions being launched last year. This workload is expected to remain approximately the same in FY 1975 with launches ranging from the smaller meteorological rockets to the larger Scout rockets which fly to altitudes as high as 18,000 kilometers.

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, 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 voice and data 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 control point. In the interest of economy, reliabiliy, and full utilization of trunk circuitry, subswitching centers have been established at a number of domestic and overseas locations.

To an increasing extent the NASA flight projects are requiring higher data transfer rates between the mission control centers and the tracking sites due to the need for realtime control of spacecraft and the onboard experiments. In addition, wideband communications will be required in FY 1975 for the Helios and Viking 1975 programs.

In order to meet the higher data transfer rates new communications technology has been implemented in the NASA communications network such as electronic circuit switching and the capability for sending an increased amount of data over a normal voice circuit. A more recent development which is being implemented allows for the transmission of data over a lesser number of circuits. This advance has been brought about by using digital techniques to transmit data at 50 kilobits per second over a specially modified voice channel whereas under previous analog techniques the equivalent of twelve voice circuits was required. This system will be expanded to those NASA facilities which require this type of data and where the commercial common carriers have the capability available.

While technology developments have reduced data transmission unit costs, some additional circuits are required on a routine basis to meet the increasing workload brought about by extended mission lifetimes and higher data rate transfer requirements of the flight programs. It also is necessary to augment the normal network configuration to support special mission needs such as the Apollo Soyuz Test Project, Helios, and Viking 1975.

The FY 1975 budget request for this operational area reflects an overall reduction from FY 1974 due to the completion of Skylab support in FY 1974. Funds requested will be used for the procurement of communications circuits and services required to operate and maintain the NASA communications network including the various domestic and overseas facilities.

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 controlling the operations 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 pre-mission 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 1975 budget request is based upon the requirement to process data from previously launched satellites, plus additional satellites that are 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, without major increases in data processing capability.

New satellites are dictating some major changes in the type of support provided. For instance, the Atmosphere Explorer 3 spacecraft launched in December 1973 has an orbit change capability which necessitates real time orbit and attitude determination. This mode of operation requires that data from the stations be transmitted to the control center at Goddard Space Flight Center and be fed directly into interconnected computers. Computations are made and scientific data are processed and placed in computer memory units where they are used on a near real time basis for determining commands to be sent to the spacecraft and are available to scientists for analysis within 24 hours after initial data acquisition.

In FY 1973, a major new image data processing facility to support Earth Resources Technology Satellites was placed in operation. This facility processes the large quantities of image data received from Earth Resources Technology Satellites and provides photographic products to the principal investigators for analysis. The FY 1974 budget included funds for the first full year of operation for this facility. The facility will continue through FY 1975 at approximately the same level of effort as the current year.

Systems Implementation

The tracking and data systems implementation program supports the NASA tracking and communications networks, control centers, data processing facilities, and aeronautics and sounding rocket instrumentation. The program provides for the engineering, development and procurement of necessary equipment, subsystems, and systems in response to the requirements of the various authorized flight missions and other research projects. It also includes the funding necessary to provide for documentation, technical integration services, acceptance testing services, initial spares provisioning, and where applicable initial computer program development.

Funds are required to maintain adequate operational performance and reliability of network systems by providing for the replacement of obsolete and worn out equipment, the modification and augmentation of existing systems to maintain compatibility with changes in associated on-board communications systems, the improvement of support utilization and efficiency of network systems, and the provision of new capabilities required to support the objectives of specific flight missions of approved programs.

The FY 1975 program includes funds for maintaining the readiness of the networks to support the large on-going program, as well as implementation of new capabilities required for the Viking, Mariner Jupiter/Saturn 1977, Pioneer Venus, Laser Geodetic Spacecraft (LAGEOS), International Ultraviolet Explorer, and Ocean Dynamics Satellite (SEASAT) missions. In addition, funds are required for integration of the new Telemetry On-Line Processing System with existing computer capabilities.

	1973	1974	1975
Spaceflight tracking and data network	$20,970,000	$18,600,000	$25,600,000
Deep space network	11,100,000	11,500,000	12,000,000
Aeronautics and sounding rocket support	3,330,000	2,700,000	3,300,000
Communications	2,400,000	2,300,000	3,200,000
Data processing	7,330,000	4,500,000	3,900,000
Total	$45,130,000	$39,600,000	$48,000,000

Spaceflight Tracking and Data Network Systems Implementation

During FY 1975 the network will continue to support approximately 35 to 40 spacecraft on an around-the-clock basis, including many ongoing missions with highly complex support requirements--such as the Earth Resources Technolgy Satellite 1, Atmosphere Explorer 3, and Radio Astronomy Explorer 2. In addition to supporting ongoing missions, the network will also provide support to a number of new missions. Among these are the Synchronous Meteorological Satellites, Applications Technology Satellite F, Nimbus F, Geodetic Earth Orbiting Satellite C, Earth Resources Technology Satellite B, Orbiting Solar Observatory I, Hawkeye Explorer, and the Small Astronomy Satellite C.

The Spaceflight Tracking and Data Network systems implementation program encompasses the procurement and implementation of systems and services necessary to sustain the network's continuing capability for reliable support to these ongoing scientific and applications satellite missions, to provide network capabilities to assure efficient and multi-purpose tracking, command, and data acquisition support for all manned and unmanned earth orbital and synchronous missions, and to meet new program support requirements for new spacecraft to be launched in the near future.

A continuing equipment modification effort is required in FY 1975 to maintain the network's required high level of performance for support of its diverse and demanding workload and to assure 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 subsystems spares, for provision and modification of test equipment, and for minor equipment modifications resulting from changes in support requirements from one mission to the next.

In addition, funds are requested for procurement of new laser tracking systems to support the Earth and Ocean Physics Applications program. These

systems will be used for precision tracking of such spacecraft as the Laser Geodynamic Satellite (LAGEOS), the Geodetic Earth Orbiting Satellite C, and later for the Ocean Dynamics Satellite (SEASAT) mission, providing basic data which will improve the scientist's understanding of motions of the earth's crust, the structure of the San Andreas Fault, the characteristics of the ocean surface, and other scientific objectives.

The Space Shuttle will employ a new and more reliable voice communications system for space-to-ground conversations. It will be necessary to provide these new systems in the network to meet the beginning of the Shuttle flight test schedule. Funds are requested in FY 1975 for the development of prototypes for these systems.

Major augmentations are also planned for the International Ultraviolet Explorer spacecraft. A new control center is being implemented to meet the operational requirements of the mission. The International Ultraviolet Explorer will place a telescope sensitive to ultraviolet wavelengths in geosynchronous orbit and operate it much like a ground-based observatory. This necessitates complex and continuous support from a special purpose control center in order to properly and safely conduct the mission. Implementation of this complex was initiated in FY 1974 and will be essentially completed in FY 1975. Other system augmentations include control center modifications to meet follow on requirements of the Atmosphere Explorer D and Earth Resources Technology Satellite B missions.

Deep Space Network Systems Implementation

FY 1975 funds are requested for systems implementation in the Deep Space Network to provide equipment and systems needed to maintain the network capability to support the various ongoing planetary flight spacecraft, and to provide needed augmentations to support approved forthcoming launches of additional planetary flight missions.

In order to support ongoing missions such as Pioneer 10, the Jupiter encounter of Pioneer 11, and the return encounter with Mercury by Mariner 10, network systems modifications and equipment replacements will be necessary to assure uninterrupted tracking and data communications. As a continuation of previous time-phased implementations, FY 1975 funds are requested to complete implementation of systems for the Viking 1975 mission and for network adaptation for the two Helios A and B missions. Additionally, long lead time development will be initiated to support the dual Mariner missions to Jupiter and Saturn in 1977 and to develop special equipment required for support of the 1978 multi-probe Pioneer mission to Venus.

Funds for support to ongoing missions are required to maintain network operational integrity and to achieve increased station performance attendant to the more demanding and complex mission requirements typified by the recent successful Pioneer 10 encounter of Jupiter. The time critical support demands

of planetary missions dictate an extremely high level of system reliability with adequate backup equipment modules to assure that uninterrupted support can be provided.

The upcoming Viking mission involves supporting four separate spacecraft, and is by far the most comprehensive planetary mission planned to date. Two missions, each consisting of an orbiter spacecraft and a lander capsule, will be separately launched during the 1975 Mars launch opportunity. After reaching Mars, the two spacecraft will orbit the planet together, and at the appropriate time will release the two soft landers for descent to the surface. To track, command, and receive data from these multiple spacecraft, extensive augmentation of the communications links between ground and space is required.

Completion of major systems implementation for Viking mission support in FY 1975 includes procurement of both radio frequency and data systems to allow simultaneous receiving and data handling of multiple telemetry radio channels originating from the orbiters and landers. This equipment, in addition to receiving and processing the spacecraft transmissions at the present S-band frequencies, will provide for the reception of tracking data at higher frequencies (X-band) at all 64-meter stations. The X-band capability being provided will also be used in the systems needed to receive the telemetry data channels from the Mariner Jupiter/Saturn 1977 mission. The use of the X-band for telemetry data is required for this mission to allow the transfer to earth of the real time science and imagery data from the spacecraft while at the extreme distances of Jupiter and Saturn and their moons. Collecting and handling this data at the station and transferring it to the mission control center requires the development of telemetry data handling equipment capable of processing the very high rates which the new X-band radio link performance provides.

Programming the more complex on-board computers on the Mariner Jupiter/Saturn spacecraft by radio signals from earth will result also in the need to increase the capabilities of the network uplink system. It is planned, therefore, to initiate in FY 1975 the development of a new high rate command processor system to perform this function. In addition, the Mariner Jupiter/Saturn mission, which is planned to perform close precision flyby of the moons of the planets, forces an increase in ground system navigation accuracy capabilities. This will be accomplished by adding special equipment and using new techniques to measure the spacecraft velocity from two tracking stations simultaneously.

It will also be necessary to initiate in FY 1975 the implementation of special tape recorders for support of the multi-probe Pioneer Venus mission to allow recovery of the telemetry data received and recorded during the turbulent probe atmospheric entry phases. Reception of radio transmission during this period will be severely distorted and will require special processing to obtain the scientific data. This equipment, essential for the Pioneer Venus mission, will also improve the quality of data recovered from other missions.

Aeronautics and Sounding Rocket Support Implementation

Various fixed and mobile ground systems are 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 under Flight Research Center and Langley Research Center programs.

To provide proper instrumentation support responsive to user's requirements for research tests conducted at Wallops Station and at various remote sites, replacement of constantly used components and spare parts must be provided as well as non-recoverable hardware such as onboard antennas and transponders for installation on the rockets. To meet specific test requirements, modification and 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.

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, YF-12, F-8 and F-15. FY 1975 funds are required to provide for the modification, replacement and updating of equipment at the stations to meet the requirements of the flight projects.

Communications Systems Implementation

Funds requested for communications equipment are utilized for the procurement of equipment for the NASA communications network to meet new program support requirements for standardization of support capability, to increase the efficiency and effectiveness of the network, and to sustain it at a high degree of reliability.

During FY 1975 the communications links to the Deep Space Network stations will be upgraded to handle data transfer rates of 7,200 bits per second for planetary mission support. Currently, the communications capability is 4,800 bits per second. Equipment using new technological developments to increase data transfer speeds with no increase in the size of the communications link will be procured for this purpose.

Equipment will also be purchased to sustain the operating efficiency of the communications network. In FY 1975 this program includes modifying the wideband switching system to permit the transfer of a complete send or receive command by means of a single command rather than by several separate commands; modifying switching system communication terminals to allow for simultaneous operation of all eight outputs of data from the terminals; the replacement of the patchcord field for data switching with a semiautomatic circuit switch

to permit rapid and reliable switching of circuits when in a data mode; and the procurement of various types of data transmission, test, and monitoring equipment to see that data circuits are maintained within their prescribed standards, thus ensuring continued system reliability.

Data Processing Systems Implementation

In FY 1975 funds are requested to bring the new Telemetry On-Line Processing Station (TELOPS) into operational readiness. This activity includes some rapid access memory augmentation for the existing Univac 1108 data processing system and initial integration of the two systems. In addition, funds are requested to complete the purchase of tape recorders which until FY 1974 had been leased. These recorders were originally leased until they had been operationally tested and a determination made as to their suitability for the data processing application. These are nine track, high density tape recorders as required for compatibility with modern computers and the American Standard Code for Information Interchange. Some of these recorders were purchased in FY 1974 and the balance is sought in FY 1975.

In addition, funds are required to maintain and improve the existing data processing systems which are operated 18 hours per day. Typical of these activities are: (1) the replacement of data cells and display systems which require high maintenance and (2) the addition of "front end" processing equipment to alleviate the input/output load of the large high speed computing systems.

The requirements of the International Ultraviolet Explorer mission will necessitate augmentation of display capability to the data reduction computer. This augmentation will also be initiated in FY 1975.

Supporting Research and Technology

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 (1) to provide new and improved network and data processing capabilities to meet the needs of approved missions and new starts; and (2) to improve the cost-effectiveness and reliability of the overall tracking and data acquisition support for the total mix of NASA flight missions. This effort includes spacecraft and ground system trade-off studies aimed at optimizing space-to-ground telecommunications links. The program for FY 1975 is comprised of activities in four basic areas which are described on the following page.

	1973	1974	1975
Tracking, orbit determination and ground-based navigation..	$2,430,000	$2,490,000	$2,140,000
Spacecraft/ground communications, telemetry and command.....	2,860,000	3,360,000	3,190,000
Network control and operations technology.....	1,720,000	1,590,000	1,840,000
Data handling and processing...	1,490,000	1,760,000	2,030,000
Total.....	$8,500,000	$9,200,000	$9,200,000

Tracking, Orbit Determination, and Ground Based Navigation

Developments and improvements in network tracking capabilities and measurement techniques will be continued to meet the tracking and ground-based navigation needs of future missions. The planetary orbiters and landers, and the outer planets missions including the gravity-assisted swingby missions all impose new and extremely accurate tracking requirements. Studies will be made of the influence of solar corona and planetary atmospheres on tracking measurements. New tracking techniques will be explored, including the use of two widely-spaced stations employing very long baseline interferometry (VLBI); this is radio frequency adaptation of a highly accurate optical measurement technique. High doppler rate missions such as the Jupiter flybys and orbiters require special developments for ground transmitter frequency control. The geodesy, earth and ocean physics programs require significant improvements in tracking accuracy along with increasing requirements for spacecraft attitude and flight control. Improved accuracies will be achieved by development of instruments and techniques in areas such as laser tracking, atomic frequency timing standards, and mathematical modeling for mission simulation.

Space-to-Ground Communications, Telemetry and Command

Network telecommunication techniques will continue to be developed in FY 1975 in order to meet future mission needs and to provide support in an economical and reliable manner. Data rates of over 100,000 bits per second from Jupiter, approximately 500 million miles away, as well as high rate communication to the region of Saturn and Uranus, where distance is measured in billions of miles, necessitate further development of microwave system technology for radio frequencies nearly four times higher than now used. Larger aperture antennas with extremely accurate control systems will be explored. Studies for improvements in the 64-meter antennas' performance will include the assessment of techniques for microwave antenna calibration at these higher frequencies, and measurements of performance degradation caused by the effects of weather. Downlink operating experience from planetary radar using these higher microwave frequencies will aid development

effort while collecting data for future mission planning. Work will continue on special telemetry receiving systems for missions which will probe the planetary atmospheres. For earth orbital mission support, improved telemetry capabilities are required to handle data rates of 100 to 250 million bits per second and higher. These rates are associated with the high resolution imaging data from earth observation spacecraft.

Development of solid-state transmitter components and a common usage spacecraft transponder will be done to achieve compatibility with the Spaceflight Tracking and Data Network and with a Tracking and Data Relay Satellite. Studies for optimization in the design of telecommunications links will be made to provide cost trade-offs among future spacecraft and ground terminals.

Network Control and Operations Technology

Effort will continue on techniques for centralized control and monitoring of tracking and data acquisition support operations, both at the stations and 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 minicomputers for functional control of station subsystems has proven to be an economical way to reduce the number of operators needed and to reduce the time required for station calibration and maintenance, thereby improving the mission-to-mission turnaround time, i.e., the time a station takes to be set up and checked out for contact with the next spacecraft on schedule. In FY 1975 this effort will include automation of network control center functions in both the Deep Space Network and the Spaceflight Tracking and Data Network. The latter is planned primarily to meet increasing requirements for control of the mission and experiments in an on-line interactive mode.

Data Handling and Processing

A very important area of Supporting Research and Technology studies and development in FY 1975 is related to data handling and processing systems where new techniques are necessary to meet requirements of real time mission control and user-interactive information systems. Studies will be concerned particularly with the problems of high-rate, on-line data handling, storage, and retrieval; and also with techniques and systems for a fully digital approach to handling and processing of imaging data from earth observation satellites.

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RESEARCH AND DEVELOPMENT

FISCAL YEAR 1975 ESTIMATES

BUDGET SUMMARY

OFFICE OF INDUSTRY AFFAIRS AND TECHNOLOGY UTILIZATION

TECHNOLOGY UTILIZATION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1973	1974	1975
Publication and dissemination.....	$1,600,000	$1,985,000	$2,900,000
Technology applications.....	1,790,000	1,845,000	2,000,000
Program control and evaluation.....	610,000	670,000	600,000
Total.....	$4,000,000	$4,500,000	$5,500,000
Distribution of Program Amount by Installation:			
NASA Headquarters.....	$4,000,000	$4,500,000	$5,500,000

HIGHLIGHTS OF BUDGET PLAN

	1973	1974	1975
Publication and Dissemination			
Stimulate the reporting of new technology through publication of Tech Briefs, and other media; promote the transfer of aerospace technology to both public and private users through a network of Regional Dissemination and Technology Application Teams and active relations with Federal, state and local organizations.....	$1,600,000	$1,985,000	$2,900,000
Technology Applications			
Modification, reengineering, and demonstration of existing NASA technologies and capabilities directed toward the solution of public sector problems identified by user organizations at the Federal, state, and local levels via Technology Applications Teams.			

	1973	1974	1975
Applications projects are designed to achieve maximum utilization of NASA's investment in capability and hardware through minimum adaptation necessary to meet performance specifications provided by user organizations (e.g., medical institutions, etc,); hardware prototypes which result are then made available for field testing or clinical evaluation by the user, and also serve as demonstration models to stimulate industrial commercialization.....	$1,790,000	$1,845,000	$2,000,000
Program Control and Evaluation			
Analysis, improvement and implementation of transfer methods; case studies of technology transfer and assessment of economic benefits of aerospace technology; and general control and support of all Technology Utilization Program functions.....	610,000	670,000	600,000

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 wide-spread 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 1975, the NASA Technology Utilization program will move toward a strengthening of its dissemination and problem-solving activities by developing a closer coupling between prospective users of NASA technology, in both private and public sectors, and the generators of this technology. An experimental program will be initiated in FY 1975 to consolidate the technology transfer functions of an established Regional Dissemination Center with those of an existing Technology Applications Team to better serve the technological needs of a defined region. The management of this Regional Applications Center (RAC) will be delegated to a NASA field center in order to more effectively couple regional technological needs directly to sources of aerospace technology. Consolidation of these NASA dissemination and problem-solving functions and the concomitant development of closer liaison with the NASA installations are expected to strengthen and improve NASA's technology dissemination and transfer efforts.

NASA will evaluate the Regional Applications Center experiment and consider expansion of the RAC concept in future years. Such expansion and consolidation would, of course, be based on the NASA Regional Dissemination Center and Application Team activities which currently exist. The ultimate objective of this experiment would be the creation of a viable national network

for technology transfer to serve regional as well as national technological needs in future years. This experiment, which is based on NASA's ten years of experience in technology transfer, will be designed to respond to the changing user environment and optimize the effective use of emergency aerospace technologies.

SUMMARY OF RESOURCES REQUIREMENTS

	1973	1974	1975
Publication and dissemination.....	$1,600,000	$1,985,000	$2,900,000
Technology Applications.....	1,790,000	1,845,000	2,000,000
Program control and evaluation....	610,000	670,000	600,000
Total.....	$4,000,000	$4,500,000	$5,500,000

BASIS OF FUND REQUIREMENTS:

Publication and Dissemination

Publication

Pursuant to Section 305(b) of the National Aeronautics and Space Act 1958, Technology Utilization Officers at all NASA installations identify new technology developed by NASA and its contractors which has potential utility for nonaerospace application and use. New advances so identified - in such diverse fields as materials research, communications, bioengineering and manufacturing - are evaluated and published in NASA Tech Briefs, compilations, handbooks and other dissemination media. During FY 1975, additional emphasis will be directed toward developing working relationships with industry-supported publication activities and direction of published technology to specific potential users.

Dissemination

During FY 1975, NASA will strive to increase dissemination program effectivity by conducting an experiment to integrate the functions of an existing Technology Applications Team and a Regional Dissemination Center to better serve the technological needs, both public and private, which exist in a defined region. The Regional Applications Center (RAC) to evolve from this experiment, will be further strengthened by providing a direct tie-in to a NASA field installation. Delegation of RAC management responsibility to a NASA field center will provide greater access to sources of technology and problem-solving capabilities and will thus facilitate the transfer of aerospace technology to regional problems. If proven successful, NASA would consider consolidation of other existing Regional Dissemination Centers and Application Teams, and expand the RAC concept in future years to ultimately create a viable national network of Regional Application Centers directed at broader technology transfer goals and objectives. It is believed that the RAC network, through increased capabilities, improved

services, dedication to regional needs, and an interactive network of centers on a national scale, would eventually be viewed by user organizations with increased value, thus encouraging a high probability for non-NASA public and private support for services rendered to the respective regional user communities.

Based on experience gained in the dissemination program, limited experimental efforts will also be udertaken in FY 1975 to direct public awareness to: NASA's patent policies as an aid to technology transfer stimulation; the advantages of technology transfer to small businesses, particularly small minority firms; and, the application of technology to local public sector problems.

Technology Applications

The technology applications effort is specifically directed toward the solution of public sector problems which have been identified and authenticated by user organizations at the Federal, state and local levels. The identification and coordination of specific problems will be accomplished by existing NASA Technology Application Teams, the experimental Regional Application Center, and the NASA Headquarters Technology Utilization Office where appropriate.

Applications projects, selected on a priority basis will be sponsored to adapt, modify, or otherwise reengineer existing NASA technology to demonstrate applicability to identified public sector problems. Technology applications projects are designed to achieve maximum utilization of NASA's investment in capability and hardware through minimum adaptation necessary to meet performance requirements specified by Federal, state or local user organizations. These projects result in the development of hardware prototypes which are made available for field testing or clinical evaluation by the user. In addition, such prototypes are used as demonstration models to stimulate industrial manufacture and commercialization. All candidate projects are fully coordinated with appropriate user agencies and groups, and efforts are made to insure concomitant industrial participation as well as user agency support during project development and implementation phases where appropriate.

Program Control and Evaluation

Program evaluation studies will be continued to determine effectiveness of selected TU projects. Included will be studies related to the technology transfer process itself, requiring the documentation of both aggregated and discrete cases of transfer. Results of these studies more precisely determine the impact and effect of such factors as time lag, technology characteristics, industrial structure, etc. on the transfer process. Documentation of instances of transfer will be constructed so as to augment and increase the public understanding of technology transfer activities.

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.

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