National Aeronautics and Space Administration

BUDGET ESTIMATES

FISCAL YEAR 1973

Volume I

AGENCY SUMMARY

RESEARCH AND DEVELOPMENT

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1973 ESTIMATES

AGENCY SUMMARY AND RESEARCH AND DEVELOPMENT

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1973 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 widely to potential users;

--promote international cooperation in peaceful activities in space; and

--effectively utilize a significant segment of the nation's scientific and engineering talents and facilities.

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 $3,379,000,000 are requested in FY 1973 to support the program described in these justifications. The budget plan is summarized below:

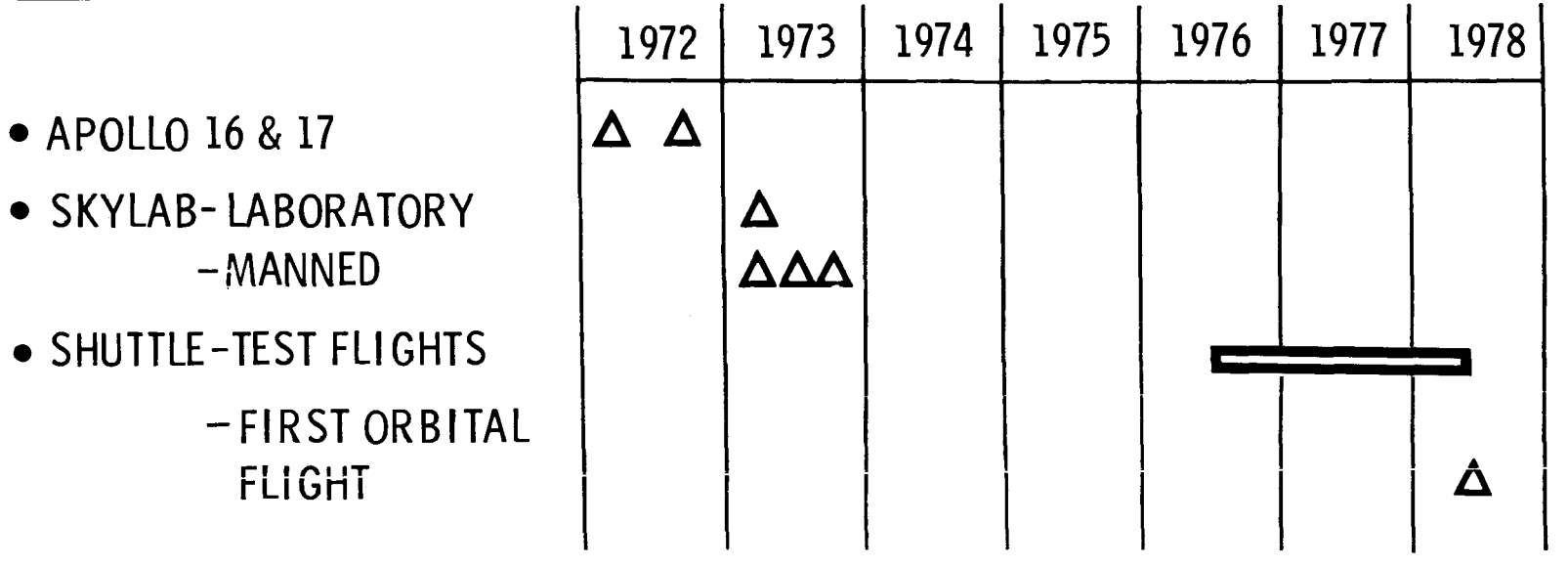
BUDGET PLAN SUMMARY

	(Thousands of Dollars)		
	1971	1972	1973
Obligational Authority			
Research and development.....	$2,542,362	$2,507,700	$2,600,900
Construction of facilities.....	28,755	52,700	77,300
Research and program management.	722,134	726,387	700,800
TOTAL BUDGET PLAN.....	$3,293,251	$3,286,787	$3,379,000
TOTAL OUTLAYS.....	$3,381,908	$3,181,000	$3,192,400

MANNED SPACE FLIGHT

- TO CONTINUE THE EXPLORATION OF THE MOON - APOLLO
- TO EXTEND MAN'S CAPABILITY TO LIVE & WORK IN SPACE - SKYLAB
- TO REDUCE SUBSTANTIALLY THE COST OF SPACE OPERATIONS - SHUTTLE

MAJOR FLIGHT ACTIVITY



SPACE SCIENCE

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

MAJOR FLIGHT ACTIVITY

	1972	1973	1974	1975	1976	1977
• ORBITING SOLAR OBSERVATORY - OSO		△				
• SOLAR PROBE- HELIOS			△	△		
• MARINER-VENUS/MERCURY		△				
• PIONEER - JUPITER	△	△				
• VIKING - MARS LANDER				△ △		
• OUTER PLANETS - JUPITER/SATURN						△ △
• ASTRONOMICAL OBSERVATORIES - OAO / HEAO	△			△		△
• SCIENTIFIC SATELLITES	△ △	△△△	△△△	△	△	

SPACE APPLICATIONS

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

MAJOR FLIGHT ACTIVITY

	1972	1973	1974	1975	1976
• NIMBUS EXPERIMENTAL WEATHER OBSERVATORY	△		△		
• HIGH ALTITUDE WEATHER SATELLITE - SMS	△	△			
• TIROS N-THIRD GENERATION OPERATIONAL WEATHER SATELLITE					△
• ADVANCED TECHNOLOGY SATELLITE -COMMUNICATIONS, NAVIGATION		△		△	
• EARTH RESOURCES TECHNOLOGY - ERTS	△	△			
• EARTH PHYSICS-OCEANOGRAPHY-GEOS		△			

AERONAUTICS

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

MAJOR PROGRAMS

- SHORT TAKEOFF & LANDING (STOL) EXPERIMENTAL AIRPLANE
- QUIET ENGINE FOR STOL AIRCRAFT
- QUIET ENGINE FOR CONVENTIONAL AIRCRAFT
- NOISE REDUCTION BY FLIGHT PROCEDURES
- ADVANCED AIR-TRANSPORT TECHNOLOGY
- VERTICAL TAKEOFF & LANDING (VTOL) RESEARCH & TEST VEHICLES

SPACE RESEARCH & TECHNOLOGY

- TO BUILD THE TECHNOLOGY BASE FOR FUTURE SPACE ACTIVITIES

PROGRAM ACTIVITIES

- SPACE ELECTRIC POWER TECHNOLOGY
- HIGH IMPULSE PROPULSION SYSTEMS
- SYNCHRONOUS LASER EXPERIMENT
- SPACE STORABLE PROPULSION MODULE EXPERIMENT
- LIFTING BODY FLIGHT TESTS

MATERIALS, STRUCTURES, GUIDANCE, CONTROL AND INFORMATION SYSTEMS

NUCLEAR POWER & PROPULSION

- TO DEVELOP SPACE POWER AND PROPULSION SYTEMS AND TECHNOLOGY TO MEET REQUIREMENTS OF CURRENT AND FUTURE MISSIONS

PROGRAM ACTIVITIES

- ENERGY CONVERSION SYSTEMS
- ADVANCED AND INTERMEDIATE REACTOR POWER SYSTEMS
- RADIOISOTOPE THERMO-ELECTRIC GENERATORS
- ELECTROPHYSICS
- DEFINITION OF A SMALL (15-20,000 POUND THRUST) NUCLEAR ROCKET SYSTEM
- MISSION ANALYSES AND TRADE-OFF STUDIES

TRACKING & DATA ACQUISITION

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

MAJOR ACTIVITIES

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

TECHNOLOGY UTILIZATION

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

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1973 ESTIMATES

SUMMARY OF APPROPRIATIONS

Appropriations	1971 (Thousands of Dollars) PL. 91-556 PL. 92-18*	1972 (Thousands of Dollars) PL. 92-78	1973 (Thousands of Dollars)
Research and Development	$2,565,000	$2,522,700	$2,600,900
Construction of Facilities	24,950	52,700	77,300
Research and Program Management	722,669	722,635	700,800
Basic appropriation	($678,725)	($722,635)	($700,800)
*Supplemental appropriation (pay increases)	($43,944)	---	---
Total	$3,312,619	$3,298,035	$3,379,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1973 ESTIMATES

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

Fiscal Year 1971	Total	Research and Development	Construction of Facilities	Research and Program Management
Basic Appropriation, PL 91-556.....	$3,268,675	$2,565,000	$24,950	$678,725
Supplemental Appropriation, PL 92-18..	+43,944	---	---	+43,944
Total Appropriated.....	3,312,619	2,565,000	24,950	722,669
Transfers between NASA appropriations..	---	-9,075	+1,200	+7,875
Transfer to "Operating Expenses National Archives and Records Service," General Services Administration (42 USC 2473 (b) and 40 USC 471 et al, 755 (b)).....	-146	---	---	-146
Total Adjusted Appropriation (Budget Authority).....	3,312,473	2,555,925	26,150	730,398
Transfer of unobligated balance in 1972 related to reprogramming.....	---	-2,605	+2,605	---
1971 funds applied to 1972 program.....	-9,000	-9,000	---	---
1971 funds applied to 1970 program.....	-1,958	-1,958	---	---
Unobligated R&PM balance available in 1972 to Sept. 30, 1971.....	-8,046	---	---	-8,046
Unobligated balance lapsing.....	-218	---	---	-218
Total Budget Plan.....	$3,293,251	$2,542,362	$28,755	$722,134

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1973 ESTIMATES

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

Fiscal Year 1972	Total	Research and Development	Construction of Facilities	Research and Program Management
Appropriation, PL 92-78.....	$3,298,035	$2,522,700	$52,700	$722,635
Transfers to other accounts:				
"Operating Expenses, Public Buildings Service," General Services Administration (85 Stat. 124).....	-131	---	---	-131
"Salaries and Expenses," Economic Stabilization Activities (85 Stat. 641).....	-2,000	---	---	-2,000
Total Adjusted Appropriation (Budget Authority).....	3,295,904	2,522,700	52,700	720,504
Unobligated R&PM balance available to Sept. 30, 1971.....	+8,046	---	---	+8,046
1971 funds applied to 1972 program.....	+9,000	+9,000	---	---
Unobligated balance lapsing.....	-26,163	-24,000	---	-2,163
Total Budget Plan.....	$3,286,787	$2,507,700	$52,700	$726,387
Fiscal Year 1973				
Appropriation request (Total Budget Plan).....	$3,379,000	$2,600,900	$77,300	$700,800

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1973 ESTIMATES

SUMMARY OF APPROPRIATION BUDGET PLANS BY INSTALLATION

(In millions of dollars)

Installation	Research and Development			Construction of Facilities			Research and Program Management			Total		
	1971	1972	1973	1971	1972	1973	1971	1972	1973	1971	1972	1973
John F. Kennedy Space Center, NASA....	180.8	169.9	195.0	.6	15.2	10.1	98.4	92.0	89.3	279.8	277.1	294.4
Manned Spacecraft Center.....	607.8	453.0	511.9	.5	---	.6	111.1	110.0	106.9	719.4	563.0	619.4
Marshall Space Flight Center.....	629.7	657.9	569.4	1.5	---	---	137.0	143.0	131.6	768.2	800.9	701.0
Goddard Space Flight Center.....	467.9	454.7	455.1	1.3	---	.6	93.0	94.0	92.0	562.2	548.7	547.7
Wallops Station.....	10.9	13.0	14.7	---	---	.4	10.3	10.9	10.5	21.2	23.9	25.6
Jet Propulsion Laboratory.....	149.3	151.9	129.6	1.9	---	.6	---	---	---	151.2	151.9	130.2
Ames Research Center.....	88.0	70.0	96.0	1.2	6.5	1.8	40.6	42.2	41.1	129.8	118.7	138.9
Flight Research Center.....	13.7	13.4	14.8	---	---	1.8	11.1	11.3	10.8	24.8	24.7	27.4
Langley Research Center.....	102.6	248.1	323.9	---	---	2.5	75.3	77.9	76.3	177.9	326.0	402.7
Lewis Research Center.....	164.2	153.5	178.5	.7	---	9.7	80.4	83.2	82.2	245.3	236.7	270.4
NASA Headquarters:	127.5	122.3	112.0	---	---	---	64.9	61.9	60.1	192.4	184.2	172.1
Headquarters.....	(127.5)	(122.3)	(112.0)	(---)	(---)	(---)	(63.4)	(60.6)	(58.9)	(190.9)	(182.9)	(170.9)
NASA Pasadena Office.....	(---)	(---)	(---)	(---)	(---)	(---)	(1.5)	(1.3)	(1.2)	(1.5)	(1.3)	(1.2)
Various Locations.....	---	---	---	5.1	19.6	27.9	---	---	---	5.1	19.6	27.9
Rehabilitation and Modification.....	---	---	---	11.5	7.9	11.6	---	---	---	11.5	7.9	11.6
Minor Construction.....	---	---	---	---	---	1.7	---	---	---	---	---	1.7
Facility Planning and Design.....	---	---	---	4.5	3.5	8.0	---	---	---	4.5	3.5	8.0
Total Budget Plan.....	2,542.4	2,507.7	2,600.9	28.8	52.7	77.3	722.1	726.4	700.8	3,293.3	3,286.8	3,379.0

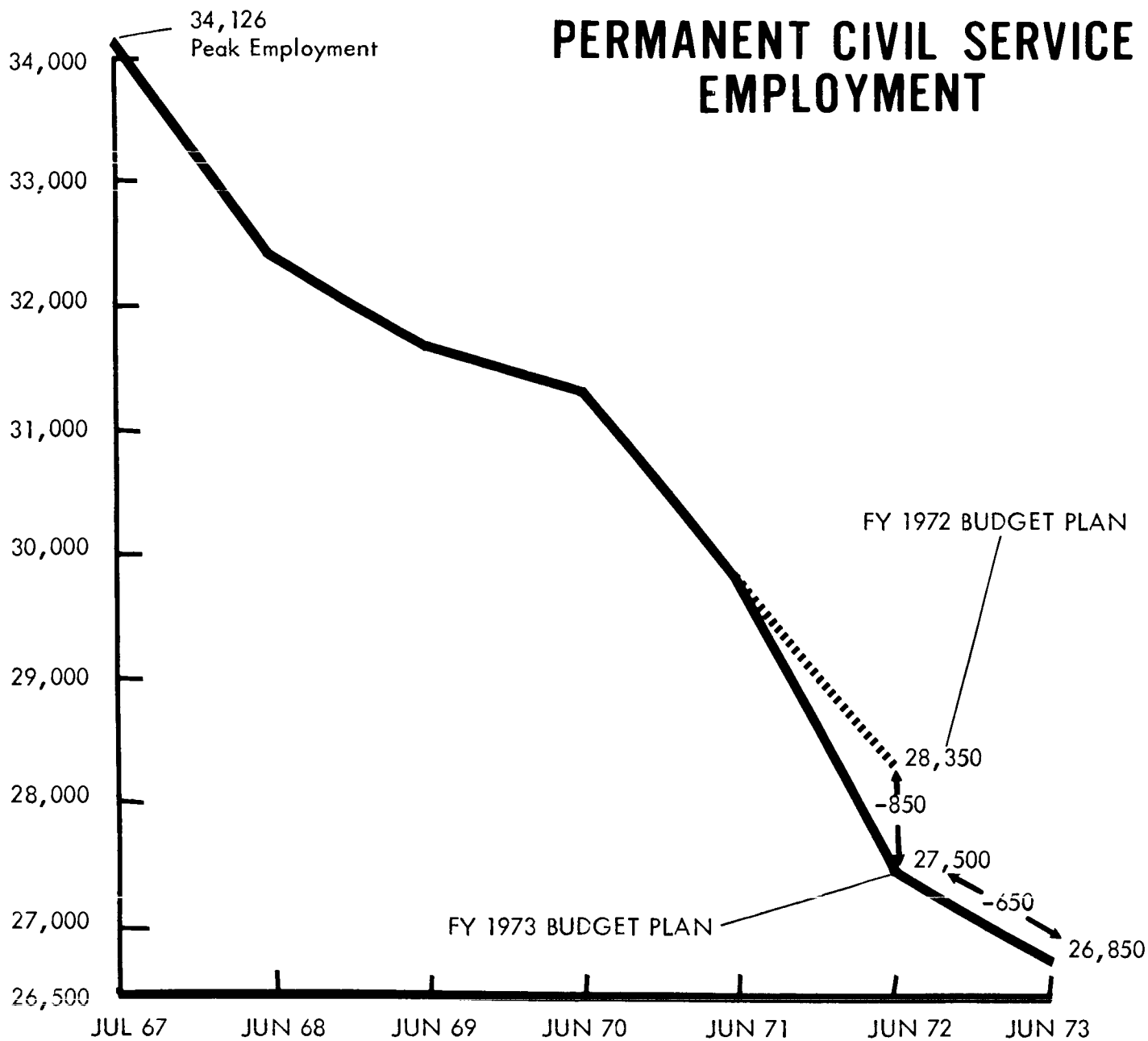
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1973 ESTIMATES

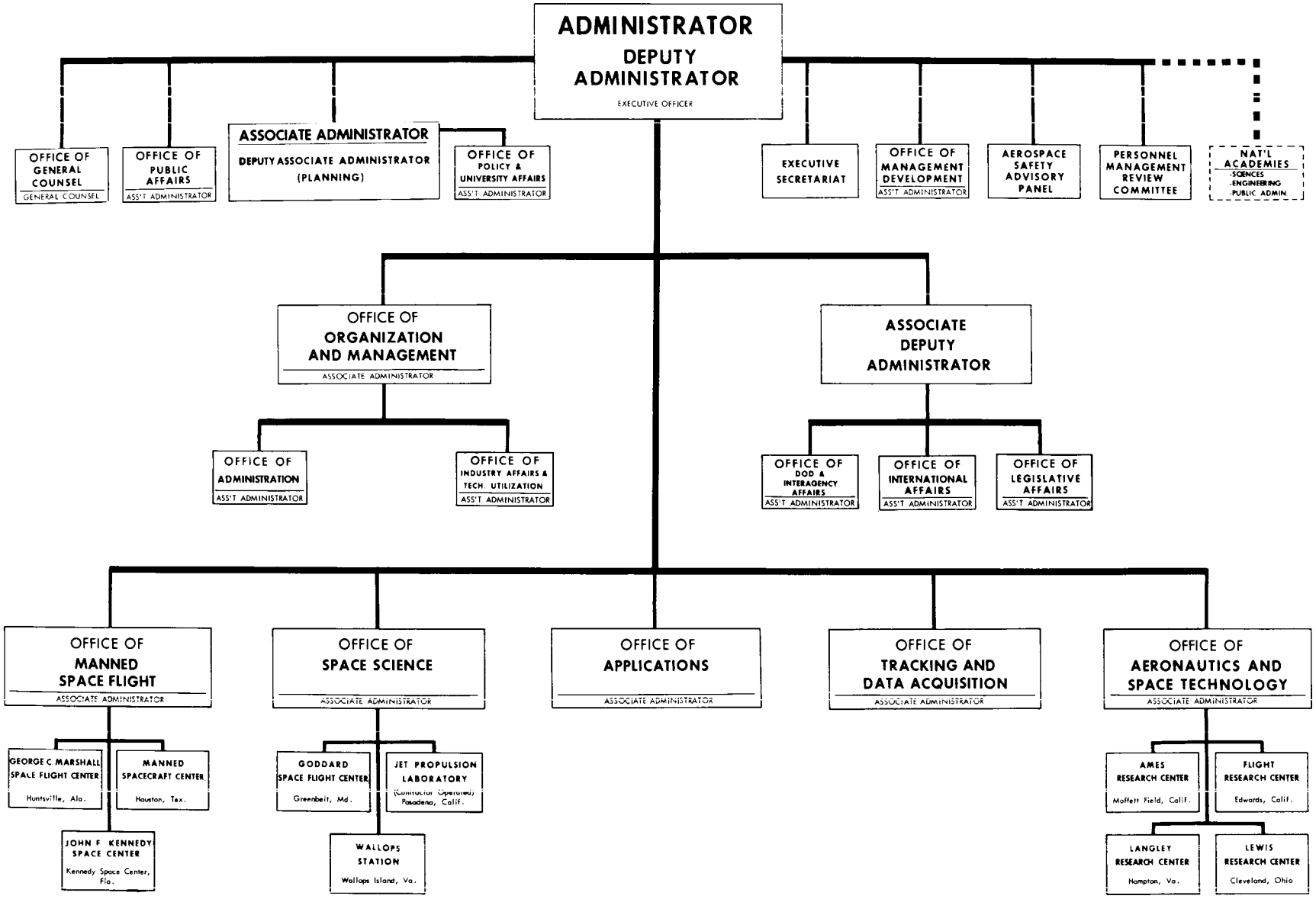
SUMMARY OF PERMANENT POSITIONS BY INSTALLATION

INSTITUTIONAL DIRECTOR AND INSTALLATION	1971	1972	1973
MANNED SPACE FLIGHT	12,605	11,625	11,350
John F. Kennedy Space Center, NASA	2,681	2,467	2,409
Manned Spacecraft Center	4,120	3,817	3,727
Marshall Space Flight Center	5,804	5,341	5,214
SPACE SCIENCE	4,900	4,509	4,403
Goddard Space Flight Center	4,412	4,061	3,966
Wallops Station	488	448	437
AERONAUTICS AND SPACE TECHNOLOGY	10,448	9,620	9,392
Ames Research Center	1,922	1,769	1,727
Flight Research Center	535	493	481
Langley Research Center	3,790	3,488	3,405
Lewis Research Center	4,201	3,870	3,779
NASA HEADQUARTERS	1,897	1,746	1,705
TOTAL	29,850	27,500	26,850

PERMANENT CIVIL SERVICE EMPLOYMENT



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION



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RESEARCH AND DEVELOPMENT

FISCAL YEAR 1973 ESTIMATES

GENERAL STATEMENT

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

MANNED SPACE FLIGHT: A program for the development of a capability for peaceful manned space operations and the utilization of that capability for earth orbit and lunar missions.

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

APPLICATIONS: Established as a program in its own right during FY 1972 to give needed emphasis to development of spacecraft systems and technology for meteorology, communications, and geodetic and earth resources observations.

AERONAUTICS AND SPACE TECHNOLOGY: A sustained effort providing the fundamental knowledge and technological base for future aeronautics and space programs.

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

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

MANNED SPACE FLIGHT

FY 1973 completes the epochal Apollo lunar exploration effort begun a decade ago; begins the flight mission of Skylab, the first long duration manned orbiting laboratory; and marks the first year of major activity in design and development of the Space Shuttle, the next leap forward in space transportation.

Apollos 14 and 15, in January and July 1971, continued the nation's successful exploration of the moon. Among their accomplishments were vastly increased lunar material and experimental data collection, deployment of automatic scientific stations, doubling of staytime, and tenfold extension of the range of exploration through use of the lunar rover.

Apollos 16 and 17 are designed for maximum scientific return. The former is scheduled for launch in the spring of 1972 and is aimed at the Descartes area. Apollo 17 is scheduled for late 1972. The landing site for this mission will be selected to take maximum advantage of the results of the other missions and to make fullest use of the scientific equipment assigned to this final Apollo mission.

Skylab operations, encompassing an 8-month period beginning in the spring of 1973, will build upon Apollo technology to achieve objectives in life sciences, astronomy, earth resources, and technology. The major focus of the orbital workshop and its associated experiment systems will be on studies of the sun, of space applications in surveying earth resources and environmental interactions, of use of the space environment for special processes, and of the effects on man of long-duration space flight. The astronaut crews will remain in orbit for periods of up to 56 days.

The space shuttle is the key element in future space operations in earth orbit. The earth-to-orbit shuttle will provide a reusable vehicle for placement, retrieval, and servicing of satellites; short-duration manned missions; and delivery of propulsive stages and payloads for high-energy missions. The shuttle is designed to introduce new concepts into space operations by making flight-to-orbit routinely available for unmanned payloads and for manned missions involving scientists and other personnel who do not have special astronaut training. The shuttle will radically reduce the cost of transportation to space. Of even greater significance will be the savings in payload costs resulting from repair and reuse of payloads and from relaxation of the stringent weight, size, and reliability requirements currently imposed on payload designers.

SPACE SCIENCE

The FY 1973 request reflects emphasis on exploration of the earth's environment, the solar system, and the universe through unmanned spacecraft and related ground-based observation.

A broad program of research and exploration involving international cooperation will be pursued. Explorer spacecraft conduct investigations ranging from the upper atmosphere to the interplanetary medium. The Orbiting Solar Observatory program will continue with OSO-I, scheduled for launch in 1973. The Orbiting Astronomical Observatory, to be launched in 1972, is directed primarily to the study of interstellar gases. A high priority development effort will be in progress on the High Energy Astronomical Observatory (HEAO) designed to identify and observe gamma, cosmic, and X-ray sources.

Planetary exploration will receive major emphasis with completion of the Mariner 9 mission in Mars orbit; launch of the Mariner mission to Venus and Mercury in 1973; launch of Pioneer missions in 1972 and 1973 to explore the region beyond the orbit of Mars, through the Asteroid Belt, and into the vicinity of Jupiter; and development of the Viking Mars orbiter and lander spacecraft for launch in 1975. Planning and initial spacecraft and experiment effort will be directed toward Mariner-class spacecraft missions to Jupiter and Saturn in the late 1970's.

In the unmanned launch vehicle program, specific emphasis will be applied to improvement of the reliability of the Delta and Centaur vehicles.

APPLICATIONS

The FY 1973 program will continue to expand the practical application of space technology in meteorology, communications, navigation, geodesy, and earth resources surveys. The first Earth Resources Technology Satellite will be launched in late FY 1972. During FY 1973, data from this satellite will be used to conduct experiments while the second satellite is readied for launch in FY 1974. At the same time, earth resources aircraft operations will be intensified.

In meteorology, launch of a Synchronous Meteorological Satellite will provide a prototype geostationary satellite. Nimbus-E, scheduled for launch in mid-FY 1973, will flight test sensors for determination of the vertical structure of the atmosphere. Development will be initiated on TIROS-N, a third generation operational weather satellite prototype, planned for launch in 1976.

A new Applications Test Satellite, ATS-F, is scheduled for launch in late FY 1973 to flight test a large space erectable parabolic antenna and to conduct a number of scientific and technology experiments. Work will continue on the Canadian Cooperative Applications Satellite, planned for launch in 1974, to provide data on communications in frequency ranges above 10 GHz.

AERONAUTICS AND SPACE TECHNOLOGY

The FY 1973 budget request provides for a major increase in aeronautics research and technology effort aimed at maintaining U.S. leadership in aviation, meeting urgent domestic requirements, and supporting military aircraft development. A concentrated effort focuses on a short take-off and landing (STOL) experimental transport aircraft. Quiet engine work will be emphasized for the STOL aircraft and for conventional aircraft. Other areas of emphasis include noise reduction by improved flight procedures, advanced air-transport technology, and vertical take-off and landing (VTOL) research and test vehicles. These specific areas of emphasis will be supplemented by a strong technology program encompassing materials, structures, avionics, propulsion, aerodynamics, configuration studies, operating procedures, and life sciences.

Space research is conducted on materials and structures, power and propulsion, information systems, guidance, control, and communications, with major effort on laser communications and reliable, long life, and high speed/density components for electronics systems. Emphasis will be placed on space electric power technology and on high specific impulse propulsion systems. The space technology program also supports requirements of the space shuttle and planetary flight programs in the areas of thermal protection, aerothermodynamics, entry technology, and long lifetime componentry.

The nuclear propulsion effort is being redirected toward definition studies by NASA and AEC of a small nuclear rocket system in the 15-20,000 pound thrust class. This activity will be part of a broader program to define and make tradeoff studies of alternative advanced propulsion systems for possible future missions to distant planets. Development of the 75,000 pound thrust NERVA engine is being terminated in favor of this reoriented program. Nuclear power activities will focus in four areas: energy conversion and generation concentrated primarily on conversion systems for advanced reactors; advanced reactor power aimed primarily at in-core thermionic and liquid-metal-cooled reactors; intermediate reactor power with emphasis on thermionic power conversion; and isotope power centered around radioisotope electric generators.

TRACKING AND DATA ACQUISITION

This program furnishes support to NASA space flight programs. Activity in FY 1972 and 1973 reflects the plans for consolidating the Satellite Network and Manned Space Flight Network into a single, consolidated Space Flight Tracking and Data Network. New imaging, data collection, and analysis requirements growing out of high data rate satellites, planetary missions, and earth resources monitoring are receiving priority attention. Studies on a Tracking and Data Relay Satellite System are continuing.

TECHNOLOGY UTILIZATION

These activities speed and widen the dissemination of scientific, technological, and engineering information and concepts flowing from NASA programs. Emphasis has been placed on initiatives in applying research funding and technology developments to major current public problems such as pollution, transportation, and law enforcement, through special government-university-industry teams.

FUNDING

The FY 1973 Research and Development program plan discussed in the budget totals $2,600,900,000, an increase of $93,200,000 over FY 1972.

Research and Development outlays in FY 1973 are estimated at $2,426,000,000, up $15,000,000 from the $2,411,000,000 estimate in FY 1972.

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, [and alteration] *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, [$2,522,700,000] *$2,600,900,000*, to remain available until expended[: *Provided*, That $39,000,000 of the amount made available shall be used only for the NERVA program in fiscal year 1972]. *(42 U.S.C. 2451, et seq.; Department of Housing and Urban Development; Space, Science, Veterans, and Certain Other Independent Agencies Appropriation Act, 1972; 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		
	1971 actual	1972 estimate	1973 estimate	1971 actual	1972 estimate	1973 estimate
Program by activities:						
Direct program:						
1. Manned space flight:						
(a) Apollo	913,669	601,200	128,700	1,012,379	750,000	257,000
(b) Space flight operations	507,300	682,775	1,094,200	566,333	641,000	976,100
(c) Advanced manned mission studies	1,500	1,500	1,500	2,416	2,000	1,700
2. Scientific investigations in space:						
(a) Physics and astronomy	122,956	120,600	180,400	112,891	121,500	160,850
(b) Lunar and planetary exploration	172,345	321,093	370,589	175,524	272,593	322,189
(c) Bioscience	12,898			14,758	8,700	
(d) Launch vehicle development and support	78,655	94,537	88,181	84,694	91,937	86,000
3. Space applications	177,060	204,020	223,630	187,267	226,270	205,011
4. Space and nuclear research and technology:						
(a) Space research and technology	106,704	75,255	66,060	122,852	90,000	79,350
(b) Nuclear power and propulsion	55,200	27,720	21,100	55,300	35,000	26,000
5. Aeronautical research and technology	100,132	110,000	163,440	109,500	105,000	125,800
6. Supporting activities:						
(a) Tracking and data acquisition	289,943	264,000	259,100	277,586	265,000	259,700
(b) Sustaining university program				11,553	10,000	3,000
(c) Technology utilization	4,000	5,000	4,000	5,337	5,000	4,700
Total direct program costs, funded	2,542,362	2,507,700	2,600,900	2,738,390	2,624,000	2,507,400
Reimbursable program:						
1. Manned space flight:						
(a) Apollo	1,677	2,950	2,120	1,782	3,727	2,120
(b) Space flight operations	650	400	350	625	631	350
2. Scientific investigations in space:						
(a) Physics and astronomy	3,687	2,717	900	1,942	2,963	900
(b) Lunar and planetary exploration		250			250	
(c) Bioscience				80		
3. Space applications	57,593	88,533	57,530	64,769	110,219	57,530
4. Space and nuclear research and technology:						
(a) Space research and technology	844	200		1,415	1,205	
(b) Nuclear power and propulsion	18,720	6,900		24,883	9,191	
5. Aeronautical research and technology	6,752	7,750	8,800	2,376	12,141	8,800
6. Supporting activities:						
(a) Tracking and data acquisition	606	300	300	159	371	300
(c) Technology utilization	28			229	84	
Total reimbursable program costs	90,557	110,000	70,000	98,260	140,782	70,000
Total program costs, funded	2,632,919	2,617,700	2,670,900	2,836,650	2,764,782	2,577,400
Change in selected resources [1]				−175,392	−23,784	93,500
10 Total	2,632,919	2,617,700	2,670,900	2,661,258	2,740,998	2,670,900

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		
	1971 actual	1972 estimate	1973 estimate	1971 actual	1972 estimate	1973 estimate
Financing:						
Receipts and reimbursements from:						
11 Federal funds	−47,512	−63,222	−47,355	−47,512	−63,222	−47,355
14 Non-Federal sources [2]	−43,045	−46,778	−22,645	−43,045	−46,778	−22,645
21 Unobligated balance available, start of year:						
For completion of prior year budget plans:						
Direct				−108,767	−104,121	
Reimbursable				−39,812	−30,782	
Available to finance new budget plans: Direct		−9,000				
22 Unobligated balance transferred from other accounts				−1,100		
Reprograming to prior year budget plans	1,958					
23 Unobligated balance transferred to other accounts	2,605				2,605	
24 Unobligated balance available, end of year:						
For completion of prior year budget plans:						
Direct				104,121		
Reimbursable				30,782		
Available to finance new budget plans: Direct	9,000					
25 Unobligated balance lapsing		24,000			24,000	
Budget authority	**2,555,925**	**2,522,700**	**2,600,900**	**2,555,925**	**2,522,700**	**2,600,900**
Budget authority:						
40 Appropriation	2,565,000	2,522,700	2,600,900	2,565,000	2,522,700	2,600,900
41 Transferred to other accounts	−9,075			−9,075		
43 **Appropriation (adjusted)**	**2,555,925**	**2,522,700**	**2,600,900**	**2,555,925**	**2,522,700**	**2,600,900**
Relation of obligations to outlays:						
71 Obligations incurred, net				2,570,701	2,630,998	2,600,900
72 Obligated balance, start of year				1,392,771	1,333,091	1,553,089
74 Obligated balance, end of year				−1,333,091	−1,553,089	−1,727,989
90 Outlays				2,630,381	2,411,000	2,426,000

Note.—Reconciliation of budget plan to obligations:

	1971 actual	*1972 estimate*	*1973 estimate*
Total budget plan	2,632,919	2,617,700	2,670,900
Deduct portion of budget plan to be obligated in subsequent years	81,584		
Add obligations of prior year budget plans	109,923	123,298	
Total obligations	2,661,258	2,740,998	2,670,900

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

	1970	*1971 adjustments*	*1971*	*1972*	*1973*
Stores	54,097	9,015	63,470	63,470	63,470
Unpaid undelivered orders	1,008,883		845,022	821,238	914,738
Advances outstanding	11,981		92	92	92
Total selected resources	1,074,961	9,015	908,584	884,800	978,300

[2] Reimbursements from non-Federal sources are receipts for services performed on Communications Satellite Corporation projects (42 U.S.C. 2473).

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1973 ESTIMATES

SUMMARY OF RESEARCH AND DEVELOPMENT BUDGET PLAN BY PROGRAM BY COGNIZANT OFFICE

OFFICE/PROGRAM	Fiscal Year 1971	Fiscal Year 1972	Fiscal Year 1973
MANNED SPACE FLIGHT.....	$1,422,469,000	$1,285,475,000	$1,224,400,000
Apollo.....	913,669,000	601,200,000	128,700,000
Space flight operations.	507,300,000	682,775,000	1,094,200,000
Advanced missions.....	1,500,000	1,500,000	1,500,000
SPACE SCIENCE.....	$398,654,000	552,900,000	669,400,000
Physics and astronomy...	115,956,000	110,100,000	156,600,000
Lunar and planetary exploration.....	144,900,000	291,500,000	321,200,000
Bioscience.....	12,898,000	---	---
Launch vehicle procurement.....	124,900,000	151,300,000	191,600,000
APPLICATIONS.....	$166,960,000	$187,500,000	$194,700,000
Space applications.....	166,960,000	187,500,000	194,700,000
AERONAUTICS AND SPACE TECHNOLOGY.....	$260,336,000	$212,825,000	$249,300,000
Aeronautical research and technology.....	100,132,000	110,000,000	163,440,000
Space research and technology.....	105,004,000	75,105,000	64,760,000
Nuclear power and propulsion.....	55,200,000	27,720,000	21,100,000
TRACKING AND DATA ACQUISITION.....	$289,943,000	$264,000,000	$259,100,000
TECHNOLOGY UTILIZATION....	4,000,000	5,000,000	4,000,000
TOTAL BUDGET PLAN.....	$2,542,362,000	$2,507,700,000	$2,600,900,000

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SPACE ADMINISTRATION

73 ESTIMATES

)GET PLAN BY INSTALLATION AND FISCAL YEAR

f dollars)

1 ght	Goddard Space Flight Center	Jet Propulsion Laboratory	Wallops Station	Ames Research Center	Flight Research Center	Langley Research Center	Lewis Research Center	NASA Headquarters
7	754	503	---	5,805	---	1,270	125	37,449
0	2,025	730	210	8,180	575	5,012	190	32,478
)0	---	200	150	6,950	250	4,150	300	25,350
5	250	470	---	---	---	440	---	28,349
5	130	---	---	100	---	335	165	16,575
)0	---	---	---	---	---	---	---	5,100
12	475	33	---	5,805	---	830	125	9,054
5	1,895	730	210	8,080	575	4,677	25	15,903
)0	---	200	150	6,950	250	4,150	300	20,250
50	29	---	---	---	---	---	---	46
00	---	---	---	---	---	---	---	---
00	---	---	---	---	---	---	---	---
53	124,022	65,481	1,821	46,981	---	37,089	64,634	50,798
74	109,255	76,885	2,635	22,610	---	191,187	80,435	50,225
15	111,211	54,897	2,950	21,886	---	247,523	104,160	62,053
65	82,542	2,665	1,677	2,425	---	1,150	---	22,407
82	66,985	489	2,585	4,805	---	1,575	---	18,853
00	66,800	500	2,900	6,300	---	400	---	19,900
63	4,520	60,439	---	40,456	---	22,885	---	15,527
20	4,239	75,566	50	17,805	---	173,445	---	19,750
--	3,727	53,597	50	15,586	---	225,910	---	21,905
85	100	1,502	144	4,100	---	28	---	6,742
---	---	---	---	---	---	---	---	---
---	---	---	---	---	---	---	---	---
940	36,860	875	---	---	---	13,026	64,634	6,122
372	38,031	830	---	---	---	16,167	80,435	11,622
815	40,684	800	---	---	---	21,213	104,160	20,248
330	129,220	1,397	2,498	765	---	5,715	1,680	12,310
300	150,393	1,100	3,655	1,470	---	4,280	3,620	10,092
300	153,155	1,000	5,790	3,575	---	6,425	4,575	5,905
330	129,220	1,397	2,498	765	---	5,715	1,680	12,310
300	150,393	1,100	3,655	1,470	---	4,280	3,620	10,092
300	153,155	1,000	5,790	3,575	---	6,425	4,575	5,905
107	6,546	18,803	100	34,440	11,682	57,375	97,702	13,553
575	4,667	18,396	60	37,806	11,247	46,696	69,195	12,881
900	4,545	20,305	150	63,545	13,175	65,140	69,425	3,115
,299	---	594	---	20,040	9,552	32,645	31,049	4,953
,025	---	1,160	60	30,844	10,047	30,124	29,941	6,799
,000	---	1,300	150	56,520	12,375	51,220	39,350	1,425
,868	6,333	14,615	100	14,060	2,130	24,165	18,090	7,615
,075	4,607	14,183	---	6,484	1,200	16,156	16,302	5,796
,100	4,485	15,555	---	6,510	800	13,510	14,210	1,690
940	213	3,594	---	340	---	565	48,563	985
475	60	3,053	---	478	---	416	22,952	286
800	60	3,450	---	515	---	410	15,865	---
385	207,361	63,149	6,437	---	2,005	1,170	---	9,436
300	188,350	54,770	6,380	---	1,615	1,005	---	11,580
300	186,250	53,150	5,700	---	1,400	700	---	11,600
---	---	---	---	---	---	---	---	4,000
---	---	---	---	---	---	---	---	5,000
---	---	---	---	---	---	---	---	4,000
),722	467,903	149,333	10,856	87,991	13,687	102,619	164,141	127,546
7,839	454,690	151,881	12,940	70,066	13,437	248,180	153,440	122,256
9,215	455,161	129,552	14,740	95,956	14,825	323,938	178,460	112,023

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1973 ESTIMATES

DISTRIBUTION OF RESEARCH AND DEVELOPMENT BUDGET PLAN BY INSTALLATION AND F

(Thousands of dollars)

PROGRAM		TOTAL	Kennedy Space Center	Manned Spacecraft Center	Marshall Space Flight Center	Goddard Space Flight Center	Jet Propulsion Laboratory
OFFICE OF MANNED SPACE FLIGHT, TOTAL	1971	1,422,469	178,335	586,581	611,647	754	503
	1972	1,285,475	166,550	437,135	632,390	2,025	730
	1973	1,224,400	191,350	496,300	499,400	---	200
Apollo	1971	913,669	169,900	454,375	259,885	250	470
	1972	601,200	145,650	254,300	183,945	130	---
	1973	128,700	7,100	70,400	46,100	---	---
Space flight operations	1971	507,300	8,435	131,631	350,912	475	33
	1972	682,775	20,750	182,285	447,645	1,895	730
	1973	1,094,200	184,050	425,400	452,500	---	200
Advanced missions	1971	1,500	---	575	850	29	---
	1972	1,500	150	550	800	---	---
	1973	1,500	200	500	800	---	---
OFFICE OF SPACE SCIENCE, TOTAL	1971	398,654	2,468	1,107	4,253	124,022	65,481
	1972	552,900	3,343	1,051	15,274	109,255	76,885
	1973	669,400	3,680	725	60,315	111,211	54,897
Physics and astronomy	1971	115,956	---	225	2,865	82,542	2,665
	1972	110,100	---	626	14,182	66,985	489
	1973	156,600	---	300	59,500	66,800	500
Lunar and planetary exploration	1971	144,900	25	685	363	4,520	60,439
	1972	291,500	---	425	220	4,239	75,566
	1973	321,200	---	425	---	3,727	53,597
Bioscience	1971	12,898	---	197	85	100	1,502
	1972	---	---	---	---	---	---
	1973	---	---	---	---	---	---
Launch vehicle procurement	1971	124,900	2,443	---	940	36,860	875
	1972	151,300	3,343	---	872	38,031	830
	1973	191,600	3,680	---	815	40,684	800
OFFICE OF APPLICATIONS, TOTAL	1971	166,960	---	13,045	330	129,220	1,397
	1972	187,500	25	12,565	300	150,393	1,100
	1973	194,700	50	13,925	300	153,155	1,000
Space applications	1971	166,960	---	13,045	330	129,220	1,397
	1972	187,500	25	12,565	300	150,393	1,100
	1973	194,700	50	13,925	300	153,155	1,000
OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY, TOTAL	1971	260,336	---	7,028	13,107	6,546	18,803
	1972	212,825	---	2,302	9,575	4,667	18,396
	1973	249,300	---	1,000	8,900	4,545	20,305
Aeronautical research and technology	1971	100,132	---	---	1,299	---	594
	1972	110,000	---	---	1,025	---	1,160
	1973	163,440	---	100	1,000	---	1,300
Space research and technology	1971	105,004	---	7,028	10,868	6,333	14,615
	1972	75,105	---	2,302	8,075	4,607	14,183
	1973	64,760	---	900	7,100	4,485	15,555
Nuclear power and propulsion	1971	55,200	---	---	940	213	3,594
	1972	27,720	---	---	475	60	3,053
	1973	21,100	---	---	800	60	3,450
OFFICE OF TRACKING AND DATA ACQUISITION	1971	289,943	---	---	385	207,361	63,149
	1972	264,000	---	---	300	188,350	54,770
	1973	259,100	---	---	300	186,250	53,150
OFFICE OF TECHNOLOGY UTILIZATION	1971	4,000	---	---	---	---	---
	1972	5,000	---	---	---	---	---
	1973	4,000	---	---	---	---	---
TOTAL BUDGET PLAN	1971	2,542,362	180,803	607,761	629,722	467,903	149,333
	1972	2,507,700	169,918	453,053	657,839	454,690	151,881
	1973	2,600,900	195,080	511,950	569,215	455,161	129,552

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1973 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR

MANNED SPACE FLIGHT PROGRAMS

Program	1971	1972	1973
Apollo.....	$913,669,000	$601,200,000	$128,700,000
Space flight operations..	507,300,000	682,775,000	1,094,200,000
Advanced missions.....	1,500,000	1,500,000	1,500,000
Total.....	$1,422,469,000	$1,285,475,000	$1,224,400,000

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1973 ESTIMATES

BUDGET SUMMARY

OFFICE OF MANNED SPACE FLIGHT — APOLLO PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1971	1972	1973
Spacecraft	$398,147,000	$138,792,000	$79,500,000
Saturn V	189,059,000	142,458,000	49,200,000
Operations	314,963,000	307,450,000	-0-
Advanced Development	11,500,000	12,500,000	-0-
Total	$913,669,000	$601,200,000	$128,700,000

HIGHLIGHTS OF BUDGET PLAN

Spacecraft	$398,147,000	$138,792,000	$79,500,000
Flight Modules - Completion of checkout and launch of Apollo 16 in April 1972; completion of spacecraft hardware deliveries, checkout and launch of Apollo 17 in December 1972; provision of space suits, life support systems, and other government-furnished equipment; contractor in-plant flight support activities; and post-mission activities including phase-out of the lunar module contractor.	$245,542,000	$55,033,000	$43,900,000
Science Payloads - Completion of experiment hardware including the lunar sounder, tidal gravimeter, mass spectrometer, and other experiments for Apollo 17; integration, operation, and principal investigator activity on Apollo 16 and 17 experiments.	106,194,000	52,100,000	23,000,000
Ground Support - Engineering support of integration, checkout, and reliability activities; maintenance of checkout equipment; transportation, inspection, fuels and propellants, and contract administration	46,411,000	31,659,000	12,600,000

	1971	1972	1973
Saturn V	$189,059,000	$142,458,000	$49,200,000
Flight Stages - Completion of modification, in-plant check-out and delivery instrument unit and propulsive flight stages to KSC; pre-launch checkout and launch activities at KSC, and contractor in-plant flight support for the Apollo 16 and 17 missions.....	161,205,000	119,480,000	38,200,000
Ground Support - Maintenance and update of ground support equipment; vehicle integration; support and systems engineering; small procurements of services & equipment; and inspection and contract administration services.....	27,854,000	22,978,000	11,000,000
Operations.....	$314,963,000	$307,450,000	---
Research & Test Operations - Engineering and test activities at Manned Space Flight centers; and application and science, and reliability, quality, & safety activities.....	90,015,000	91,567,000	-0-a/
Crew & Flight Operations - Crew, flight mission control, and mission-related activities.....	66,229,000	80,862,000	-0-a/
Operations Support - On-site technical services at Manned Space Flight centers; and off-site technical & production facility maintenance at the White Sands, Mississippi Test, and Michoud Assembly.....	78,798,000	60,364,000	-0-a/
Launch Systems Operations - Maintenance and operation of KSC launch facilities; integration and checkout; operation of ground support equipment; logistics support; and conduct of a launch.....	65,109,000	65,332,000	-0-a/

	1971	1972	1973
Operations (Cont'd.)			
OMSF Engineering Support - Systems engineering for integrated program technical support review & analysis. No FY 1973 funds requested.....	$14,812,000	$9,325,000	-0-a/
Advanced Development - Study & development activities involving long lead items, experimental systems & operational techniques; and establishment of specifications & design requirements.	$11,500,000	$12,500,000	-0-b/

a/ Funded under Apollo in FY 1972 and prior years. FY 1973 requirements are included in the Development, Test, and Mission Operations line item of Space Flight Operations.

b/ Funded under Apollo in FY 1972 and prior years. FY 1973 requirements included in Orbital Systems & Payloads line item of Space Flight Operations.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1973 ESTIMATES

OFFICE OF MANNED SPACE FLIGHT

APOLLO PROGRAM

FLIGHT SCHEDULE

PROJECT	MISSION	DATE
Apollo	16	April 1972
Apollo	17	December 1972

OFFICE OF MANNED SPACE FLIGHT APOLLO PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

With the completion of four successful Apollo lunar exploration missions, we have substantially increased our knowledge of the moon and the solar system. The Apollo 15 mission in particular, because of its greatly increased capability for astronaut mobility, surface staytime, sample return and orbital science, added as much new data about the moon and its environment as the three previous missions combined. An even greater data return is anticipated from the two remaining missions: Apollo 16 (April 1972), to land at Descartes and explore a highland area; and Apollo 17 (December 1972), whose landing site is still under review. These final two missions are designed to acquire as much knowledge as possible concerning the moon and the relationships between the earth, moon, and sun since current planning does not anticipate returning to the moon before the 1980's.

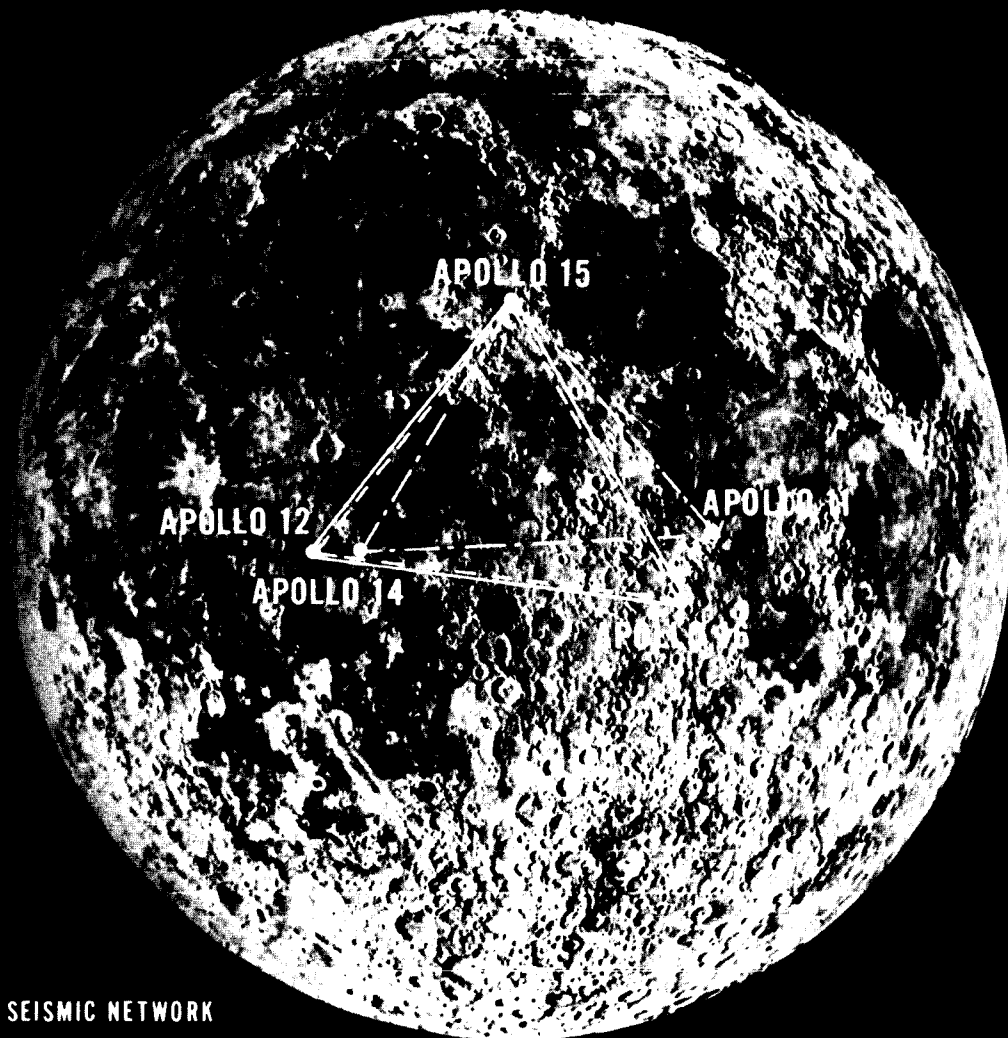
The primary scientific objectives of the Apollo 16 mission are to explore for the first time, the lunar highlands, emplace a carefully selected group of surface experiments and conduct a continuing program of orbital surveys and experiments initiated during the Apollo 15 mission.

Fiscal year 1973 activities will be devoted primarily to preparation for and conduct of the Apollo 17 mission. There are several candidate sites under consideration for the Apollo 17 mission. After a further review of Apollo 15 data, one will be selected mainly on the basis of its potential to provide the greatest scientific return using the new and improved experiments.

The Apollo Lunar Science Experiment Package (ALSEP), to be deployed during this mission, is being redesigned to increase its design lifetime to two years, compared to the one year lifetime of the present designs. Long term monitoring of the moon has always been a goal of participating scientists since statistical analysis based on long term data recording is a major requirement for nearly every experiment. Experience to date with the first three packages indicates that the life of the Apollo 17 package will exceed the design goals. For instance, the Apollo 12 package is already two years old and still functioning.

The tidal gravimeter to be used on this mission has perhaps more potential for discovering fundamental laws of the universe than any other experiment we will have carried at any time in the program. This experiment will seek

APOLLO SCIENCE GEOPHYSICAL STATIONS



——— PASSIVE SEISMIC NETWORK

— — — — LUNAR SURFACE MAGNETOMETER NETWORK

—·—·—LASER RANGING RETROREFLECTOR NETWORK

NASA HQ MA72-5196
REV 1-24-72

to discover the nature of gravity and perhaps will prove the hypothesis that gravity is propagated in wave form. Conclusive proof of this characteristic of gravity would have a revolutionary effect upon study of this fundamental physical phenomenon. The experiment will also give us new insight into the internal structure of the moon.

Three surface experiments designed to provide totally new information will be carried on Apollo 17: a mass spectrometer to measure the constituents of the lunar atmosphere--the findings of which will be correlated with the findings of the mass spectrometers carried previously in lunar orbit; a lunar ejecta and meteorites experiment to determine the frequency and energy of the small meteorites which constantly impact the moon; and a lunar seismic experiment using large explosive charges at distances of several kilometers from the landing site to extend our knowledge of the structure and layering in the shallow subsurface of the moon.

New experiments will also be carried by the Lunar Roving Vehicle. One (Surface Electrical Properties) will search the subsurface for traces of water. A second, a traverse gravimeter, will investigate the use of gravity as an exploration technique and is expected to provide an important tool in developing our understanding of the moon's subsurface structure.

In addition to the cameras flown on Apollos 15 and 16, a new complement of advanced orbital experiments has been assigned to Apollo 17. A three frequency, pulsed radar Lunar Sounder has the potential for identifying areas where layering of the lunar crust exists. The Lunar Sounder will provide the opportunity to study the detailed physical structure to depths of one kilometer and to locate regions where subsurface water or ice might exist. This will complement and extend several surface experiments. An Infrared Scanning Radiometer will provide, for the first time, a high resolution thermal map of the moon including the far side. The location of lunar hot spots and their relationship to geologic features may isolate regions of possible volcanic activity or areas whose cooling and heat loss are significantly different from the norm. The complementary physical properties of the surface data obtained from thermal and Lunar Sounder experiments should allow general conclusions about mineralogy to be drawn. Finally a Far Ultra-Violet Spectrometer will measure variations in the composition and density of the lunar atmosphere. Since this experiment has the capability of measuring these variations as a function of altitude, it will greatly extend the knowledge of the lunar atmosphere that was gained through the use of the Mass Spectrometers on Apollo 15 and 16.

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SUMMARY OF RESOURCES REQUIREMENTS:

	1971	1972	1973
Spacecraft	$398,147,000	$138,792,000	$79,500,000
Saturn V	189,059,000	142,458,000	49,200,000
Operations	314,963,000	307,450,000	---
Advanced development	11,500,000	12,500,000	---
Total	$913,669,000	$601,200,000	$128,700,000

Distribution of Program Amount by Installation:

John F. Kennedy Space Center	$169,900,000	$145,650,000	$7,100,000
Manned Spacecraft Center	454,375,000	254,300,000	70,400,000
Marshall Space Flight Center	259,885,000	183,945,000	46,100,000
Goddard Space Flight Center	250,000	130,000	---
Jet Propulsion Laboratory	470,000	---	---
Ames Research Center	---	100,000	---
Langley Research Center	440,000	335,000	---
Lewis Research Center	---	165,000	---
NASA Headquarters	28,349,000	16,575,000	5,100,000

BASIS OF FUND REQUIREMENTS:

Spacecraft

	1971	1972	1973
Flight modules	$245,542,000	$55,033,000	$43,900,000
Science payloads	106,194,000	52,100,000	23,000,000
Ground support	46,411,000	31,659,000	12,600,000
Total	$398,147,000	$138,792,000	$79,500,000

Flight Modules.

FY 1972 funding supports the hardware contractors' in-plant and Kennedy Space Center efforts associated with the prelaunch, launch, and postlaunch requirements of Apollo 15 and 16 and the initiation of prelaunch activities for the Apollo 17 mission, and the procurement and maintenance of government furnished equipment and other related procurement, such as spacesuits and portable life support systems, associated with the spacecraft. Although all major hardware deliveries have been completed, FY 1973 funding is required for Flight Module engineering support, which is the essential contractor engineering and technical effort necessary to support the flight

program. Minimum levels of critical skills will be maintained to assure flight safety and to resolve problems which arise during the launch preparation and flight phases of the mission. Tasks which will be performed by contractor personnel at the plants and at Manned Space Flight centers include mission support, field and flight problem resolution, failure analysis, and repair and subsequent retesting. In addition, certain personnel are required to maintain and calibrate special test equipment and to maintain required tooling and documentation.

Contractor engineering support for the Command and Service Module will be provided by North American Rockwell at Downey, California. Support for the Lunar Module will be by Grumman at Bethpage, New York. Engineering support for the computer programs in the guidance and navigation system will be furnished by MIT, Boston, Massachusetts and DELCO Electronics, Milwaukee, Wisconsin.

The engineering flight support described above will be maintained through December 1972. After that time, the Skylab program will provide funding to continue these activities by contractors involved in that program. The Apollo program funding for FY 1973 will provide for phase out after the Apollo 17 mission of activities not required for the Skylab program.

Science Payloads.

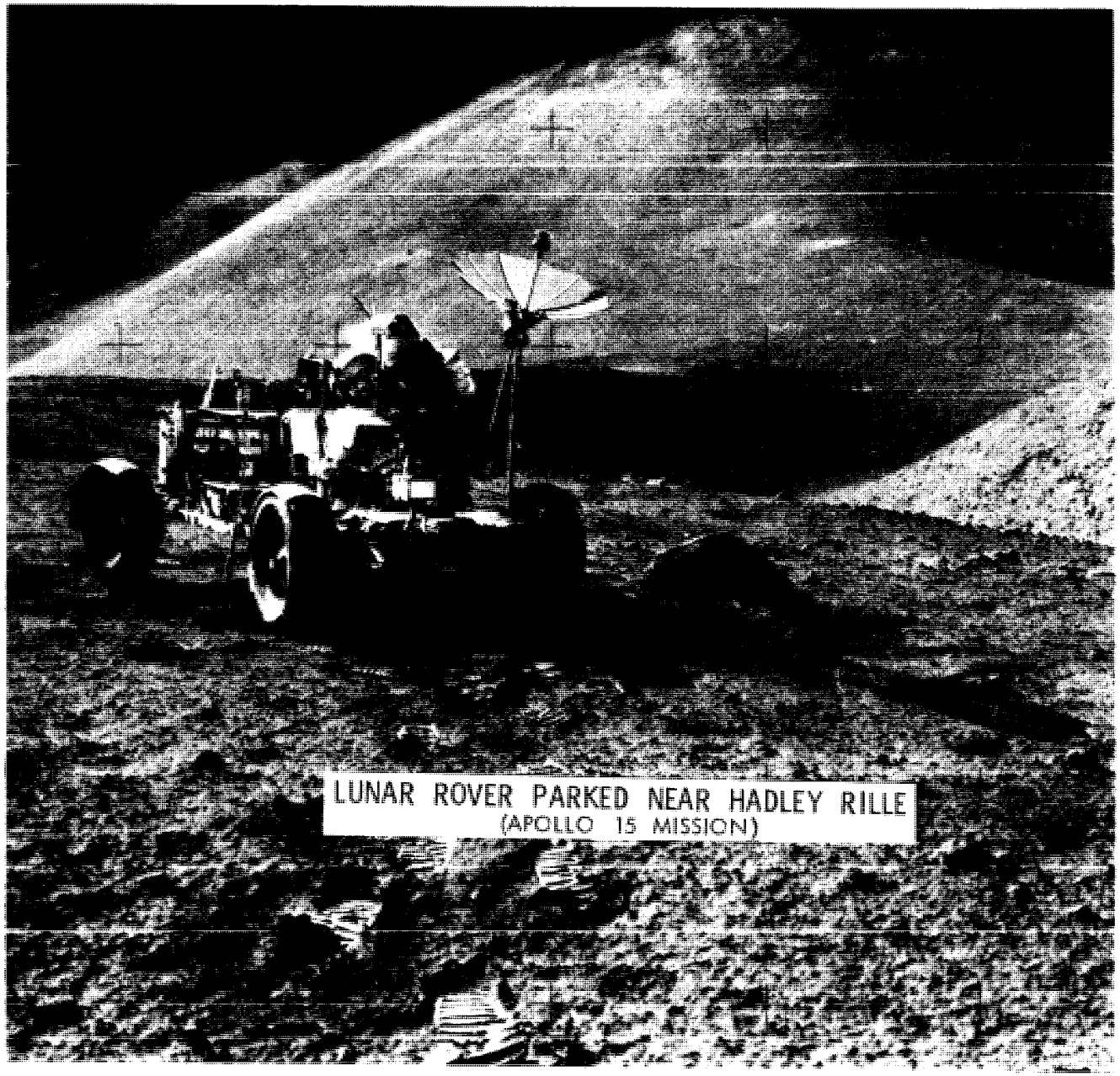
FY 1972 funding is devoted primarily to the completion and testing of the final experiments to be flown on Apollo missions; activities related to the checkout, launch and flight activities of Apollo 16; and the post-mission data analysis associated with Apollo 12, 14, 15, and 16.

The Apollo 16 Science Payloads, Lunar Roving Vehicle, Lunar Surface Experiments Package (ALSEP) and Orbital Experiments, have been delivered to Kennedy Space Center where they are being prepared for the April 1972 mission. The Apollo 17 Lunar Roving Vehicle is in storage and will be delivered by the end of FY 1972. The Apollo 17 ALSEP will be delivered in early FY 1973. The orbital experiments for Apollo 17 will be delivered by the end of FY 1972.

FY 1973 Science Payloads funding will cover completion of experiment hardware, integration of experiments into the spacecraft in preparation for launch, operation of the experiments during and after the mission and continued support of principal investigator activities.

Ground Support.

FY 1972 and FY 1973 funding provides for engineering support in the areas of integration, checkout and reliability of the spacecraft, and the maintenance and operation of spacecraft ground automatic checkout equipment.



LUNAR ROVER PARKED NEAR HADLEY RILLE
(APOLLO 15 MISSION)

Funding also provides for spacecraft transportation requirements, acceptance inspection, fuels and propellants and contract administration services provided by the Department of Defense.

Saturn V

	1971	1972	1973
Flight stages.....	$161,205,000	$119,480,000	$38,200,000
Ground support.....	27,854,000	22,978,000	11,000,000
Total.....	$189,059,000	$142,458,000	$49,200,000

Flight Stages.

FY 1972 funding provides for stage contractor check-out and launch of the Saturn V vehicles for Apollo 15 and 16 at Kennedy Space Center and for initiation of prelaunch check-out for Apollo 17. In addition, the funding provides for the contractor in-plant support activities essential to maintain confidence in mission safety and success. These requirements involve the three Saturn V stages, the Instrument Unit, and the rocket engines. The basic in-plant engineering and manufacturing support provided by stage and engine contractors includes performing necessary modification to existing hardware systems to correct prior mission anomalies, resolving anomalies encountered during launch preparations, providing for online mission support during the flights and providing for postflight analysis of flight engineering and performance data.

FY 1973 Saturn V funding provides for the maintenance of these essential and critical contractor in-plant flight support efforts through December 1972 to meet the prelaunch, launch, and postlaunch requirements for Apollo 17. In addition the FY 1973 funding provides for completion of vehicle check-out and launch activities at Kennedy Space Center. The Apollo program funds these in-plant and launch site activities through completion of the flight program in December 1972. After that date, the necessary activities in this area are funded under the Skylab program.

Ground Support.

Saturn V ground support funding in FY 1972 and FY 1973 includes the design support and update of ground support equipment, vehicle integration, vehicle support, systems engineering, small procurements of services and equipment related to the overall vehicle, and inspection and contract administration services provided on a reimbursable basis by the Department of Defense. All these activities support the launch of the remaining Apollo missions. Requirements beyond December 1972 are included in the funds requested for the Skylab program.

Operations

	1971	1972	1973
Research and test operations.....	$90,015,000	$91,567,000	---
Crew and flight operations.....	66,229,000	80,862,000	---
Operations support.....	78,798,000	60,364,000	---
Launch systems operations.....	65,109,000	65,332,000	---
MSF engineering support.....	14,812,000	9,325,000	---
Total.....	$314,963,000	$307,450,000	---

No funds are being requested for Operations in the Apollo program in FY 1973. Through FY 1972 these activities which supported the basic requirements of all manned space flight programs have been funded under the Apollo program. To provide for continuing support of these essential activities during completion of the Apollo missions and initiation of Skylab operations, these activities are carried in FY 1973 under the Development, Test and Mission Operations line item in the Space Flight Operations program.

Advanced Development

	1971	1972	1973
Advanced development.....	$11,500,000	$12,500,000	---

Advanced development activities relevant to manned flight programs have been funded within the Apollo program in FY 1972 and prior years. These requirements for FY 1973 are included in the Orbital Systems and Payloads line item under Space Flight Operations request.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1973 ESTIMATES

BUDGET SUMMARY

OFFICE OF MANNED SPACE FLIGHT

SPACE FLIGHT OPERATIONS PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1971	1972	1973
Skylab	$405,200,000	$545,400,000	$540,500,000
Space shuttle	78,500,000	100,000,000	200,000,000
Orbital systems and payloads	23,600,000	17,600,000	23,000,000
Space life sciences	(28,600,000)	19,775,000	25,500,000
Development, test, and mission operations	(327,480,000)	(319,050,000)	305,200,000
Total	$507,300,000	$682,775,000	$1,094,200,000

HIGHLIGHTS OF BUDGET PLAN

Skylab	$405,200,000	$545,400,000	$ 540,500,000
Workshop Cluster	$223,566,000	$282,300,000	$ 154,200,000
Orbital Workshop - Completion of flight unit; fabrication and assembly of backup unit; completion of component qualification testing; assembly, checkout, and launch activities at KSC; contractor in-plant activities, including pre-launch, launch, and post-launch flight support	96,665,000	157,500,000	95,900,000
Multiple Docking Adapter - Completion of manufacture, integration, in-plant checkout of the prime flight unit, and backup; pre-launch activities at KSC; in-plant support of pre-launch and flight activities	27,600,000	29,800,000	9,000,000
Airlock - Completion of testing, manufacture, and assembly; pre-launch checkout; in-plant support of pre-flight and flight activities	85,300,000	83,900,000	45,400,000

	1971	1972	1973
Skylab (Cont'd.)			
Workshop Cluster (Cont'd.)			
Telescope Mount - Completion of flight unit, thermal, and vibration tests; refurbishment of prototype for backup flight unit; pre-launch checkout; field support.....	$ 14,001,000	$ 11,100,000	$ 3,900,000
Experiment Development.....	$ 58,565,000	$ 45,100,000	$ 23,400,000
Application and Science - Completion of experiment hardware; principal investigator, pre-launch checkout, and flight data analysis activities.....	35,608,000	21,800,000	15,200,000
Technology and Engineering - Completion of experiment hardware; principal investigator, pre-launch checkout, and flight data analysis activities.....	16,337,000	19,900,000	7,000,000
Medical - Integration of training hardware into crew trainer; development and analysis of pre-flight baseline control data thru testing; principal investigator, pre-launch checkout, and flight data analysis activities.....	6,620,000	3,400,000	1,200,000
Payload Integration - Mission planning and analysis, configuration and interface management, support requirements, flight planning, flight crewman/machine integration, mechanics and structure analysis, and systems engineering and documentation.....	$ 27,803,000	$ 29,800,000	$ 22,800,000
Program Support - Procurement of GSE; telescope mount ACE station operation; thermal and vibro-acoustic testing; program-wide systems engineering support; complementary earth-based astronomy program; major hardware transportation; and contract administration.....	$ 15,050,000	$ 35,200,000	$ 31,000,000

	1971	1972	1973
Skylab (Cont'd.)			
Space Vehicles.....	$ 67,699,000	$141,400,000	$309,100,000
Saturn V - Completion of vehicle modifications and delivery to KSC; pre-launch checkout and launch activities at KSC; contractor engine, GSE, and vehicle support; contractor in-plant support of pre-launch, launch, and post-launch activities.....	---	4,100,000	75,100,000
Spacecraft - Completion of in-plant checkout and delivery of spacecraft hardware; KSC pre-flight checkout activities on three spacecraft, launch of the first manned mission; contractor in-plant flight support; sub-system test and evaluation, and spacecraft support, including mission analysis.....	42,040,000	98,200,000	168,100,000
Saturn IB - Completion of stage modifications and delivery of stages to KSC; pre-launch checkout activities on three vehicles and launch of the first; contractor in-plant flight support activities.....	25,659,000	39,100,000	65,900,000
Operations - FY 1973 requirements are included under the Development, Test, and Mission Operations line.....	$ 12,517,000	$ 11,600,000	$ ---
Space Shuttle.....	$ 78,500,000	$100,000,000	$200,000,000
Engine Design and Development- Continued engine design and development; engine/orbiter interface drawings; testing of the ignition system, the oxidizer, and fuel turbopump; thrust chamber and pre-burner testing.....	$ ---	$ 31,000,000	$ 50,000,000
Orbiter Design and Development - Initiation of design; selected long lead procurement; start of structural test article fabrication and assembly.....	$ ---	$ 2,500,000	$ 90,000,000

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	1971	1972	1973
Space Shuttle (Cont'd.)			
Booster Design and Development - Completion of definition studies and configuration selection; initiation of detailed design; start of booster engine or rocket motor development.....	$ ---	$ 1,700,000	$ 40,000,000
Technology and Related Development - Continued supporting development activities in the area of avionics, aerothermodynamics, structural and thermal protection systems, auxiliary propulsion, dynamics and aeroelasticity, and cryogenics.....	$ 10,600,000	$ 45,000,000	$ 20,000,000
Engine Definition - Shuttle main engine definition will be completed in FY 1972.....	$ 20,900,000	$ 10,800,000	$ ---
Vehicle Definition - Vehicle definition and configuration selection will be completed in FY 1972.....	$ 47,000,000	$ 9,000,000	$ ---
Orbital Systems and Payloads...	$ 23,600,000	$ 17,600,000	$ 23,000,000
Advanced Development - Development of long lead items, experimental systems, and operational techniques; establishment of specifications and design requirements for planned and potential manned space flight programs...	(11,500,000)	(12,500,000)	11,000,000
Payloads - Definition of manned experiments in advanced technology, material science, manufacturing, and on-orbit payload checkout; space shuttle payload integration planning.....	12,525,000	10,500,000	6,000,000
Research and Application Modules - Definition of modules and breadboarding of long lead systems; concept verification testing; in-house "Sortie Can" preliminary design.....	---	---	6,000,000
Space Station - Current definition study efforts are being completed in FY 1972.....	11,075,000	7,100,000	---

	1971	1972	1973
Space Life Sciences	($ 28,600,000)	$ 19,775,000	$ 25,500,000
Biomedical Research - Medical, behavioral, and biological research as related to space environment, including studies of the human body, closed environment, and absence of gravity effects on biological systems.....	a/	8,777,000	12,000,000
Life Support and Protective Systems - Technology development through testing of life support and protective devices including breathing atmosphere, thermal control, crew equipment, food, water, and waste management systems.....	a/	7,255,000	8,900,000
Bioengineering - Study and technology advancement in development and test of bioinstruments, bioassay concepts, and integrated bioinstrumentation systems.....	a/	3,743,000	4,600,000

a/In FY 1971, funding and direction of Life Sciences activities were distributed among several NASA programs.

Development, Test, and Mission Operations.....	($327,480,000)	($319,050,000)	$305,200,000
Research and Test Operations..	($ 90,015,000)	($ 91,567,000)	$ 80,800,000
Engineering and Test - Engineering support and test activities at MSC/MSFC, including developing hardware fabrication and assembly methods; manufacturing experimental prototype structures, models, mockups; test chamber simulators of zero-G conditions; thermal vacuum environmental chamber testing, and reverberant chamber testing to verify structural integrity for flight environment during launch.....	(60,721,000)	(66,793,000)	58,100,000

	1971	1972	1973
Applications and Science - Support of Skylab earth resources data management; Apollo lunar science data analysis assistance; maintenance and operation of curatorial facility (lunar material); study support in physics and astronomy; medical research and operations.....	($ 19,786,000)	($ 15,392,000)	$ 12,400,000
Reliability, Quality and Safety - Support efforts involving reliability assurance, risk analysis, tests, checkout, subsystems, components, and support equipment as related to manufacture, delivery, pre-launch checkout, and launch of space vehicles and payloads.....	(9,508,000)	(9,382,000)	10,300,000
Crew and Flight Operations....	($ 77,892,000)	($ 90,162,000)	$ 86,000,000
Crew - Crew training; integration of crew activities and flight mission planning; operational costs of mission simulators, trainers, and aircraft	(28,244,000)	(26,776,000)	19,800,000
Flight - Flight operations activities, including mission planning, flight control, operational support, recovery, and mission trajectory development	(22,414,000)	(18,478,000)	22,000,000
Mission Control - Mission control center maintenance and operation, including real time computer complex, switchboards communications equipment and lease of land lines; contractor technical support; communication systems studies.....	(27,234,000)	(44,908,000)	44,200,000
Operations Support.....	($ 79,094,000)	($ 61,357,000)	$ 57,000,000
On-Site - Technical services at MSF centers involving maintenance, post-launch refurbishment, renovations, rigging, training and test facility closed circuit TV monitoring, documentation and			

	1971	1972	1973
Development, Test, and Mission Operations (Cont'd.)			
Operations Support (Cont'd.)			
On-Site (Cont'd.) technical report preparation, logistics support, chemical purging, telecommunications, electronic component fabrication and photo support; Air Force Eastern Test Range test and launch support.....	($ 47,384,000)	($ 45,494,000)	$ 42,200,000
Off-Site - Maintenance and support of technical and manufacturing facilities at White Sands Test Facility, Mississippi Test Facility, and Michoud Assembly Facility.....	(31,710,000)	(15,863,000)	14,800,000
Launch Systems Operations....	($ 65,667,000)	($ 66,639,000)	$ 81,400,000
Mechanical Ground Systems - Operation and maintenance of launch facilities and equipment, including mobile transporters, converter compressor facility, mobile service structure, propellant loading and pneumatic systems, altitude chambers, vehicle assembly building adjustable work platforms; services such as propellant handling, life support, technical shops, chemical cleaning and decontamination, and systems safety.....	(34,522,000)	(36,224,000)	45,400,000
Electrical Instrumentation Systems - Operation and maintenance of electrical/electronic systems and launch instrumentation systems such as spacecraft and vehicle automatic checkout equipment, computation, operational voice and TV communications, measurements, and telemetrics.	(31,145,000)	(30,415,000)	36,000,000

	1971	1972	1973
Development, Test, and Mission Operations (Cont'd.)			
OMSF Engineering Support - Activities which have been performed by Bellcomm, Boeing, and General Electric in support of the Office of Manned Space Flight are being phased out.....	($ 14,812,000)	($ 9,325,000)	$ ---

FLIGHT SCHEDULE

PROJECT	MISSION	DATE
Skylab	Workshop Cluster	April 1973
Skylab	First Manned Mission	May 1973
Skylab	Second Manned Mission	July 1973
Skylab	Third Manned Mission	October 1973
Space Shuttle	First Horizontal Flight	1976
	First Manned Orbital Flight	1978

OFFICE OF MANNED SPACE FLIGHT SPACE FLIGHT OPERATIONS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Space Flight Operations program includes the Skylab and Space Shuttle projects as well as development and supporting activities in Orbital Systems and Payloads; Space Life Sciences and in Development, Test and Mission Operations.

Flight missions in this program will begin in April 1973 with the launch of the Skylab, our first experimental space station. The Skylab Workshop, a modified third stage of a Saturn V, provides living quarters and a laboratory for the scientist/astronaut crews who will occupy the orbital facility. Three Skylab crews will carry out the most extensive experiment program yet conducted in space, involving over 50 experiments in biomedical sciences, earth resources, astronomy, space physics, space engineering, and manufacturing technology.

In the latter part of the decade, the space shuttle, a reusable vehicle capable of carrying large payloads, will become operational to provide economical space transportation to and from earth orbit. It is designed to make near-earth space more readily accessible for a great variety of manned and unmanned activities. The space shuttle represents the single most significant contribution to the advancement of space travel. Its primary objective is to provide low cost space transportation with an operational flexibility that will not only reduce transportation costs to space, but will also lead to new payload concepts and lower payload costs. The shuttle development plan anticipates the first manned orbital flight near the end of the decade.

Orbital Systems and Payloads relates to future earth orbital space flight using the space shuttle and includes advanced development, payload definition, and the research and application module studies.

Complementing all space activities, underway and planned, is Space Life Sciences. This integrated medical and biological program provides for the study and investigation of the effects of space on man and other living organisms, and the translation of these effects into meeting man's requirements to live and work effectively in space.

Development, Test and Mission Operations provides for the basic engineering and test operations, operation support, crew training, launch and flight

operations, recovery, and Department of Defense support required for all manned space flight programs.

SUMMARY OF RESOURCES REQUIREMENTS:

	1971	1972	1973
Skylab.....	$405,200,000	$545,400,000	$ 540,500,000
Space shuttle.....	78,500,000	100,000,000	200,000,000
Orbital systems and payloads.	23,600,000	17,600,000	23,000,000
Space life sciences.....	(28,600,000)	19,775,000	25,500,000
Development, test and mission operations.....	(327,480,000)	(319,050,000)	305,200,000
Total.....	$507,300,000	$682,775,000	$1,094,200,000

Distribution of Program Amount by Installation:

John F. Kennedy Space Center, NASA.....	$8,435,000	$20,750,000	$184,050,000
Manned Spacecraft Center....	131,631,000	182,285,000	425,400,000
Marshall Space Flight Center	350,912,000	447,645,000	452,500,000
Goddard Space Flight Center.	475,000	1,895,000	---
Jet Propulsion Laboratory...	33,000	730,000	200,000
Wallops Station.....	---	210,000	150,000
Ames Research Center.....	5,805,000	8,080,000	6,950,000
Flight Research Center.....	---	575,000	250,000
Langley Research Center.....	830,000	4,677,000	4,150,000
Lewis Research Center.....	125,000	25,000	300,000
NASA Headquarters.....	9,054,000	15,903,000	20,250,000

BASIS OF FUND REQUIREMENTS:

Skylab

By this time next year, we will be approaching the final phases of our preparations to launch Skylab, our first experimental space station and by far the largest manned spacecraft we have ever built. The flight crews, which will include physicians, engineers and scientists, will carry out the most intensive scientific experiment program yet conducted in earth orbit.

The Skylab project is designed to extend our capabilities in space to gain detailed understanding of the capability of human beings to function effectively in space for extended time periods, and to carry out important investigations in earth applications, astronomy, biomedicine and space technology.

Skylab missions will begin in April 1973 with the launch of the unmanned Skylab Workshop from the Kennedy Space Center. It will be inserted into a near-circular orbit of about 435 kilometers (235 nautical miles) with a nominal inclination of 50 degrees. On the following day, the first of the

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Skylab crews will be launched in a modified Apollo Command and Service Module on a Saturn IB vehicle. They will rendezvous, dock with and activate the Skylab for the initial 28 day staytime. During the scheduled eight months flight phase of Skylab, a total of three crews will work in the Workshop conducting earth observations, solar astronomy, biomedical and other technical and scientific experiments.

A rescue capability is being developed which, although not providing rescue for all failure situations, does provide coverage for the more probable ones. A modification kit has been designed to convert a Skylab Command and Service Module into a rescue vehicle which can accommodate five crewmen instead of three by removing and relocating stowage lockers and substituting two additional crew couches. Under the plan, if a Command and Service Module which is docked with the Workshop Cluster becomes disabled, the crew will remain in the orbiting Skylab to await rescue. The next scheduled Command and Service Module will be converted and launched as early as possible with a two man crew to retrieve the three stranded crewmen. A backup Saturn IB vehicle and spacecraft will be available to provide a rescue capability for the last scheduled revisit mission.

A complete backup set of hardware, including experiments, is being readied to be used in the event it is needed. Current planning is based on maintaining a decision capability through the second manned mission--five months after launch of the Skylab. At any point up to that time, a decision can be made to launch the backup Workshop within approximately 10 months after the decision date.

Skylab

	1971	1972	1973
Workshop cluster.....	$223,566,000	$282,300,000	$154,200,000
Experiment development.....	58,565,000	45,100,000	23,400,000
Payload integration.....	27,803,000	29,800,000	22,800,000
Program support.....	15,050,000	35,200,000	31,000,000
Space vehicles.....	67,699,000	141,400,000	309,100,000
Operations.....	12,517,000	11,600,000	---
Total.....	$405,200,000	$545,400,000	$540,500,000

Workshop Cluster

Orbital workshop.....	$96,665,000	$157,500,000	$95,900,000
Multiple docking adapter.....	27,600,000	29,800,000	9,000,000
Airlock.....	85,300,000	83,900,000	45,400,000
Telescope mount.....	14,001,000	11,100,000	3,900,000
Total.....	$223,566,000	$282,300,000	$154,200,000

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

The Orbital Workshop:

The Orbital Workshop is a modified S-IVB stage outfitted for long duration manned habitation in orbit and is built by the McDonnell Douglas Astronautics Corporation in its Huntington Beach Plant in California. It contains crew provisions, living quarters, food preparation and waste management facilities and is provisioned to support a crew of three for a total planned occupancy of 140 days over an eight month period. It also contains certain experiment hardware and the necessary support facilities for its operation.

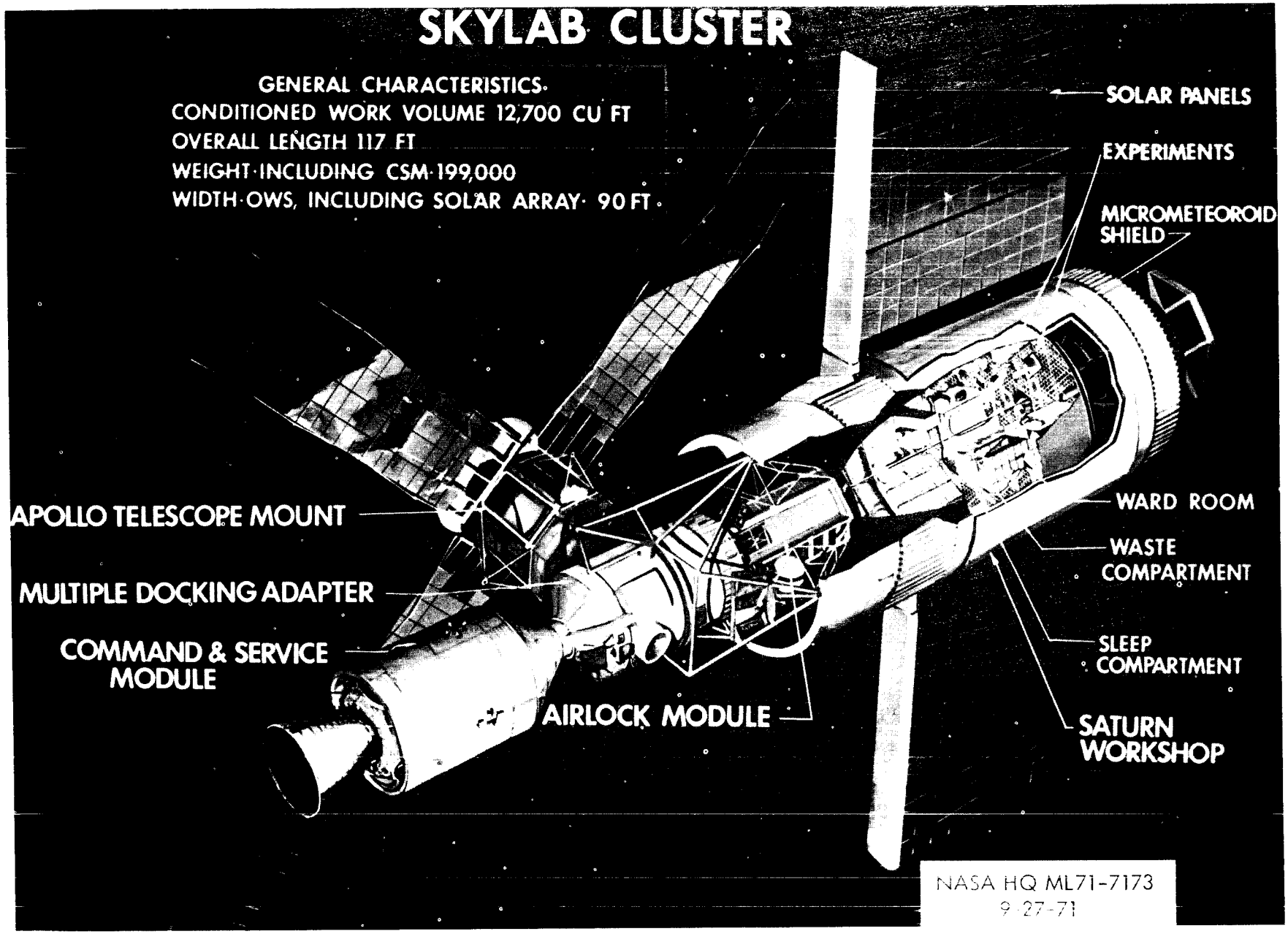
During FY 1972, training and test hardware deliveries will be completed and vibro-acoustic testing of the dynamic and static test article accomplished. Static and meteoroid shield testing will also be completed at the Marshall Space Flight Center (MSFC). The flight unit will progress through equipment installation and systems checkout and will be delivered in early FY 1973. Fabrication of the backup flight unit will continue with delivery planned for late FY 1973.

FY 1973 funding supports the completion of the flight unit; fabrication and assembly of the backup unit; completion of component qualification testing; the extensive assembly and checkout activities at the Kennedy Space Center (KSC) which begin early in the Fiscal Year with the mating of the Workshop to the launch vehicle; and the contractor in-plant support required during the prelaunch activities at KSC, the launch itself and the initial in-orbit activities of the Workshop. Essential and critical contractor in-plant capability must be retained to provide the ability to solve Workshop problems that may occur during the mission. The prelaunch activities at KSC will begin early in FY 1973 when the Workshop is stacked on the launch vehicle. From that point on, extensive checkout operations will occur leading to total integrated testing and checkout of all elements of the space vehicle and launch late in April 1973.

Multiple Docking Adapter:

The Multiple Docking Adapter provides the docking interface for the Command and Service Module to the Workshop. The Multiple Docking Adapter, fabricated at MSFC and subsequently delivered to the Martin Marietta Corporation, Denver, Colorado, for equipment installation and acceptance testing has two docking ports--an axial port for normal Command and Service Module docking and a radial port for contingency. In addition, it contains control and display consoles for the Telescope Mount and the Earth Resources Experiment Package together with specific experiment hardware.

By the end of FY 1972, all training hardware will have been delivered; vibroacoustic testing of the structural test article will be completed; and the mating of the flight Multiple Docking Adapter with the Airlock for


SKYLAB CLUSTER
GENERAL CHARACTERISTICS.
CONDITIONED WORK VOLUME 12,700 CU FT
OVERALL LENGTH 117 FT
WEIGHT INCLUDING CSM 199,000
WIDTH OWS, INCLUDING SOLAR ARRAY 90 FT
SOLAR PANELS
EXPERIMENTS
MICROMETEOROID SHIELD
WARD ROOM
WASTE COMPARTMENT
SLEEP COMPARTMENT
SATURN WORKSHOP
APOLLO TELESCOPE MOUNT
MULTIPLE DOCKING ADAPTER
COMMAND & SERVICE MODULE
AIRLOCK MODULE
NASA HQ ML71-7173
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testing under simulated flight and altitude conditions will be accomplished. Component qualification testing will continue, and fabrication and assembly of backup hardware will be initiated.

FY 1973 funds are required to support the completion of the backup unit and the activities at the Kennedy Space Center leading to the Workshop launch in April 1973. A significant engineering capability will also be retained at the Martin Marietta Denver plant during the prelaunch and flight phase of the Skylab project for problem solving in event of any malfunctions in the Multiple Docking Adapter and its installed equipment.

Airlock:

The Airlock provides a pressurized passageway between the Multiple Docking Adapter and the Orbital Workshop. It contains an airlock for astronaut extravehicular activity and the supply, distribution and control center for cluster atmosphere and thermal control. It also contains the equipment for electric power control and distribution to the Workshop Cluster and the docked Command and Service Module and provides support for communications and data handling, including voice communications with the ground. Development, manufacture, and test of the Airlock is the responsibility of the McDonnell Douglas Astronautics Corporation-Eastern Division, St. Louis, Missouri.

Fiscal Year 1972 funding is being devoted to the completion of the one "G," zero "G," and neutral buoyancy trainers; completion of the vibroacoustic testing of the structural test article; completion of fabrication and assembly of the flight article and initial fabrication of the backup; and the initiation of simulated flight and altitude chamber testing.

FY 1973 funding is required to complete tests and the related rework activity on the flight article; complete manufacture and assembly of the backup module; provide for prelaunch and checkout efforts at the launch site; and for maintaining the engineering competence to support the preflight and flight activities involving the Airlock.

Telescope Mount:

The Telescope Mount with its solar telescopes will provide for the first U.S. use of manned solar telescopes in space to observe, monitor and record the structure and behavior of the sun, particularly solar flare activity. It provides telescope pointing and attitude controls for the entire cluster. A solar array and battery system supplies the required electrical power, generating nearly 12,000 watts when illuminated by the sun. It incorporates provisions for astronaut extravehicular retrieval and installation of the film used for the Telescope Mount instruments.

In FY 1972, the Telescope Mount trainers were delivered to the Manned Spacecraft Center; fabrication and test of the structural and thermal test articles were completed; vibroacoustic testing will be completed; prototype thermal and vibration testing will be accomplished; and fabrication and checkout of the flight article will also be completed.

FY 1973 funding provides for the completion of thermal and vibration testing of the Telescope Mount flight unit; refurbishment of the prototype Telescope Mount as a backup flight article; integration of the Telescope Mount into the space vehicle stack in preparation for the mission launch in April 1973; and related field support.

Experiment Development

	1971	1972	1973
Applications and science.....	$35,608,000	$21,800,000	$15,200,000
Technology and engineering.....	16,337,000	19,900,000	7,000,000
Medical.....	6,620,000	3,400,000	1,200,000
Total.....	$58,565,000	$45,100,000	$23,400,000

A large number of experimental investigations will be conducted in science, technology, engineering and medical areas using a complex array of sensors, instruments and other experimental equipment.

Applications and Science:

These experiments fall into three general categories: earth resources, solar astronomy and astrophysics. The Skylab Earth Resources Experiment Package (EREP) will permit remote sensing of ground sites and will complement the Earth Resources Technology Satellite (ERTS) measurements. Coordinated ERTS/EREP measurements of specific ground test sites in conjunction with aircraft underflights will provide the means for assessing the feasibility and value of using remote sensing from space for earth resources applications. Initial Skylab earth resources investigations will examine agriculture, ecology, natural resources, land use, and weather on a global basis. Data acquired from EREP will permit further investigations of the feasibility of using remote sensing to assist in regional planning and land use in the Boston to Washington, D.C. corridor; land use in Brevard County, Florida; analysis of marine and coastal processes in the Puerto Rico-Virgin Island complex; highway engineering in Maine; evaluating earthquake hazards in California; evaluating water color and circulation in the Cheaspeake Bay; and in many other areas such as pollution assessment and detection of the concentration of geological and biological natural resources.

Skylab will carry about 1,000 kilograms (2,200 pounds) of solar instrumentation in the Telescope Mount. Four basic features of the sun's emission are to be studied, as follows:

(1) Hydrogen-alpha emission, a red light emitted by the hydrogen gas near the surface of the sun.

(2) Ultraviolet radiation emanating from the chromosphere which extends from 1,600 to 3,200 kilometers (1,000 to 2,000 miles) above the sun's surface and has temperature variation from 5,000°C to more than 100,000°C.

(3) X-Ray radiation from the sun's corona, beginning about 3,200 kilometers

(2,000 miles) above the solar surface and continuing far out into space. The corona's density is low, but its temperatures vary from about 1,000,000°C in quiet places to over 10,000,000°C in certain places during solar flares.

(4) White light emissions from the corona. Because of its high temperature, the corona contains many free electrons that scatter the white visible light radiated from the surface of the sun. The white light coronograph will use this phenomena to trace the corona several million kilometers out from the surface of the sun.

In addition to the experiments in the Telescope Mount, an X-Ray/Ultra Violet Solar Photography experiment will be mounted in an airlock in the wall of the workshop to produce spectrum plots of selected activities at specific areas of the sun. This combination of solar experiments concentrates on observations which are not possible from earth because of the effects of the atmosphere. The results will significantly advance our understanding of the sun by providing information on the solar atmosphere, the types of atoms present, and the mechanisms through which energy is supplied to the solar atmosphere. The experiments have potential application in improving our understanding of the impact of the sun's activities such as solar flares on communications and earthquakes. A better understanding of the sun's energy producing process may provide a basis for improved power sources for use on earth.

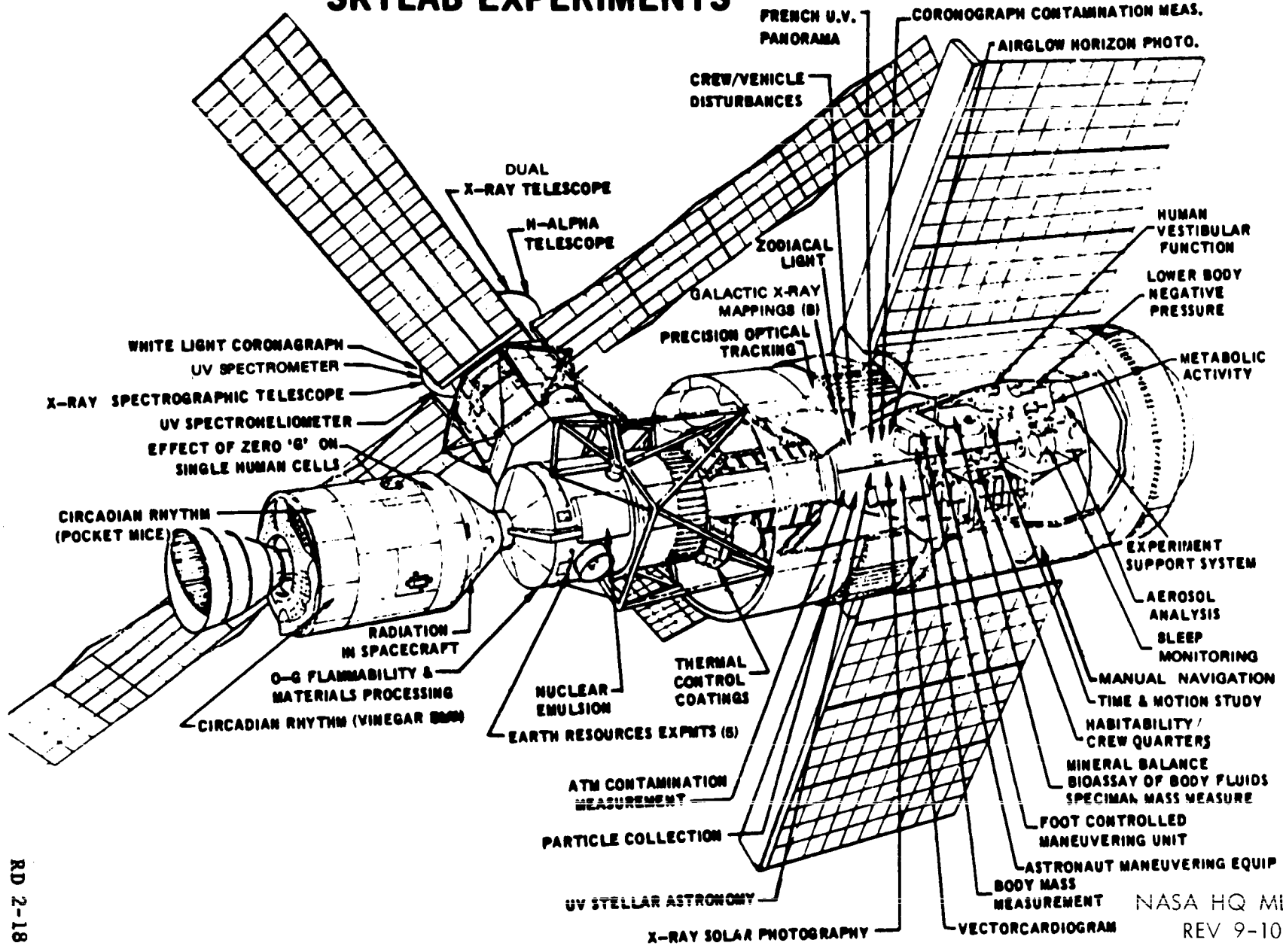
In FY 1972, the instrument fabrication for Applications and Science experiments will be nearly completed. FY 1973 funding will provide for completion of fabrication and testing; retrofit activity where required; the activities of experiment sponsors (principal investigators) and contractors during the launch checkout period; and data analysis during the initial operational period of the Skylab project.

Technology and Engineering:

This effort includes zero-gravity experiments which will provide collection of data regarding the effects of the workshop environment on the crew in terms of safety, comfort and operational effectiveness. These experiments will also provide an understanding of the effects that crew movement will have on the workshop cluster and on the attached experiments. Spacecraft environment investigations will study the effects of radiation and spacecraft effluents on spacecraft surfaces and sensors. The degradation of thermal control coatings will also be studied. Materials processing and zero-gravity flammability experiments will be our first investigations into basic physics and chemistry in space. The tasks will involve melting, brazing and casting of metals, crystal growth and how to maintain and control fire for practical uses in that environment. It is hoped that such research will lead to the practical use of space for processing a variety of materials, from crystals to pharmaceuticals.

The majority of the technology and engineering experiment hardware will be delivered in FY 1972. FY 1973 funds will be used to complete the remaining experiment hardware, to prepare for data acquisition, and to provide for the

SKYLAB EXPERIMENTS



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activities of the principal investigators and contractors during installation and prelaunch checkout. Funds will also be used for analysis of data obtained during the initial manning of the workshop.

Medical:

Medical studies will include an intensive biomedical study of normal, healthy men and their reactions to the numerous stresses of space flight.

The delivery of the medical experiment equipment to McDonnell Douglas and to North American will be completed in FY 1972. FY 1973 funding will provide for the integration and checkout of the equipment in the flight stages; the integration of flight type training hardware into the crew trainer; the collection and analysis of preflight ground baseline control data from the Skylab Medical Experiments Altitude Test; the crew trainer and the laboratory testing conducted by the principal investigators; the preparing of methods, procedures and facilities for the postflight analysis of returned flight specimens; and the actual analysis of inflight and postflight data from the first Skylab mission.

Payload Integration

	1971	1972	1973
Payload integration.....	$27,803,000	$29,800,000	$22,800,000
Total.....	$27,803,000	$29,800,000	$22,800,000

Skylab represents this country's most ambitious earth orbital endeavor and the Workshop, with its experiment payload, is the most complex spacecraft ever developed by the United States. Mission success depends upon the interaction of all elements of the program--the Workshop Cluster, the experiment hardware, the launch vehicle, and the Saturn IB/CSM logistics system. Payload Integration activities are designed to insure that the proper relationships and interfaces exist so that, when in orbit, the Skylab will truly be a functional space laboratory. The Martin Marietta Corporation, Denver Division, is under contract to achieve this payload integration effort.

During FY's 1972 and 1973, the funding provides for mission planning and analysis, configuration and interface management, support requirements, flight planning and flight crewman/machine integration, mechanics and structure analysis, systems engineering, and documentation.

Program Support

Program support.....	$15,050,000	$35,200,000	$31,000,000
Total.....	$15,050,000	$35,200,000	$31,000,000

As in FY 1972, FY 1973 funding provides for a wide range of activities out-

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side the major prime hardware contractor structure. Included are procurement of ground support equipment; operation of the Automatic Checkout Equipment Station in support of the Telescope Mount development at the Marshall Space Flight Center; thermal and vibroacoustic testing at the Manned Spacecraft Center; calibration rocket data analysis; program-wide systems engineering in support of the Skylab program office; an earth-based astronomy program designed to complement the in-orbit astronomy observations; transportation of launch vehicles, spacecraft and other major component hardware; and the reimbursement to the Department of Defense for contract administration services.

Space Vehicles

	1971	1972	1973
Saturn V.....	---	$4,100,000	$75,100,000
Spacecraft.....	$42,040,000	98,200,000	168,100,000
Saturn IB.....	25,659,000	39,100,000	65,900,000
Total.....	$67,699,000	$141,400,000	$309,100,000

The Space Vehicles item includes the Saturn launch vehicles and modified Apollo spacecraft that are used in the Skylab project to launch the Workshop Cluster and to provide the logistics system for crew transfer from earth to the Workshop and return.

Saturn V:

The Skylab launch vehicle consists of the first two stages--the S-IC and the S-II--and the Instrument Unit of a Saturn V launch vehicle. Two Saturn V's have been made available to the Skylab project from Apollo, one to launch the Workshop Cluster, the other to provide the capability to launch the back-up cluster if necessary.

FY 1972 funding provides for the modifications to the Saturn V stages and Instrument Unit necessary to meet Skylab requirements. These stages will be delivered to Kennedy Space Center (KSC).

FY 1973 funding will provide for vehicle stage checkout activities at the Kennedy Space Center. Prelaunch checkout of the primary launch vehicle at KSC will begin early in FY 1973 in preparation for the launch in April 1973. Delivery of backup Saturn V hardware to KSC for storage will be completed during FY 1973. The Skylab project backup plan includes vehicle checkout necessary to permit a backup launch within ten months from a go ahead decision. This capability will be maintained for five months following the initial Skylab launch.

FY 1973 funding also provides for the maintenance of an inplant flight support capability required for the last six months of FY 1973. This inplant capability consists of engineering and manufacturing support provided by stage

and engine contractors including resolving anomolies encountered during launch preparations, performing any necessary modifications, providing on-line mission support, postflight analysis and logistic support activities. This inplant capability will be funded under the Apollo program through the first half of FY 1973. The Skylab project funding provides for continuation of these activities by the Boeing Company for the S-IC stage at the Michoud Assembly Facility, New Orleans, Louisiana; by North American Rockwell for the S-II stage at Seal Beach, California; and by the IBM Corporation at its Huntsville, Alabama, facility for the Instrument Unit.

Spacecraft:

Three Apollo Command and Service Modules assigned to the scheduled manned missions and a fourth backup/rescue spacecraft are being modified to meet the unique operational and support requirements of Skylab resulting from longer mission durations, new orbital rendezvous requirements, Workshop support requirements, cluster attitude constraints during the mission, increased return payload capability, and experiment support requirements. These modifications include: removal of one fuel cell and the provision of electrical umbilical connectors to the Workshop; insulation, heaters and control wiring installed in the Service Module to permit long duration propellant storage at low temperature; removal of three large unneeded Service Module propellant and pressurization tanks to save weight; provision of a battery pack to allow reactivation of the Command Module prior to undocking and re-entry; changes to the caution, warning and communications subsystems to facilitate operations within the cluster; guidance and control system software changes unique to Skylab; and special provisions for experiments to be carried in the Command and Service Module. Modification, systems installation and post-manufacturing checkout and test of the four Command and Service Modules are being accomplished by North American Rockwell at Downey, California.

During FY 1972, systems installation and checkout will be completed on two Command and Service Modules; the third flight article will complete systems installation and begin checkout; and the fourth, the rescue/backup spacecraft, will begin systems installation. FY 1973 funds will be used to complete inplant checkout of the third spacecraft and the systems installation and checkout on the rescue/backup spacecraft; to accomplish the extensive prelaunch checkout activities at the Kennedy Space Center prior to the launches of the initial Skylab mission in April 1973 and the first revisit in July 1973; and to initiate prelaunch checkout of the final revisit spacecraft. FY 1973 funding also provides for subsystem test and evaluation and spacecraft support including mission analysis.

Saturn IB:

Four Saturn IB launch vehicles are involved in the Skylab project. Three vehicles have specific schedule assignments to launch the Skylab astronaut crews who will operate the research laboratory. The fourth vehicle will be available for a backup or a rescue launch. The major components of the Saturn IB (the S-IB stage manufactured by the Chrysler Corporation, the S-IVB

manufactured by the McDonnell Douglas Astronautics Corporation, the Instrument Unit manufactured by IBM, the H-1 and J-2 engines developed and built by the Rocketdyne Division of North American Rockwell) were completed several years ago and placed in storage.

During FY 1972, the necessary modification, refurbishment and checkout of the Saturn IB hardware to assure flight readiness is being accomplished. Modification and checkout of the first of the S-IB stages will be completed during FY 1972; modification of the second will be completed and its checkout started; and modification of the third will be started. All four S-IVB stages are being shipped to Kennedy for storage during FY 1972 after undergoing modification, refurbishment and checkout. Prelaunch processing on the first S-IVB stage at KSC will begin in June 1972. The Instrument Units will be subjected to activity similar to the stages, with shipments to KSC beginning early in FY 1973. FY 1973 Saturn IB funding provides for all remaining modification, refurbishment, and the major portion of inplant and prelaunch checkout activities required for the four Saturn IB vehicles. This funding also provides for supporting activities for the engine, ground support equipment and vehicle systems contractors. Three of the four S-IB stages will be delivered to the Kennedy Space Center. Work will be completed on the fourth S-IB stage, and it will be delivered to KSC in the early part of the following fiscal year. The second and third S-IVB stages will be withdrawn from storage at Kennedy to start prelaunch preparation. Also predelivery work on the remaining three Instrument Units for the Saturn IB vehicles will be completed in FY 1973 and all except one will be delivered to the Kennedy Space Center; the fourth unit will be held for delivery until early in FY 1974. FY 1973 funds will also provide flight support at the contractors' plants. Flight support includes preflight and postflight problem resolution, design support for modification kits, and laboratory and test support for qualification and failure analysis.

Operations

	1971	1972	1973
Operations.....	$12,517,000	$11,600,000	---
Total.....	$12,517,000	$11,600,000	---

No funds are being requested for Operations in Skylab in FY 1973. These activities are included in the development, test and mission operations line item.

SPACE SHUTTLE

	1971	1972	1973
Engine Design and Development	---	$31,000,000	$50,000,000
Orbiter Design and Development	---	2,500,000	90,000,000
Booster Design and Development	---	1,700,000	40,000,000
Technology and Related Development.....	$10,600,000	45,000,000	20,000,000
Engine Definition.....	20,900,000	10,800,000	---
Vehicle Definition.....	47,000,000	9,000,000	---
Total.....	$78,500,000	$100,000,000	$200,000,000

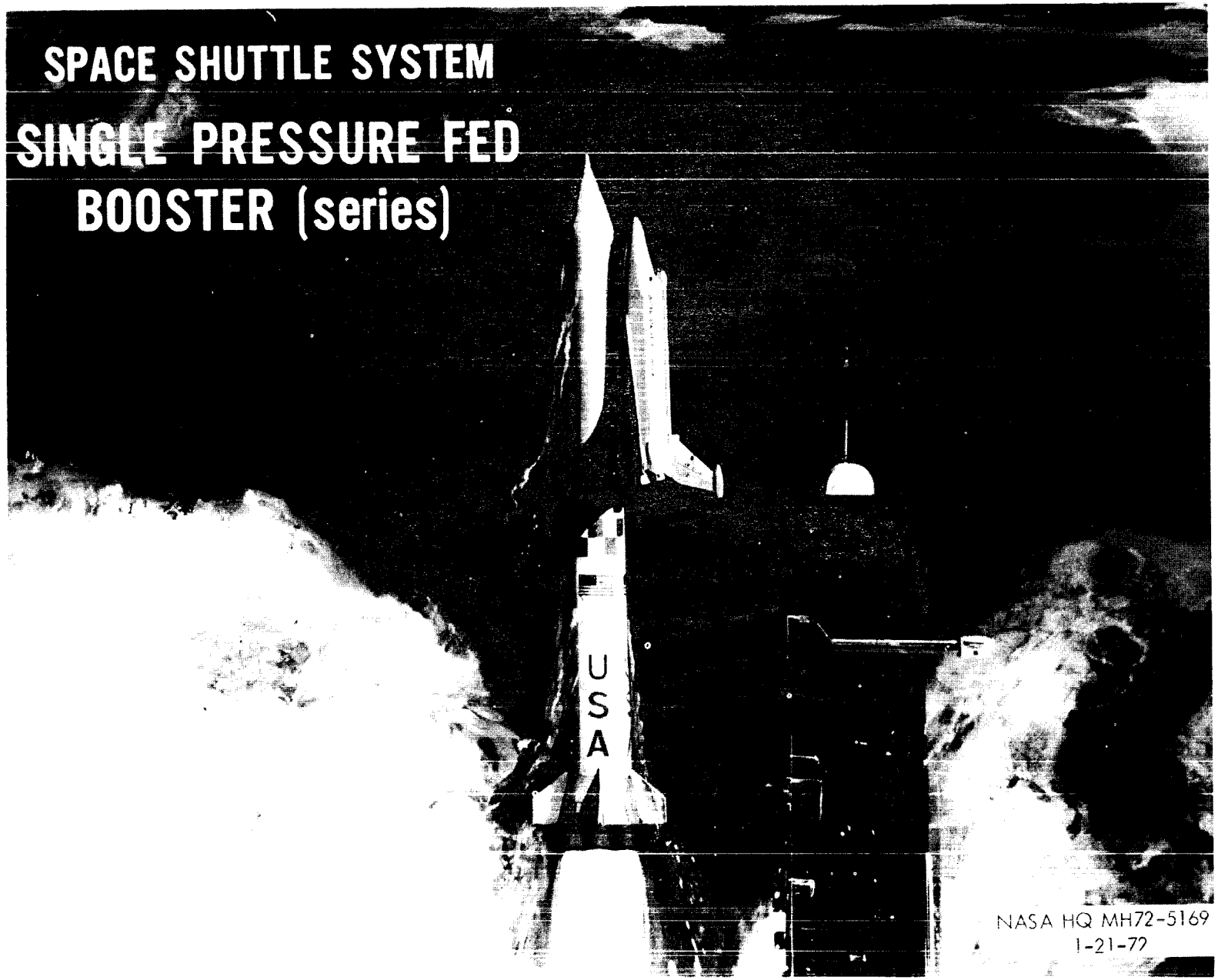
Program Description

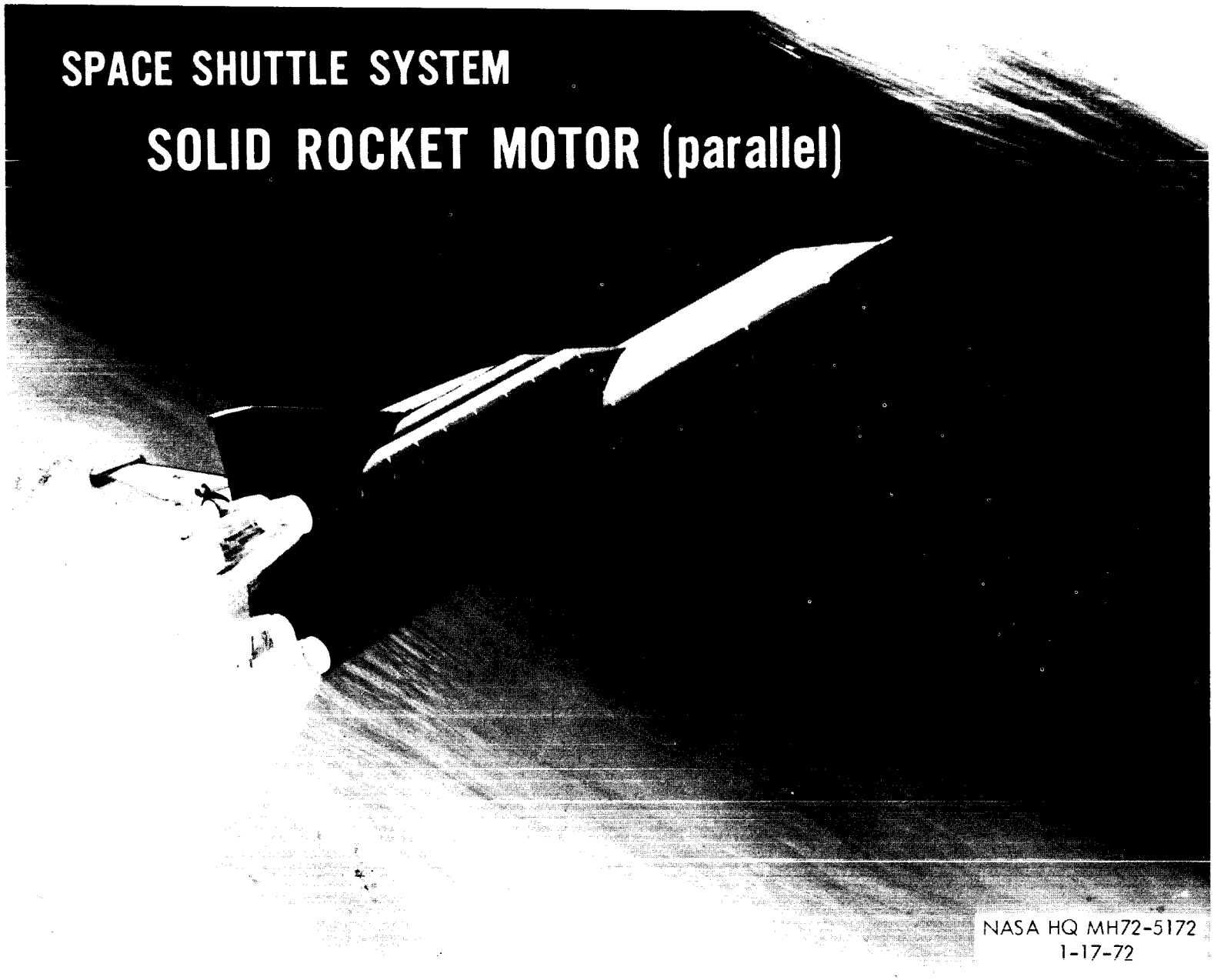
The key to future space applications and exploration is the Space Shuttle--the first reusable space vehicle. The Shuttle will revolutionize the nature of space activities by providing a multipurpose transportation system for routine roundtrip access to near earth space and by sharply reducing the cost and complexity of systems and operations. Its versatility will open up vast new opportunities to realize the promise of space for practical applications on earth and for expanding the frontiers of science.

The Shuttle will consist of two stages: a booster and an orbiter. It will take-off like a rocket, fly in orbit like a spaceship, and land like an airplane. The orbiter will have a delta wing and will look much like a modern airplane. It will be powered by three high pressure, oxygen-hydrogen engines, each with a thrust of 213,000 kilograms (470,000 pounds). The orbiter is about the size of a DC-9. It measures about 36 meters (120 feet) in length and has a wing span of 22.5 meters (75 feet). Propellants for the orbiter will be carried in an external jettisonable tank. Two boosters are still under consideration. One uses liquid propellants, pressure fed engines, and is recoverable; the other uses solid rocket motors which would be expendable. One of the two booster options will be selected in the spring of 1972. Fully fueled and ready for launch, the Shuttle will weigh approximately 2.3 million kilograms (5 million pounds) on the launch pad.

The orbiter will have a payload bay that can accommodate payloads up to 4.5 meters (15 feet) in diameter and 18 meters (60 feet) in length. A hatch on top of the compartment will open in orbit to permit deployment or recovery of large spacecraft.

The personnel compartment interior of the Shuttle will be pressurized so that the crew can travel in shirtsleeve comfort without spacesuits. No special flight training would be required for passengers, making it possible to send scientists, doctors, technicians, and photographers into space.


SPACE SHUTTLE SYSTEM
SINGLE PRESSURE FED
BOOSTER (series)
USA
NASA HQ MH72-5169
1-21-72


SPACE SHUTTLE SYSTEM
SOLID ROCKET MOTOR (parallel)
NASA HQ MH72-5172
1-17-72

The orbiter will normally carry an operational crew of two pilots and two payload handlers. Provision can also be made to carry passengers in shirt sleeve comfort in space modules carried in the payload bay. The orbiter will have a nominal seven-day mission capability. When the mission is completed, the orbiter will be flown back to earth for an airplane-type landing at the launch site. Other landing fields could be used in emergencies.

The multipurpose Shuttle will replace most present expendable launch vehicles. It will be capable of carrying into space virtually all of this nation's payloads, scientific and applications, manned and unmanned, and civilian and military. It will also accommodate the future needs of commercial users, other government agencies, and foreign governments.

Its versatile capability and low operational cost make it suitable for a wide variety of missions. Initially the Shuttle will be employed in:

Satellite Placement and Return

Satellites will be transported to low earth orbit in the cargo bay where they will be given a final checkout at the desired orbit before beginning their assigned mission. Satellites can also be retrieved by the Shuttle and returned to earth for modification or servicing.

On-Orbit Repair and Servicing of Satellites

The Shuttle will be able to visit orbiting satellites for periodic servicing, including film retrieval, component replacement, and consumable replenishment.

Delivery of Propulsive Stages and Satellites

Propulsive stages and payloads for high energy missions can be delivered by Shuttle to low earth orbits. After a final on-orbit checkout the propulsive stage and its payload are removed from the cargo bay and positioned for launch. The propulsive stage will transport the payload to a geosynchronous orbit or to escape.

Short Duration Science and Applications Missions

The Shuttle can be outfitted to conduct special purpose short duration missions. In this manner, the Shuttle could be a precursor to a space station for unique earth or sky viewing mission opportunities.

Research Laboratory

The Shuttle can also serve as a space research laboratory. The development and testing of new components and space systems can be enhanced by using the Shuttle to check them out in the environment of space.

Space Rescue

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

Future Space Station Support

Eventually the shuttle can provide support to space stations that may be placed in orbit in the future. Personnel and cargo can be routinely transported from earth to a space station and returned.

The shuttle will be operational by the end of this decade. The first manned orbital flight is planned for 1978. Development costs are estimated at $5.5 billion (in current dollars) over a six-year period. Development costs include all research, development and test, and evaluation expenses, as well as two flight test vehicles. In addition, facility requirements for development and operations are estimated to cost about $300 million.

The reusable space shuttle will radically reduce the cost of space operations. Once in operation, the shuttle will deliver payloads to orbit at a cost of about $8 million per launch. For large payloads, the transportation cost to orbit will be about $100 to $150 per pound. In addition to this savings in transportation costs, additional economies will be achieved through reduction of the number and types of launch vehicles needed to support the nation's space effort, and in the cost of the satellites themselves. With the shuttle, automated satellites can be repaired or serviced in space or returned to earth for refurbishment and reuse. Moreover, the size and weight-carrying capacity of the orbiter will free designers from constraints which make design more difficult and costly. This will make it possible to use relatively inexpensive laboratory type equipment in place of specially constructed, highly miniaturized equipment which is expensive to develop and test.

With the savings in launch costs, payload costs, and payload development time, it is expected that the shuttle will greatly increase the use of space by government agencies and commerical users, and will lead to the discovery of new uses for space. A primary reason for development of the shuttle is to enhance the use of space for the practical benefit of mankind. With it we will be better able to survey the earth's resources, monitor and predict weather, improve worldwide communications, develop improved manufacturing processes, enlarge our knowledge of the earth and our solar system, and perhaps even harness the sun's energy as a source of pollution-free energy.

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Program Plan

The FY 1972 budget presented to Congress last year provided for shuttle engine development and for continuing studies or starting development on the shuttle itself, depending on the progress made in the studies. These studies have progressed to the point where a definite decision on configuration concept has been made and the final trade-off decisions necessary to initiate development can be made, leading to issuance this spring of a request for proposals from prospective development contractors.

The shuttle configuration concept has been selected on the basis of studies involving several NASA centers and more than a dozen aerospace contractors. Careful evaluation of the results of these studies considering the optimum balance between system performance characteristics, technical risk, and costs have led to selection of the delta wing orbiter described above. This orbiter with external, jettisonable oxygen/hydrogen tanks will be much smaller and less costly to develop than the fully reusable orbiter with internal tanks envisioned in the earlier studies. Evaluation of the study results has also led to selection of an unmanned ballistic booster rather than the more complex and costly manned fly-back booster concept.

Trade-off studies now in progress will provide the basis for decision between solid rocket motors and a recoverable, liquid fueled booster using pressure-fed engines. In the pressure-fed booster, the propulsion system is simplified by using gas pressure, instead of turbine drive pumps, to force the propellants through the engines. In this concept the booster will fly ballistically, make a parachute landing at sea, and be recovered for reuse. The solid rocket motors would also fly ballistically, but would not be recoverable.

Application of Funds

Engine Design and Development

The 213,000 kilogram (470,000 pounds) thrust engine will be used in a cluster of three on the Shuttle Orbiter. The current engine development plan provides for delivery of the first engines for qualification testing in 1976 and final flight configuration in 1977.

FY 1972 funds will be used to start engine design. Long lead procurement of subsystem test equipment and test articles will also be initiated.

FY 1973 funding will continue engine design leading to a preliminary design review in the middle of the fiscal year and will provide for the start of ignition systems testing, thrust chamber and preburner testing, and the oxidizer and fuel turbo pump testing. Orbiter/Engine interface drawings are scheduled for release by the end of FY 1973.

Booster and Orbiter Design and Development

The current planning for the Shuttle vehicle, booster and orbiter, anticipate that development work by the contractors who are yet to be selected will begin in mid-Calendar Year 1972. Fabrication and assembly of the first flight test vehicles are scheduled to start in 1974 with delivery to the horizontal test site in 1976. The first horizontal flight test of the orbiter is scheduled later in 1976 with the first manned orbital flight in 1978. As previously stated, an operational capability will be achieved by the end of the decade.

FY 1972 funding provides for vehicle definition effort leading to the beginning of booster and orbiter design and development.

FY 1973 funds will be used to proceed with the development effort. Detailed design drawings for the orbiter will be produced. FY 1973 funding will also provide for long lead procurement, the beginning of fabrication, and assembly of the structural test article. FY 1973 funding for the booster also provides for detailed design drawings. At this writing, the booster configuration has not yet been selected. Booster concepts now under study include pressure-fed systems and solid rocket motor systems. If the pressure-fed concept is adopted, work in FY 1973 will also include the start of the new pressure-fed engine required for this type of booster.

Technology and Related Development

Technology and Related Development funding provides for supporting development efforts in the areas of Avionics, Aerothermodynamics, Structures, Thermal Protection Systems (TPS), Auxiliary Propulsion, Dynamics, Aeroelasticity, and Cryogenics.

In FY 1972, emphasis is being placed on the development of avionics breadboards; related flight and ground system simulation of the following items: guidance and navigation systems, post-retrofire, reentry, and landing systems, data management, displays and control systems, flight control systems, and on-board self check equipment and systems. Also emphasized are studies of reusable surface insulation materials; efforts relating to hot structure capabilities, including evaluation of the United States Air Force work in this area; demonstrations of fabrication techniques; demonstrations of high temperature bearings, lubrications, and seals; and auxiliary propulsion system studies and component investigations of various earth storable monopropellant and bi-propellant system options for the reaction control system, Orbital Maneuvering System, and auxiliary propulsion unit applications.

FY 1973 funding will allow an orderly progression from initial avionic breadboards and flight investigations to integrated avionics simulation and to more advanced guidance and navigation and flight control simulation in aircraft; continued investigation of reusable surface insulation materials and applications; and the demonstration of critical components and critical system interactions for earth storable propellants for auxiliary propulsion and electrical power generation systems suitable for long life and reuse.

Engine Definition

No Engine Definition funds are being requested in FY 1973.

FY 1972 funding is being used to continue Space Shuttle Main Engine efforts and for study of pressure-fed engines and solid rocket motors for use in the decision process related to the final selection of the booster configuration.

Vehicle Definition

No vehicle definition funds are requested in FY 1973.

Definition efforts in FY 1972 have concentrated on the step-by-step approach to vehicle configuration that was described to the Congress in the FY 1972 budget request and have provided the basis for the decisions that have been made on the configuration concept for the Space Shuttle System.

Orbital Systems and Payloads

Advanced development.....	($11,500,000)	($12,500,000)	$11,000,000
Payloads.....	12,525,000	10,500,000	6,000,000
Research and applications modules.....	---	---	6,000,000
Space station.....	11,075,000	7,100,000	---
Total.....	$23,600,000	$17,600,000	$23,000,000

Orbital Systems and Payloads includes work relating to future manned space flights. This work focuses on Advanced Development, Payloads, and Research and Application Modules studies.

Advanced Development:

Advanced Development is directed toward development of long lead items, experimental systems, operational techniques, and toward the establishment of specifications and design requirements for designated and potential manned space flight programs. It provides a basis for decisions related to future goals within the space program in addition to providing support and answers to problems within ongoing programs.

Present efforts include the development and requirements needed to integrate nuclear power conversion units into space hardware; investigation of solar cell problems and the development of cell stack technology; the development of steerable microwave phased array at S-Band to provide a high data rate, telecommunications capability; development of advanced space computer hardware, software, and computer peripheral device technology; development of high power short pulse laser devices to provide capability for more observatory stations around the world to participate in the lunar laser ranging program thus freeing larger observatories for other activities; development of aero-breaking techniques to reduce propulsion requirements for return to earth orbit and to allow space tug missions not otherwise feasible; in conjunction with the Air Force, the establishment of a point design for a high performance engine of about 4,536 kilograms (10,000 pounds) thrust for consideration in multiple space program applications including the Space Shuttle, tug, and unmanned upper stages; investigation of docking mechanisms required for international rendezvous and docking; and studies relating to problems with lightning around the launch pad, handling and storage of cryogenics in orbit, atmospheric contamination and sonic boom.

In FY 1972 and prior years, funding for these advanced development activities has been included in the Apollo program. FY 1973 funding provides for the continuation of many of the present efforts described above. In addition new tasks which cover a broad range of space system developments will be initiated. The development of techniques for and simulation of manufacturing and utilization of lunar oxygen is one such task. A benefit resulting from this development would be the reduction of logistics requirements in lunar base and space propulsion operations. Flight operations will receive support from studies and developments in onboard maintenance techniques and spacecraft contamination controls. FY 1973 funding will also provide development of satellite collision avoidance techniques and controls which will provide further safety margins in space flight.

Payloads:

This item provides for the experiment definition activities required to identify and verify, through ground experimentation and analysis, those worthwhile payloads and experiments to be carried on future Space Shuttle missions.

Early identification is necessary to plan and define a balanced program of payloads and experiments. Before an experiment can be developed and committed to a flight program, it must be feasible for missions planned in the program and assessed for its specific contribution to the program objectives. In addition, it must have well defined funding and schedule projections. Specifications for power, temperature, volume and similar mission constraints must also be fully developed. FY 1972 funding supports the initiation and continuation of a broad spectrum of definition studies related to Space Shuttle payloads.

FY 1973 Payloads funding provides for the definition of Manned Space Flight experiments, and provides for the integration planning necessary to the accommodation of science and applications payloads into the Space Shuttle system. Specific FY 1973 requirements include definition studies in advanced technology, material science and manufacturing, general studies concerned with on-orbit payload checkout requirements, the impact of the Shuttle on experiment hardware development specifications, and definition studies to support the integration of experiment payloads into the Shuttle.

Research and Application Modules:

This activity is focused on study and definition of a family of manned or man-tended payload carriers that provide flexible and economical payload accommodations for delivery to earth orbit by the Shuttle. The family of Research and Application Modules will be defined so that it can evolve in capability from an austere shuttle "sortie can" through more sophisticated dedicated laboratory and observatory facilities into a future space station composed of shuttle launched modules whose development, structures and subsystems evolve from those of the preceding modules.

FY 1973 funds will be focused primarily on definition of Research and Application Modules and will also support limited activity continuing the definition breadboarding of long lead systems which were shown by the definition studies to be critical to program accomplishment. Major areas of effort include concept verification test activities which will verify, by actual testing, the performance of the integrated Shuttle payload carriers and their supporting systems prior to commitment of these systems to hardware design and fabrication; and in-house preliminary design of a sortie can--a pressurized and habitable module which can be transported to and from orbit in the Shuttle cargo bay. The sortie can will provide a simple, low cost, versatile and economical laboratory and observatory facility for short term research and applications investigations and experimentation in earth orbit inside the Shuttle.

Space Station:

The current Space Station definition studies are being completed in FY 1972. No FY 1973 funds are being requested for Space Station.

Space Life Sciences

	1971	1972	1973
Biomedical research.....	---	$8,777,000	$12,000,000
Life support and protective systems.....	---	7,255,000	8,900,000
Bioengineering.....	---	3,743,000	4,600,000
Total.....	($28,600,000)	$19,775,000	$25,500,000

Space Life Sciences is composed of three primary disciplinary elements: Biomedical Research, Life Support and Protective Systems technology, and Bioengineering technology. Each element is structured to provide a continuing program of advanced research and technology which directly supports the development of spacecraft and space mission design criteria for advanced manned missions. Space Life Sciences supports earth based investigations using space flight environmental analogies and provides for the design and conduct of inflight experimentation.

Biomedical Research:

FY 1972 and FY 1973 funding provide for medical, behavioral and biological research programs. The medical program includes investigations of the human body which may be influenced by the space environment. For example, cardiovascular studies will focus on the mechanisms by which changes in body fluid dynamics and muscular responses are produced by and following weightlessness in order to improve the ability to predict the time and course of such changes, to interpret their significance and to define physiological mechanisms for evaluating the effectiveness of preventive techniques. Bone/muscle investigations will continue to acquire additional data on the effects of prolonged simulated space flight as a precursor to the development of countermeasure approaches appropriate to nutrition and musculoskeletal functions. Behavioral studies will investigate crew command structure, group dynamics, social interaction and interpersonal adaptation in closed environments and how these affect performance. The study of daily rhythm, sleep scheduling and work/rest cycles--including the performance effects of sleep loss and rhythm desynchronization are also included in behavioral studies. Biological investigations will include radiation biology and associated space flight experiment definition. Space flight biology experiments are also being designed to determine mechanisms by which biological systems are affected by the absence of gravity and how earth organisms can adapt to the stresses of the space environment.

Life Support and Protective Systems:

This item provides for the development of advanced technology through the testing of experimental life support and protective devices necessary to provide a safe habitable space flight environment. Investigations are underway on systems for providing breathing atmospheres; thermal control; crew equip-

ment; and food, water, and waste management.

FY 1972 and FY 1973 funding supports the development of advanced life support and protective system technology. Specific areas include the development of water and waste management systems; the development and testing of an advanced prototype model of a carbon dioxide concentrator which removes a very high percentage of carbon dioxide from an atmosphere; development of intravehicular emergency lightweight spacesuit systems technology to meet requirements for a backup pressurization system for emergency operations in future space transportation systems; and, studies involving regenerative portable life support system techniques which would require less expendables and would allow the crewmen on advanced space flights to perform extravehicular activities of longer duration.

Bioengineering:

Includes the study and advancement of technology in the development and test of bioinstruments, bioassay concepts and integrated bioinstrumentation systems.

FY 1972 and FY 1973 bioengineering funding provides for advanced bioinstrumentation technology to measure or detect biological, psychological and physiological responses of man and/or other biological species during space flight. Specific areas of research include the integration of developed bioinstrumentation system elements to measure medical, psychological, and physiological parameters during manned space flights of extended duration; and, special emphasis in FY 1973 involving the development of a remotely controlled manipulator and sensor system to augment human sensory and physical control capabilities in space flight.

Development, Test and Mission Operations

Development, Test and Mission Operations is a new FY 1973 line item under Space Flight Operations and includes the basic engineering and test operations and operation support together with the crew training, launch systems operations, flight, recovery and Department of Defense support required for manned space flights regardless of program. It also includes those activities necessary for specific missions. In FY 1972 and prior years, these capabilities were funded almost entirely in the Apollo program.

Development, Test and Mission Operations

	1971	1972	1973
Research and test operations..	($90,015,000)	($91,567,000)	$80,800,000
Crew and flight operations....	(77,892,000)	(90,162,000)	86,000,000
Operations support.....	(79,094,000)	(61,357,000)	57,000,000
Launch systems operations.....	(65,667,000)	(66,639,000)	81,400,000
OMSF engineering support.....	(14,812,000)	(9,325,000)	---
Total.....	($327,480,000)	($319,050,000)	$305,200,000

Research and Test Operations

	1971	1972	1973
Engineering and test.....	($60,721,000)	($66,793,000)	$58,100,000
Applications and science.....	(19,786,000)	(15,392,000)	12,400,000
Reliability, quality and safety.....	(9,508,000)	(9,382,000)	10,300,000
Total.....	($90,015,000)	($91,567,000)	$80,800,000

Research and Test Operations provide the NASA in-house capabilities necessary to support the ongoing Apollo and Skylab programs; to assist in the definition, design and component and subsystem testing activities associated with the Space Shuttle and to undertake predefinition and definition of future programs. Research and Test Operations cover a wide spectrum of technical, engineering, scientific and medical disciplines supporting not only Manned Space Flight activities but also efforts of the other program offices of the National Aeronautics and Space Administration, and other government agencies, which are undertaken at Manned Space Flight installations.

Program support is provided by Research and Test Operations through directing and monitoring highly technical system and subsystem development. This is accomplished by maintaining an in-house research and test staff and the required labs and test equipment to assure fulfillment of technical needs as they relate to each program. In addition, Research and Test Operations activities involve overall systems engineering and integration, specification and standards management and the actual design and development of selected hardware items. In-house contractor support is provided to maintain critical skills needed to operate technical facilities. This independent in-house capability to solve problems and to test systems is essential to the maintenance of effective management control over technical inputs to the program.

Engineering and Test:

FY 1973 funding supports activities in all the engineering disciplines required to conduct a space flight program at the laboratories and divisions of the Marshall Space Flight Center and the Manned Spacecraft Center. Examples of the activities included are developing fabrication and assembly methods for space hardware; manufacturing experimental prototype structures, models and mock-ups; simulating zero-G conditions in test chambers; operating facilities such as the thermal-vacuum environmental chambers to simulate the space environment; and operating the large reverberant test chamber and the excitation equipment for high force vibration testing designed to verify structural integrity required for the flight environments encountered during launch.

Applications and Science:

FY 1973 funds provide for Applications and Science activities both at MSC

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and MSFC. These activities include real time support for management of data from the Earth Resources Experiment Package included in the Skylab program; assisting the scientific community in the analysis of data acquired from the Apollo missions; maintenance and operation of the lunar sample curatorial facility; providing highly specialized analyses in astronomy including ultraviolet spectroscopy, cosmic ray physics and upper atmosphere aeronomy; and medical research and operations.

Reliability, Quality and Safety:

FY 1973 funding will support efforts involving reliability assurance, risk analysis, tests and checkout of space vehicle and payload systems, subsystems, components and related support equipment to assure technical adequacy and performance of industry in the manufacture, delivery, test and launch of space vehicles and space vehicle payloads. It provides advanced test and checkout equipment and techniques to improve product assurance capability and to keep pace with advancements in manufacturing processes and techniques. Reliability, Quality and Safety provides the personnel required to develop design, manufacturing and operational requirements and to assure compliance with these requirements through monitoring of the tests and inspection procedures and through actual testing and inspection when required. This item also provides for surveillance to ensure effective reporting of problems and the status of corrective actions.

Crew and Flight Operations

	1971	1972	1973
Crew.....	($28,244,000)	($26,776,000)	$19,800,000
Flight.....	(22,414,000)	(18,478,000)	22,000,000
Mission control.....	(27,234,000)	(44,908,000)	44,200,000
Total.....	($77,892,000)	($90,162,000)	$86,000,000

The Manned Spacecraft Center is the headquarters for all crew and flight operations. The astronauts are based at this Center along with most of their essential training equipment. This equipment includes proficiency aircraft, spacecraft mockups and procedures simulators. The Manned Spacecraft Center is also responsible for mission simulation and other astronaut training equipment located at the Kennedy Space Center. Also at MSC is the Mission Control Center with its computer complex and communications links to the tracking network and other worldwide data sources. The Mission Control Center controls flight operations from shortly after lift-off to recovery. The tempo of Crew and Flight Operations will increase markedly in FY 1973 to accommodate Apollo 17, the initial Skylab operations and to prepare for the second manned mission to the Skylab which will take place early in FY 1974.

In addition to basic expenses to support these operations, there are requirements that are directed to specific missions such as mission planning, including trajectory analysis; failure analysis and evaluation of operational performance; and recovery operations which encompass the planning, development and operational

phases of recovery activity including the location and retrieval of the astronauts and spacecraft following touchdown.

Crew:

FY 1973 funding will provide for training and integration of flight crew activities with the engineering design and development of manned spacecraft and with flight mission planning. Also included is the operational cost of mission simulators, part task trainers, and aircraft required for crew training.

Flight:

FY 1973 funds will support flight operations in the areas of planning, support, and actual accomplishment of the spacecraft mission from lift-off through recovery which involves the broad areas of mission planning, flight control, and operational support including recovery. Specific mission trajectory development costs are also included.

Mission Control:

FY 1973 funding will provide for the maintenance and operation of the Mission Control Center including the Real-Time Computer Complex; lease of land lines, switchboards, and miscellaneous communications equipment used in the MCC; contractor assistance to solve special technical problems in the mission control systems area; and for communications system studies.

Operations Support

	1971	1972	1973
On site.....	($47,384,000)	($45,494,000)	$42,200,000
Off site.....	(31,710,000)	(15,863,000)	14,800,000
Total.....	($79,094,000)	($61,357,000)	$57,000,000

Operations Support funding provides for approximately 2,000 manyears of effort to provide the on and off-site services highlighted below. Thirteen contractors are involved. The funding also provides for the procurement of supplies and equipment related to these efforts. Funds will be used as follows:

On Site:

FY 1973 funding provides for overall technical services at the Kennedy Space Center, Marshall Space Flight Center, and the Manned Spacecraft Center. These include such activities as special facility maintenance; post launch refurbishment; renovations; rigging; closed circuit television monitoring directly related to training and test facilities; documentation and technical report preparation; logistics support; chemical purging services; detailed

design and drafting effort required for launch equipment and facilities; telecommunications; electronics component fabrication; and photo support. Additionally, the Air Force Eastern Test Range supplements the Kennedy Space Center operations support by providing test and launch support for both manned and unmanned missions, which is reimbursed based on costs incurred.

Off Site:

FY 1973 funding will provide for the maintenance of technical and production facilities at the White Sands Test Facility, the Mississippi Test Facility and the Michoud Assembly Facility.

Launch Systems Operations

	1971	1972	1973
Mechanical ground systems....	($34,522,000)	($36,224,000)	$45,400,000
Electrical instrumentation systems.....	(31,145,000)	(30,415,000)	36,000,000
Total.....	($65,667,000)	($66,639,000)	$81,400,000

Launch systems operations are performed at Kennedy Space Center and include the technical services required in the test and launch operations and the operation and maintenance of the launch facilities and ground support equipment.

Mechanical Ground Systems:

FY 1973 funding provides for the operation and maintenance of launch complex facilities and related equipment such as mobile transporters, the converter compressor facility, mobile service structure, altitude chambers, propellant loading systems, pneumatics, and Vehicle Assembly Building adjustable work platforms. Additionally, launch related services such as propellant handling, life support, technical shops, chemical cleaning and decontamination and systems safety are provided.

Electrical Instrumentation Systems:

FY 1973 funding 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.

OMSF Engineering Support

	1971	1972	1973
OMSF engineering support.....	($14,812,000)	($9,325,000)	---
Total.....	($14,812,000)	($9,325,000)	---

The engineering support activities which have been performed by Bellcomm, Boeing and General Electric in support of the Office of Manned Space Flight are being phased out. Therefore, no FY 1973 funds are requested.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1973 ESTIMATES

BUDGET SUMMARY

OFFICE OF MANNED SPACE FLIGHT — ADVANCED MISSIONS PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1971	1972	1973
Advanced Missions.....	$1,500,000	$1,500,000	$1,500,000

HIGHLIGHTS OF BUDGET PLAN

	1971	1972	1973
Advanced Missions - future program concepts and requirements development including Space Tug definition, operations and interfaces; and lunar exploration, space safety, and Apollo hardware utilization studies.....	$1,500,000	$1,500,000	$1,500,000

OFFICE OF MANNED SPACE FLIGHT — ADVANCED MISSIONS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

Advanced mission activities require a continuing review of current and future manned space flight programs and provide a basis for developing program concepts and requirements for future space systems. The capability of industry is utilized to perform conceptual design studies and to provide comparative technical data to supplement in-house activities. The results of both in-house and contracted studies provide the necessary information to assess and direct the future course of this nation's manned space flight program.

SUMMARY OF RESOURCES REQUIREMENTS:

	1971	1972	1973
Advanced mission studies.....	$1,500,000	$1,500,000	$1,500,000
Total.....	$1,500,000	$1,500,000	$1,500,000

Distribution of Program Amount by Installation:

John F. Kennedy Space Center, NASA	---	$150,000	$200,000
Manned Spacecraft Center.....	$575,000	550,000	500,000
Marshall Space Flight Center....	850,000	800,000	800,000
Goddard Space Flight Center.....	29,000	---	---
NASA Headquarters.....	46,000	---	---

BASIS OF FUND REQUIREMENTS:

Advanced Mission Studies

	1971	1972	1973
Advanced mission studies.....	$1,500,000	$1,500,000	$1,500,000
Total.....	$1,500,000	$1,500,000	$1,500,000

Fiscal Year 1972 funding is being used to emphasize studies of advanced systems and techniques which investigate standard platforms and support systems for sensor elements to be carried on geosynchronous orbit; space transportation system studies related to software and hardware required to lower cost space operations; requirements studies for orbital operations; and a study of manned space flight goals designed to formulate requirements for future missions.

Areas of study that will receive emphasis during FY 1973 are:

Tug Operations and Interfaces - For future high orbit missions, the reusable Space Tug will be attached to payloads and delivered to low earth orbit inside the Space Shuttle cargo bay. On-orbit payload delivery and retrieval operations to be performed by the Tug will be examined. Technical understanding of the salient interfaces is of vital importance to Shuttle/Tug/Payloads planning and systems definition. This study activity is a continuing and focused effort to understand the potential and the requirements of new transportation modes in relation to payloads and support operations.

Lunar Surface Missions - Lunar exploration studies for the 1980's will be conducted. The initial study effort will consider objectives, potential utilization of lunar resources for logistics support, and the economics and performance implications of space transportation system elements.

Safety Studies - An integrated space program safety study will be conducted to provide guidance in establishing new safety concepts as they relate to the development of advanced missions.

Additional Studies - Studies will be conducted in support of the Space Tug definition effort, Apollo hardware utilization, new mission requirements and European cooperative efforts. There will be continued investigations of alternative operating modes with the resulting impacts on interface requirements and systems designs, as well as the distribution of functions among future space hardware elements.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1973 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR

SPACE SCIENCE PROGRAMS

Program	1971	1972	1973
Physics and astronomy.....	$115,956,000	$110,100,000	$156,600,000
Lunar and planetary exploration.....	144,900,000	291,500,000	321,200,000
Bioscience.....	12,898,000	---	---
Launch vehicle procurement.....	124,900,000	151,300,000	191,600,000
Total.....	$398,654,000	$552,900,000	$669,400,000

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RESEARCH AND DEVELOPMENT

FISCAL YEAR 1973 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE — PHYSICS AND ASTRONOMY PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1971	1972	1973
Large observatories.....	$ 40,141,000	$ 45,400,000	$ 79,700,000
OSO.....	(16,931,000)	(18,600,000)	(14,500,000)
OAO.....	(23,210,000)	(13,400,000)	(5,600,000)
HEAO.....	(---)	(13,400,000)	(59,600,000)
Orbiting explorers.....	25,837,000	22,600,000	32,000,000
Sub-Orbital programs.....	24,865,000	21,690,000	25,000,000
Supporting activities.....	25,113,000	20,410,000	19,900,000
Total.....	$115,956,000	$110,100,000	$156,600,000

HIGHLIGHTS OF BUDGET PLAN

Large observatories.....	$ 40,141,000	$ 45,400,000	$ 79,700,000
Orbiting Solar Observatories (OSO).....	(16,931,000)	(18,600,000)	(14,500,000)
Spacecraft design, development, and testing; OSO-I to be launched in 1973.	8,315,000	11,383,000	7,776,000
Experiment development for OSO-I, data analysis for OSO-7 and prior missions, and definition studies for future missions....	8,616,000	7,217,000	6,724,000
Delta (Launch Vehicle Procurement).....	(300,000)	(1,700,000)	(1,800,000)
Orbiting Astronomical Observatories (OAO).....	(23,210,000)	(13,400,000)	(5,600,000)
Spacecraft construction and testing in preparation for final launch (OAO-C) in mid-1972.....	13,858,000	8,078,000	1,654,000
Experiments including data analysis, orbital operations, and continuation of the guest observer program.....	9,352,000	5,322,000	3,946,000

	1971	1972	1973
Large Observatories (Cont'd.)			
Atlas/Centaur (Launch Vehicle Procurement).....	$ (1,900,000)	$ (300,000)	$ (---)
High Energy Astronomy Observatories (HEAO).....	$ (---)	$(13,400,000)	$(59,600,000)
Spacecraft design and development of HEAO A&B for launch in 1975 and 1977.....	---	2,900,000	29,100,000
Experiment design and development for missions A&B and definition studies for mission C. The HEAO series will study the universe in the high energy range of the electromagnetic spectrum.....	---	10,500,000	30,500,000
Titan III E (Launch Vehicle Procurement).....	(---)	(1,800,000)	(9,000,000)
Orbiting explorers.....	$ 25,837,000	$ 22,600,000	$ 32,000,000
Atmospheric Boundary Explorers:			
Three missions in the Atmosphere Explorer (AE) series scheduled for launch in 1973, 1975, and 1976...	3,300,000	8,350,000	13,400,000
Delta (Launch Vehicle Procurement).....	(1,700,000)	(1,500,000)	(300,000)
Interplanetary and Magnetospheric Boundary Explorers:			
Interplanetary Monitoring Platform (IMP) series; missions to be launched in 1972 and 1973, continued analysis of prior mission results and advanced studies of future missions.....	6,800,000	5,310,000	5,200,000
Delta (Launch Vehicle Procurement).....	(3,000,000)	(1,400,000)	(2,500,000)
Magnetospheric Explorers:			
Two missions in the Air Density/Injun series, a cooperative mission with West Germany (AEROS) and analysis of data from other missions previously launched.....	3,669,000	2,633,000	5,340,000
Scout (Launch Vehicle Procurement).....	(100,000)	(3,350,000)	(3,100,000)

	1971	1972	1973
Orbiting explorers (Cont'd.)			
Astronomy and Astrophysics Explorers: Small Astronomy Satellite (SAS) and Radio Astronomy Explorer (RAE) series; also includes international cooperative missions with the Netherlands (ANS) and United Kingdom (UK-5). Analysis of data from other missions launched prior to FY 1973 and for advanced studies of potential future missions.....	$ 12,068,000	$ 6,307,000	$ 8,060,000
Delta (Launch Vehicle Procurement).....	(---)	(---)	(2,600,000)
Scout (Launch Vehicle Procurement).....	(---)	(450,000)	(4,500,000)
Sub-Orbital programs.....	$ 24,865,000	$ 21,690,000	$ 25,000,000
Sounding Rockets-Continuation of sub-orbital rocket-borne experiments.....	18,900,000	18,000,000	20,000,000
Airborne Research-Construction and installation of an infrared telescope in a C-141 aircraft and for continued studies in infrared astronomy from aircraft.....	4,965,000	2,690,000	4,000,000
Balloon Program-Support for balloon-borne experiments of various types.....	1,000,000	1,000,000	1,000,000
Supporting activities.....	$ 25,113,000	$ 20,410,000	$ 19,900,000
Supporting Research and Technology (SR&T)-Support for the development of theory, instrument development, supporting laboratory studies, and ground-based observations.....	17,235,000	15,410,000	14,900,000
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)	7,878,000	5,000,000	5,000,000

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1973 ESTIMATES

OFFICE OF SPACE SCIENCE

PHYSICS AND ASTRONOMY PROGRAM

FLIGHT SCHEDULE

PROJECT	MISSION	CALENDAR YEAR
Large Observatories:		
Solar Observatories	OSO-I	1973
Astronomical Observatories	OAO-C	1972
High Energy Astronomy Observatories	HEAO-A HEAO-B	1975 1977
Explorers (Including International Cooperative Satellites)	4 - 6 launches per year	
Suborbital Programs:		
Sounding Rockets	About 90 launches per year	
Balloon Flights	About 50 launches per year	

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1973 ESTIMATES

OFFICE OF SPACE SCIENCE — PHYSICS AND ASTRONOMY PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The major objective of the Physics and Astronomy program is to increase human knowledge 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 investigation of cosmic ray, gamma ray, ultraviolet, infrared, and radio emissions, not possible from ground-based observatories because of the obscuring effect of the earth's atmosphere, gives us a unique opportunity to study the sun and other celestial bodies. In this way, we are increasing our knowledge of the fundamental laws and principles of nature.

To gather information on these phenomena, NASA employs 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 generated and the technology developed in the program are made available to the scientific and technical community for applications and for advancement of future scientific research, education, and technology.

SUMMARY OF RESOURCES REQUIREMENTS:

	1971	1972	1973
Large observatories.....	$ 40,141,000	$ 45,400,000	$ 79,700,000
Orbiting explorers.....	25,837,000	22,600,000	32,000,000
Sub-orbital programs.....	24,865,000	21,690,000	25,000,000
Supporting activities.....	25,113,000	20,410,000	19,900,000
Total.....	$115,956,000	$110,100,000	$156,600,000

Distribution of Program Amount by Installation:

	1971	1972	1973
Manned Spacecraft Center...	$ 225,000	$ 626,000	$ 300,000
Marshall Space Flight Center	2,865,000	14,182,000	59,500,000
Goddard Space Flight Center	82,542,000	66,985,000	66,800,000
Jet Propulsion Laboratory..	2,665,000	489,000	500,000
Wallops Station.....	1,677,000	2,585,000	2,900,000
Ames Research Center.....	2,425,000	4,805,000	6,300,000
Langley Research Center....	1,150,000	1,575,000	400,000
NASA Headquarters.....	22,407,000	18,853,000	19,900,000

BASIS OF FUND REQUIREMENTS:

Large Observatories

	1971	1972	1973
Orbiting Solar Observatories (OSO)			
OSO Spacecraft.....	$ 8,315,000	$11,383,000	$ 7,776,000
OSO Experiments.....	8,616,000	7,217,000	6,724,000
Subtotal OSO.....	$16,931,000	$18,600,000	$14,500,000
Orbiting Astronomical Observatories (OAO)			
Spacecraft.....	$13,858,000	$ 8,078,000	$ 1,654,000
Experiments.....	9,352,000	5,322,000	3,946,000
Subtotal OAO.....	$23,210,000	$13,400,000	$ 5,600,000
High Energy Astronomy Observatories (HEAO)			
Spacecraft.....	$ ---	$ 2,900,000	$29,100,000
Experiments.....	---	10,500,000	30,500,000
Subtotal HEAO.....	$ ---	$13,400,000	$59,600,000
Subtotal Large Observatories.....	$40,141,000	$45,400,000	$79,700,000
(Launch Vehicle Procurement program):			
Delta (OSO).....	($ 300,000)	($ 1,700,000)	($ 1,800,000)
Centaur (OAO).....	(1,900,000)	(300,000)	(---)
Titan III (HEAO).....	(---)	(1,800,000)	(9,000,000)
Total (including Launch Vehicles).....	($42,341,000)	($49,200,000)	($90,500,000)

Orbiting Solar Observatories (OSO)

The objective of the OSO program is to obtain new knowledge of the sun, 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 interactions with the earth.

In FY 1972, OSO-H, now designated as OSO-7, was successfully launched and is conducting detailed studies of the solar corona, and the spectrum of solar and cosmic X-rays.

FY 1972 funds have been used for OSO-7 tests, launch, and in-orbit operations; for spacecraft design and development; and for experiment design and development for the OSO-I mission.

FY 1973 spacecraft funds for OSO-I will be used to complete the design and continue the development and fabrication effort on the basic structure, interfaces for experiments, power systems, telemetry, control and data handling systems. Also in FY 1973, observatory integration and environmental tests will be initiated.

FY 1973 experiment funds will be used to continue support of the OSO-7 in-orbit operations, to provide for the analysis of the data obtained from that mission, and for ground-based observations supporting the in-orbit observations. Eight experiment groups will be funded to study the results of OSO data acquisition and correlative ground-based observations.

OSO-I experiment funds will be used to complete the design and continue the development and fabrication of the individual instruments for this mission. The seven U. S. experiments will enter the manufacturing phase, including selection and testing of components. An eighth experiment, for one of the two major solar pointed investigations, is being funded and developed by the French National Center for Space Studies. Definition studies for future missions will also be funded.

Orbiting Astronomical Observatories (OAO)

The OAO program provides astronomers with an accurately stabilized, automated space observatory for telescopic observations of celestial objects primarily in the ultraviolet region of the electromagnetic spectrum. The program consists of a series of missions with increasingly sensitive and precise spectroscopic instrumentation.

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

Fiscal Year 1972 funds supported the preparation of OAO-C for launch and initial operations, and the inflight operations and data analyses of OAO-2. FY 1973 funds will provide for launch and support of the in-orbit operations of OAO-C, and the reduction and analyses of data obtained by the scientific experiments.

High Energy Astronomy Observatory (HEAO)

The scientific objective of the HEAO project is to observe our galaxy and the universe in the X-ray and gamma-ray regions of the electromagnetic spectrum and to measure the energy spectrum and chemical composition of the corpuscular cosmic radiation. Limited information in each of these areas has been obtained from balloon, rocket, and small satellite flights; however, heavier and more sensitive instruments are required for long duration observations if we are to achieve a significant increase in knowledge.

The HEAO project will provide a total sky survey which is necessary to describe the universe. The more sensitive instruments provide a potential opportunity to probe deeper into the nature of elementary matter by observations of higher energy interactions than now achievable elsewhere.

The HEAO missions will provide potential for a major impact on the understanding and development of new energy processes and the creation of matter. A direct study of matter from outside our solar system will be achieved. For the first time from orbit, the nature of matter will be studied and the existence of anti-matter will be investigated.

The understanding of observed phenomena such as quasars, pulsars, novas, and supernovas will be greatly increased. In addition, HEAO offers a high potential for surprises from the vast undetected phenomena of the universe.

This program of investigations has been given the highest priority by various advisory boards, including the National Academy of Sciences (Woods Hole Summer Study), the Astronomy Missions Board, and the Space Program Advisory Council of NASA.

HEAO-A will perform a total sky survey in cosmic ray, X-ray, and gamma-ray emissions. This first mission will operate in an automated mode using subsystems which are currently available and experiments which are either fully developed or under advanced development, e.g., balloon payloads. The HEAO-B mission will provide pointing capability for improved observations of areas of specific interest.

The HEAO spacecraft must have the capability for carrying the large experiment instrumentation required for the surveys. The approximate dimensions will be a nine foot octagonal cylinder, thirty feet long. It is expected to weigh about 9,000-11,400 kg (20-25,000 pounds), carry up to 5,700 kg (12,500 pounds) of experiment instrumentation, and require approximately 750 watts of power generated by solar cells. The spacecraft will be designed for a nominal one year lifetime in a 200 nautical mile orbit.

The Titan III launch vehicle has been identified for the initial missions and studies are underway to take advantage of the Space Shuttle capability for later missions, i.e., launch, repairs, and updating.

The Marshall Space Flight Center (MSFC) is assigned responsibility for the technical management of the HEAO project.

HEAO-A experimenters have completed their definition phase studies, with final flight assignment of HEAO-A flight experiments to be made and design and development contracts awarded early in 1972. HEAO-B experiments are completing the predefinition studies and entering definiton phase studies of approximately one year duration.

Most of the FY 1973 spacecraft funding will go to the selected prime contractor, TRW, Inc., to complete the design of the spacecraft, to procure long lead-time items, and to fabricate system qualification units. The remaining funds will provide for required supporting activities.

The major portion of FY 1973 experiment funding will be used by selected flight experimenters for the HEAO-A mission to complete the design of their instruments and to procure critical long-lead items such as large crystals. FY 1973 funding will also be used by HEAO-B experiments to complete the definition phase and proceed with design and development of their instruments. A small amount will also be used for definition studies related to the next two missions of this planned four mission series.

Orbiting Explorers

	1971	1972	1973
Atmospheric boundary explorers.....	$ 3,300,000	$ 8,350,000	$13,400,000
Interplanetary and magnetospheric boundary explorers	6,800,000	5,310,000	5,200,000
Magnetospheric explorers....	3,669,000	2,633,000	5,340,000
Astronomy and astrophysics explorers.....	12,068,000	6,307,000	8,060,000
Subtotal, Orbiting Explorers.....	$25,837,000	$22,600,000	$32,000,000
(Launch Vehicle Procurement program):			
Delta.....	($ 4,700,000)	($ 2,900,000)	($ 5,400,000)
Scout.....	(100,000)	(3,800,000)	(7,600,000)
Total (including Launch Vehicles).....	($30,637,000)	($29,300,000)	($45,000,000)

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 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 missions launched in prior years are still providing valuable scientific information. For example, Explorer 42 has discovered a number of previously unknown sources, including some X-ray pulsars, which appear to differ in some respects from the more commonly known radio pulsars. Other explorer missions studying the physics of the sun/earth environment have mapped in broad detail the interplanetary region, the earth's magnetosphere, solar and galactic cosmic rays, and other phenomena. Future missions are planned to provide a better understanding of these complex solar-terrestrial relationships.

In FY 1973, funds will be used for the following explorer missions:

Atmospheric Boundary Explorers

Atmosphere Explorers (AE) are aimed at investigating the detailed processes which occur as a result of solar energy absorption by the earth's upper atmosphere. Three missions are planned for launch during the 1973-1976 time period, each of which will be equipped with an onboard 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 allowing studies of this interesting region 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.

The absorption of solar energy in the upper atmosphere produces the ionosphere, responsible for long distance radio wave propagation, and a large variety of complex phenomena. While many of these have been investigated in isolation, the detailed processes which govern them are not understood. To investigate the processes which occur as a result of the absorption of solar energy, the AE program is being implemented by a team of investigators who will make detailed cause and effect studies of the incoming solar radiation, the background neutral atmosphere, and the ionized constituents which result from their interaction. These measurements will be available for the first time on the same spacecraft, and in the altitude region where the maximum absorption of solar energy takes place.

Approximately one-third of the FY 1973 funds will be used for experiments and two-thirds for fabrication of spacecraft hardware.

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. Two flights in the IMP series are currently in the hardware phase (IMP-H&J) and advanced studies are planned for two additional missions. Earlier IMP's have mapped in broad detail the interplanetary region, the earth's magnetosphere, solar and galactic cosmic rays, and other complex solar-terrestrial relationships. They have also been used in conjunction with Apollo missions, providing early warning of solar flares and increases in solar proton levels, and making coordinated measurements with Apollo instruments on the moon to map the moon's magnetic field and internal composition. IMP missions have also provided the basis for great improvements in sensor and spacecraft technology. The orbits of the IMP-H&J missions were selected to be particularly favorable for studies of the geomagnetic tail and of the interplanetary medium.

FY 1973 funds will also provide for analysis of data from IMP-I (Explorer 43) launched in March 1971, and for definition studies related to future missions, including a mission to investigate phenomena associated with boundaries in the magnetosphere; and a solar-terrestrial probe of phenomena in the solar wind which may affect the earth.

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 Dual Air Density, Injun-F, and AEROS, a cooperative mission with West Germany, each in the hardware phase of development. Also included for FY 1973 funding is the analysis of data from Explorer 45 (SSS-A), San Marco-3, Ariel-4 (UK-4), and ISIS-2. The latter three missions are cooperatives with Italy, the United Kingdom, and Canada, respectively.

Astronomy and Astrophysics Explorers

Included here are the Small Astronomy Satellites (SAS) and the Radio Astronomy Explorers (RAE). During FY 1973, hardware development and construction will continue for SAS-B&C, and for RAE-B. Analysis of data from SAS-A (Explorer 42) will also be funded.

Cooperative astronomy missions with the United Kingdom and the Netherlands, UK-5 and ANS, will be funded for the development and construction of U. S. experiment instruments to be flown on these missions.

Advanced studies are planned to be continued for SAS-D, an ultraviolet astronomy mission, and for missions to test Einstein's theory of relativity.

Sub-Orbital Programs

	1971	1972	1973
Sounding rockets.....	$18,900,000	$18,000,000	$20,000,000
Airborne research.....	4,965,000	2,690,000	4,000,000
Balloon program.....	1,000,000	1,000,000	1,000,000
Total.....	$24,865,000	$21,690,000	$25,000,000

Sounding Rockets

The objectives of the Sounding Rocket program can be classed as follows:

1. To conduct a coordinated program to study:
   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, or other astrophysical experiments with flight requirements which cannot be covered by or do not require long duration satellite observations.

2. To support the basic objectives of the Physics and Astronomy projects by providing the means to flight test experiments being developed for flight on satellites, observatories, and space probes, and in addition, to calibrate or obtain vertical profiles in correlation with currently orbiting spacecraft.

3. To provide means to improve the technical maturity of graduate students, new experimenters, and supportive personnel in space science experimentation, both on a domestic and an international cooperative basis.

A flexible stable of relatively inexpensive vehicles and associated supporting instrumentation will continue to be utilized to support the scientific instrumentation for the above objectives in the disciplines of planetary atmospheres, magnetodynamics, galactic and radio astronomy, and solar physics.

The FY 1973 funding level requested is $20.0 million. Approximately $8 million of these funds will be used to provide flight experiment payloads for some 55 to 60 experimenter groups from universities, NASA centers, and other government agencies. The other $12 million will be used to support the flights of these payloads, that is, to provide rocket, telemetry pointing control, and mechanical devices associated with the individual flights. A

small portion of the flight support money will be used to enhance the state of the art in rockets, telemetry systems, and pointing control systems.

The requested budget will permit the following new and additional effort:

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

2. Increased emphasis on stellar and solar astronomy as recommended by the National Academy of Sciences report, "Priorities for Space Research". In stellar astronomy, additional emphasis will be placed on payloads associated with the ultraviolet region of the spectrum, with some additional effort on the soft X-ray region of the spectrum not currently being measured by satellites.

   In solar astronomy, increased emphasis will be placed on correlative rocket measurements associated with the ATM Skylab project. Specific payloads will involve collimated X-ray spectroscopy of the sun.

3. In the area of magnetodynamics, observations from unique geographical sites are proposed. For example, the mechanism whereby solar wind particles penetrate the magnetosphere has, until recently, been only a matter of speculation. Recent measurements made on NASA satellites have indicated the penetration of solar wind particles through "neutral cusp" regions at the magnetosphere boundary at high latitudes. Although the above measurements suggest the penetration of solar wind particles through neutral cusps and the formation of mid-day aurora, as well as a possible heating mechanism for the high latitude ionosphere, experimental proof requires the vertical profile measurements which can only be made using sounding rockets.

As mentioned previously, some funding will be utilized to update the state of the art in supporting systems. It is expected to flight test a new vehicle system, the "Astrobee-F", which will be a solid fuel replacement for the liquid fuel Aerobee and produce a more economical vehicle with increased performance allowing longer viewing time for stellar and solar observations. In addition, advancement in the application of fluidic control for solar pointing control systems will be undertaken to produce greater reliability with signficantly better pointing accuracy.

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 and space station operations in the future.

The Physics and Astronomy Airborne Research project emphasizes the support of infrared astronomy and investigations of the physics of the aurora and airglow. Infrared astronomy of the sun, planets, and galaxies with small telescopes has been undertaken from the CV-990 and Lear Jet aircraft. A large telescope is now being built for observations from a C-141A jet aircraft.

The FY 1972 airborne research funding is almost entirely allocated for the continuation of the IR telescope construction.

The FY 1973 airborne research budget is also programmed primarily for the IR airborne observatory and will be utilized for the completion of the telescope and its integration into the C-141A aircraft. The remaining funding will be allocated to the development by participating scientists of experiment hardware to be used with their specific observation programs, to the interim continuation of research with the existing airborne telescope system, for continuity of scientific research output, and to ensure scientific and technological readiness for the C-141 and possible other future systems (e.g., space shuttle).

Balloon Program

Balloons play an important role in the Physics and Astronomy program by providing timely and relatively low cost flight opportunities for (a) testing proposed satellite instrumentation in the space environment, (b) obtaining observations at altitudes which are not accessible to satellites, (c) lifting instruments which are too heavy and voluminous for flight in present automated satellites, (d) utilizing instruments which can be safely recovered and reused, and (e) obtaining observations for relatively extended periods of time (in contrast to short duration rocket flights). Approximately one million dollars are expended annually to support about 50 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).

Supporting Activities

	1971	1972	1973
Supporting research and technology.....	$17,235,000	$15,410,000	$14,900,000
Data analysis.....	7,878,000	5,000,000	5,000,000
Total.....	$25,113,000	$20,410,000	$19,900,000

Supporting Research and Technology/Advanced Studies

This effort helps assure continued excellence and viability of the future programs and increases the scientific and technological returns from current

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1973 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE

LUNAR AND PLANETARY EXPLORATION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1971	1972	1973
Mariner	$ 41,840,000	$ 61,600,000	$ 43,000,000
Viking	35,000,000	176,200,000	229,500,000
Outer planets missions	---	10,000,000	7,000,000
Pioneer/Helios	41,675,000	15,264,000	12,500,000
Supporting research and technology/Advanced studies*	18,005,000	18,236,000	18,700,000
Planetary astronomy	4,800,000	4,800,000	4,800,000
Data analysis	3,580,000	3,200,000	3,500,000
Planetary quarantine*	---	2,200,000	2,200,000
Total	$144,900,000	$291,500,000	$321,200,000

*Planetary Quarantine and the Exobiology part of SR&T were, in FY 1971, part of the Bioscience program.

HIGHLIGHTS OF BUDGET PLAN

	1971	1972	1973
Mariner	$41,840,000	$61,600,000	$43,000,000
Mariner-Mars 1969	188,000	100,000	---
Mariner Mars 1971	31,291,000	16,900,000	11,400,000
Hardware development of two spacecraft launched in May 1971	21,700,000	200,000	---
Mission operations for basic 90 day orbital period	6,000,000	11,300,000	3,500,000
Extended mission operations for an additional 9 months	---	2,500,000	7,000,000
Project management and project integration	3,591,000	2,900,000	900,000

	1971	1972	1973
Mariner Venus/Mercury 1973..	$10,361,000	$44,600,000	$31,600,000
Spacecraft design, development, and test leading to delivery to KSC in June 1973.....	8,661,000	38,100,000	26,600,000
Science instruments to return ultraviolet and visual television pictures, atmosphere and ionosphere data, and thermal maps from both Venus and Mercury.....	1,600,000	5,400,000	3,300,000
Mission operations preparations for mission beginning in November 1973.....	100,000	1,100,000	1,700,000
Atlas/Centaur (Launch Vehicle Procurement).....	(3,045,000)	(6,693,000)	(6,089,000)
Viking.....	$35,000,000	$176,200,000	$229,500,000
Orbiter			
Spacecraft design, development, and test leading to delivery of two spacecraft to KSC in early 1975....	7,100,000	33,900,000	65,100,000
Science instruments to obtain planetary data, including water vapor and thermal mapping, for at least three months.....	1,200,000	6,000,000	8,700,000
Lander			
Spacecraft design, development, and test leading to delivery of three spacecraft to KSC early in 1975.....	18,000,000	88,500,000	102,200,000
Science instruments to transmit biological, geological, meteorological, and other data to earth for 90 days	6,700,000	36,600,000	35,100,000
Project Management and Project Integration.....	2,000,000	11,200,000	18,400,000
Titan/Centaur (Launch Vehicle Procurement).....	(6,100,000)	(11,200,000)	(26,000,000)

	1971	1972	1973
Outer Planets Missions	$ ---	$10,000,000	$7,000,000
Spacecraft Design and Development.....	---	6,000,000	4,000,000
Spacecraft system design, completion of existing subsystem design verification, and required design modification and new technology developments. Preparation of spacecraft system RFP			
Science.....	---	2,000,000	1,000,000
Project Management and Mission Design.....	---	2,000,000	2,000,000
Pioneer/Helios	$41,675,000	$15,264,000	$12,500,000
Pioneer 6-9.....	1,579,000	600,000	400,000
Spacecraft.....	91,000	---	---
Science.....	535,000	---	---
Operations.....	953,000	600,000	400,000
Receipt and reduction of scientific data on magnetic tapes.			
Pioneer F/G.....	38,196,000	12,164,000	9,800,000
Spacecraft.....	29,321,000	7,209,000	5,473,000
Fabrication and acceptance testing of Pioneer G systems			
Science.....	8,018,000	2,889,000	2,430,000
Analysis of scientific data collected during the F&G missions			
Operations.....	857,000	2,066,000	1,897,000
Support the F&G missions at the Space Flight Operations Facility and Deep Space Network by controlling the spacecraft, tracking it, and recording data on magnetic tapes.			

	1971	1972	1973
Pioneer/Helios (Cont'd.)			
Helios A&B.....	$ 1,900,000	$ 2,500,000	$ 2,300,000
Science.....	1,849,000	2,340,000	1,757,000
Development and test of three U. S. scientific instruments leading to delivery of prototypes to Germany in early FY 1973. Delivery of flight instruments later in this fiscal year.			
Operations.....	51,000	160,000	543,000
Review of German telecommunications system design. Preparation of tracking and data systems			
Centaur (Launch Vehicle Procurement).....	(18,300,000)	(11,700,000)	(17,300,000)
Supporting Research and Technology/Advanced Studies....	$ 18,005,000	$ 18,236,000	$ 18,700,000
Lunar Science.....	6,000,000	2,200,000	2,900,000
Interpret the data acquired from lunar missions.			
Planetary Science.....	4,660,000	4,936,000	4,700,000
Supports research in planetary atmospheric phenomena; planetary geology, including geochemistry, geophysics, and photogeology.			
Planetary Advanced Technical Development.....	6,145,000	6,000,000	6,000,000
Assures technological readiness and performs detailed advanced planning for candidate planetary missions.			
Planetary Advanced Studies.	1,200,000	1,200,000	1,200,000
Evaluates feasibility of potential future scientific missions to planets; develops up to date mission opportunity catalog.			

	1971	1972	1973
Supporting Research and Technology/ Advanced Studies (Cont'd.)			
Exobiology..... Supports research toward understanding the controlling factors in the origin of life, and determining the uniqueness of life on earth.	$ ---	$ 3,900,000	$ 3,900,000
Planetary Astronomy..... Ground-based astronomy support of the planetary exploration program objectives.	$ 4,800,000	$ 4,800,000	$ 4,800,000
Data Analysis..... Support of scientists analyzing data of flight programs after the initial period funded in the basic mission.	$ 3,580,000	$ 3,200,000	$ 3,500,000
Planetary Quarantine..... All feasible measures to avoid the transfer of viable terrestrial life forms to the planets.	$ ----	$ 2,200,000	$ 2,200,000

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1973 ESTIMATES

OFFICE OF SPACE SCIENCE

LUNAR AND PLANETARY EXPLORATION PROGRAM

FLIGHT SCHEDULE

PROJECT	MISSION	CALENDAR YEAR
Pioneer	Pioneer F	1972
	Pioneer G	1973
	Helios A	1974
	Helios B	1975
Mariner	Venus Mercury 1973 (1)	1973
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 the satellites, asteriods, comets and the particles and fields of interplanetary space. The lunar program includes investigations of lunar materials and phenomena utilizing ground based astronomy and the Apollo series. The goal of the Planetary Exploration program is to explore all the planets of our solar system; to understand the origin and evolution of the solar system, the origin and evolution of life, and the dynamic processes that shape man's terrestrial environment. The planetary program employs ground based astronomy and automated spacecraft to flyby, orbit and land on other planets in our solar system.

The planetary and interplanetary programs have experienced a high degree of success beginning with the Mariner 2 flyby of Venus in 1962 and continuing with the most recent successful orbit of Mars in November 1971 by the Mariner 9. Knowledge of Mars and its environment will be expanded by the launch of two Viking spacecraft in 1975 to orbit and land on the Martian surface in 1976. In 1973, another Mariner is planned to flyby Mercury utilizing the increased velocity achieved by a close flyby of Venus. Pioneer F&G launches are planned for February 1972 and April 1973 to provide the first measurement of interplanetary medium in the region beyond Mars, the asteriod belt and the mysterious and giant planet Jupiter. Two cooperative US/German spacecraft, Helios A&B, will be launched in 1974 and 1975 to investigate the properties in interplanetary space in the close proximity to the sun, about . 3 AU. An astronomical unit (AU) is the distance between the earth and the sun or 93,000,000 miles.

SUMMARY OF RESOURCES REQUIREMENTS

	1971	1972	1973
Mariner.....	$41,840,000	$61,600,000	$43,000,000
Viking.....	35,000,000	176,200,000	229,500,000
Outer planets missions.....	---	10,000,000	7,000,000

	1971	1972	1973
Pioneer/helios.....	$41,675,000	$15,264,000	$12,500,000
Supporting research and technology/advanced studies*..	18,005,000	18,236,000	18,700,000
Planetary astronomy.....	4,800,000	4,800,000	4,800,000
Data analysis.....	3,580,000	3,200,000	3,500,000
Planetary quarantine*.....	---	2,200,000	2,200,000
Total.....	$144,900,000	$291,500,000	$321,200,000

*Planetary Quarantine and the exobiology part of SR&T were, in FY 1971, part of the Bioscience program.

Distribution of Program Amount by Installation:

John F. Kennedy Space Center, NASA.....	25,000	---	---
Manned Spacecraft Center.....	685,000	425,000	425,000
Marshall Space Flight Center.	363,000	220,000	---
Goddard Space Flight Center..	4,520,000	4,239,000	3,727,000
Jet Propulsion Laboratory....	60,439,000	75,566,000	53,597,000
Wallops Station.....	---	50,000	50,000
Ames Research Center.....	40,456,000	17,805,000	15,586,000
Langley Research Center.....	22,885,000	173,445,000	225,910,000
Headquarters.....	15,527,000	19,750,000	21,905,000

BASIS OF FUND REQUIREMENTS:

Mariner

Mariner Mars 1969.....	188,000	100,000	---
Mariner Mars 1971.....	31,291,000	16,900,000	11,400,000
Mariner Venus Mercury 1973.....	10,361,000	44,600,000	31,600,000
Total Spacecraft and Support.	$41,840,000	$61,600,000	$43,000,000
Atlas Centaur (Launch Vehicle Procurement program).....	($3,045,000)	($6,693,000)	($6,089,000)
Total, (including Launch Vehicle).....	($44,885,000)	($68,293,000)	($49,089,000)

The Mariner series of spacecraft have been a significant tool in the planetary program. These spacecraft have evolved from the 450 pound Mariner 2, used for man's first successful flyby mission to another planet, to the 2,200 pound Mariner 9 which was successfully inserted into an orbit of Mars in November 1971.

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Mariner Mars 1971	1971	1972	1973
Project management and project integration.....	$3,591,000	$2,900,000	$900,000
Spacecraft development.....	21,700,000	200,000	---
Mission operations.....	6,000,000	11,300,000	3,500,000
Extended mission operations....	---	2,500,000	7,000,000
Total.....	$31,291,000	$16,900,000	$11,400,000

Mariner 8 was launched from the Eastern Test Range on May 8, 1971, but was lost due to a launch failure. Mariner 9 was launched successfully on May 30, 1971, and was inserted into orbit around Mars on November 13, 1971. As of January 13, 1972, over two-thirds of the basic mission objectives had been accomplished and all spacecraft systems were operating within acceptable performance margins. At the time of encounter, there was an extensive dust storm on Mars which has abated so that we are now mapping Mars as planned. Much scientific data has been received. We plan to extend mission operations of Mariner 9, 9 months after the basic 90 day mission i.e., from mid-February 1972 to mid-November 1972.

Project Management and Project Integration - The Jet Propulsion Laboratory (JPL) is responsible for the accomplishment of the Mariner Mars 1971 project. To fulfill this responsibility, the project manager's staff during FY 1972 consisted of about 30 personnel. This number will be reduced to an average of about 15 people during FY 1973. JPL travel, miscellaneous procurement, and supporting services are also funded under this item.

Spacecraft Development - Spacecraft development activities were completed in FY 1972 and no funding is requested in FY 1973.

Mission Operations - The basic mission and the analysis of the data obtained from this mission are funded primarily with FY 1972 funds. However, preparation of the final science report for the basic mission, which is due for publication during August 1972 will be funded partially with FY 1973 funds.

Extended Mission Operations - FY 1972 and 1973 funds will be used to support mission operations for the extended mission from mid-February 1972 to mid-November 1972. FY 1973 funds will also be used to fund science support and data analysis for the extended mission until July 1, 1973. After that date, all further science support and data analysis will be funded under the Data Analysis project.

Mariner Venus/Mercury 1973	1971	1972	1973
Spacecraft.....	$8,661,000	$38,100,000	$26,600,000
Science instruments.....	1,600,000	5,400,000	3,300,000
Mission operations.....	100,000	1,100,000	1,700,000
Total.....	$10,361,000	$44,600,000	$31,600,000

A single modified Mariner spacecraft will be used to study both Venus and Mercury in 1974. Although the similarities of Mars, Venus, and Earth make the study of these planets important to our knowledge of Earth and its place in the solar system, the knowledge of other planetary bodies can also make a significant contribution. During the 1973 opportunity, using the same rocket thrust required to go to Venus, the spacecraft will be accelerated by Venus' gravity and orbital velocity so that it will also swing by Mercury and begin the exploration of this, the closest planet to the sun. The Mariner Venus/Mercury 73 spacecraft, launched by an Atlas Centaur, will return ultraviolet and visual television pictures, atmosphere and ionsphere data, and thermal maps from both Venus and Mercury. Additionally, the space environment in the unexplored regions between Venus and Mercury will be monitored.

Funds requested will be used as follows:

Spacecraft. During FY 1972, design of subsystems was virtually completed and the fabrication was started. During FY 1973, fabrication and acceptance testing of the spacecraft subsystems will be completed. The primary activity after delivery of the subsystems to the Spacecraft Assembly Facility in January 1973 will be system testing. This activity involves testing the compatibility of the subsystems and instruments with each other, and verifying overall spacecraft system performance. The test and flight spacecrafts are subjected to simulated launch and space environments as the final step before the preshipment review of the spacecraft in June 1973.

Science Instruments. FY 1972 effort focuses on completion of design of the science instruments. Fabrication and acceptance testing of these instruments will be completed during FY 1973. After the science instruments are delivered to the Spacecraft Assembly Facility in January 1973, the system testing will begin.

Mission Operations. During FY 1973, activities in the mission operations area will include detail design, software development, and definition of tracking and data systems capabilities. The detail design includes the definition of a detailed mission sequence and of various operational procedures such as those for inflight calibrations and spacecraft maneuvers. Various documents, such as the "Space Flight Operations Plan," the "Interface Control Document," and the "Master Test Plan," will be published during this period. Software will be developed for telemetry, mission control, navigation, spacecraft analysis, science analysis, and data records.

Viking

	1971	1972	1973
Orbiter spacecraft.....	$7,100,000	$33,900,000	$65,100,000
Orbiter science.....	1,200,000	6,000,000	8,700,000
Lander spacecraft.....	18,000,000	88,500,000	102,200,000
Lander science.....	6,700,000	36,600,000	35,100,000
Project management and project integration.....	2,000,000	11,200,000	18,400,000
Total.....	$35,000,000	$176,200,000	$229,500,000
Titan Centaur (Launch vehicle procurement program).....	($6,100,000)	($11,200,000)	($26,000,000)
Total (including launch vehicles).....	($41,100,000)	($187,400,000)	($255,500,000)

The Viking 1975 mission will greatly expand the exploration of Mars initiated by the earlier Mariner missions. The objectives of the Viking program are 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. Emphasis will be placed on obtaining biological, chemical, and environmental factors relevant to the existence of life on the planet.

Two Viking spacecraft will be launched in 1975 by Titan-Centaur vehicles. Each spacecraft will consist of an Orbiter and a Lander. The Orbiter will have the capability of placing itself and the attached Lander into an orbit about Mars. The Lander will separate from the Orbiter about 10 days after arrival at Mars and descend through the atmosphere to the surface. The Lander, designed with the softlanding technology of the Surveyors and Apollo lunar modules, will transmit biological, geological, meteorological, and other scientific data to earth for a planned 90 days. Instruments on the Orbiter will obtain planetary data for at least the same period.

During FY 1972, program funds were used to begin the detailed design of the Orbiter, Lander, and their procured systems and instruments, and development tests.

Funds requested for FY 1973 will be used as follows:

Orbiter

Spacecraft Design - The detailed design of the Orbiter will be completed, culminating in a critical design review. Drawings will be released to begin fabrication and assembly of the two development

models and one qualification model of the spacecraft. One development model will be used chiefly for static and dynamic structural tests. The other will be used in thermalvacuum tests which simulate the deep-space environments.

Science Instruments - Orbiter science instruments include television cameras, an infrared spectrometer for water vapor mapping, and an infrared radiometer for thermal mapping. All instruments will complete their design phases and be subjected to a design review. Fabrication and assembly will begin for the prototype models. Fabrication will begin on the type-approval models to be used in qualification testing.

Lander

Spacecraft Design - Completion of the detail design for the Lander will occur in FY 1973. After the complete design has been reviewed, fabrication and assembly will occur for the thermal, dynamic, and static models used in development tests. The Lander system test bed will be assembled and used for integrating the development models of the various subsystems and science instruments. The high altitude qualification tests of the parachute system will be completed late in the summer of 1972. Most of the major subsystems and components of the Lander will undergo the functional and environmental tests to qualify their designs for flight. Assembly will begin for the proof test capsule to be used later to qualify the complete Lander system for flight.

Science Instruments - Lander science instruments include facsimile cameras, a biology instrument, a gas chromatograph/mass spectrometer for molecular analysis, meteorology instruments, seismometer, mass spectrometer and retarding potential analyzer for upper atmosphere composition, and pressure and temperature sensors for atmospheric structure. The designs of all instruments will be completed in this period. Testing of the early development instruments will be completed. Fabrication and assembly will be started on the instrument models to be used in spacecraft integration tests and design qualification.

Project Management and Project Integration

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

In FY 1973, project management will be heavily involved in reviewing the detailed designs of the spacecraft as they are completed. Effort will continue in the mission analysis and design areas with much refinement of the initial mission plans. Results of the 1971 missions to

Mars will be reviewed and the Viking plans modified accordingly. Plans will be made for alternate mission modes and contingency actions. Development effort will begin on the computer software to be used in flight operations.

Outer Planets Missions

	1971	1972	1973
Project management and mission design	---	$2,000,000	$2,000,000
Spacecraft design and development	---	6,000,000	4,000,000
Science	---	2,000,000	1,000,000
Total	---	$10,000,000	$7,000,000

Marked differences exist between the outer planets and the more familiar terrestrial planets that must be investigated if we are to understand the origin and evolution of the solar system and the processes that shape man's environment. A unique alignment of the outer planets in the latter half of the 1970's makes feasible a broad range of missions to these planets to begin such investigations. These mission opportunities range from the three and four planet "Grand Tour" missions which we proposed in the FY 1972 budget down to two planet missions or even single planet missions of various types to the nearer planets.

In response to budget restrictions and advice from scientists and the Congress, we have reviewed the Outer Planets Missions and have made the decision to forego the "Grand Tours" and, instead, to develop a more modest program. We have studied a number of possible missions to the outer planets for inclusion in our program. The most promising of these and the one on which our budget request is based would involve the use of an improved Mariner spacecraft to provide the first mission to a planet beyond Jupiter. This mission would involve launches in 1977 using gravity-assist swingby techniques to gather data at Jupiter and Saturn. The spacecraft would be accelerated by Jupiter's gravity and orbital velocity for the trip to Saturn, thus vielding encounter data on both planets. In addition to obtaining information on the planets, themselves, and on the interplanetary medium, the trajectories of these spacecraft could be designed to yield close flybys of various massive satellites of both these planets - a first for the outer planets. Exciting Saturn encounters could include flying through the Cassini ring division and a very close encounter of Saturn's satellite, Titan, which is comparable in size to the planet Mercury and is the only satellite in the solar system known to possess an atmosphere. The mission plan with dual spacecraft would have flexibility to use a different flyby trajectory for the second spacecraft based on data from the first flyby, as was so beneficial on the Mariner 1969 mission to Mars.

The spacecraft would encounter Jupiter about 1½ years after launch and Saturn about 3 to 3½ years after launch. The launch vehicle would be the Titan IIID(5)/Centaur/Burner II combination.

While this mission looks promising we are also examining other attractive alternatives. We are reviewing the program with our internal science advisor groups and with the Space Science Board prior to making a final decision to assure that we proceed with the most productive scientific mission.

During FY 1972 we will define the mission and develop an understanding of the total resources required to carry out that mission. A preliminary spacecraft design has been undertaken based on Mariner/Viking Orbiter designs to a depth necessary to establish performance capabilities and resource requirements. Steps are being taken aimed at validation of the Mariner/Viking subsystem designs and at identification of specific requirements for design changes and new designs. Other spacecraft design options will also be studied. The Outer Planets Science Steering Group has met at regular intervals to develop a science strategy for the various missions being considered and to evaluate the capabilities of a wide class of experiments for those missions.

Funds requested in FY 1973 will be used as follows:

Project Management and Mission Design

Design of the mission, development of a project implementation plan, and a concurrent analysis of the total required resources will continue through FY 1973. The functions to be performed by the various elements of the project will be defined and analyzed. The role of the spacecraft system contractor will be defined.

Spacecraft Design and Development

Efforts will be undertaken to prepare a Request for Proposals (RFP) for the spacecraft system contract. The subsystem design validation and required design modifications will be completed. Development of required new technology and new designs will continue. The spacecraft system design will be undertaken to the level necessary to prepare the spacecraft system RFP.

Science

The science experiments will be selected for the mission. The selected experiments and their associated instruments will be further defined in a science detail definition effort. The experiment contracts will be signed at the end of the fiscal year. Early science selection permits incorporation of the actual payload and its requirements and constraints in the spacecraft RFP.

Pioneer/Helios

	1971	1972	1973
Pioneer 6-9	$1,579,000	$600,000	$400,000
Spacecraft	91,000	---	---
Science	535,000	---	---
Operations	953,000	600,000	400,000
Pioneer F and G	38,196,000	12,164,000	9,800,000
Spacecraft	29,321,000	7,209,000	5,473,000
Science	8,018,000	2,889,000	2,430,000
Operations	857,000	2,066,000	1,897,000
Helios A and B	1,900,000	2,500,000	2,300,000
Science	1,849,000	2,340,000	1,757,000
Operations	51,000	160,000	543,000
Subtotal	$41,675,000	$15,264,000	$12,500,000
Centaur (Launch Vehicle Procurement program)	($18,300,000)	($11,700,000)	($17,300,000)
Pioneer F and G	(16,300,000)	(5,400,000)	(---)
Helios A and B	(2,000,000)	(6,300,000)	(17,300,000)
Total	($59,975,000)	($26,964,000)	($29,800,000)

Pioneer 6-9

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

Spacecraft. During FY 1973, no funds are requested for effort under this category.

Science. During FY 1973, funds from planetary data analysis and supporting research and technology accounts, as appropriate, will be used for the analysis of data by selected investigators. FY 1972 funds and the funds requested for FY 1973, are needed to collect the data from their spacecraft on magnetic tapes. These data will concern changes in interplanetary space of solar plasma, cosmic rays, electrical and magnetic fields and radio propagation. Much of this data will be correlated with similar information gathered from the instruments on Pioneer F at widely separated points in heliocentric space.

Pioneer F and G

The feasibility of a long range exploratory mission to Jupiter and beyond was confirmed in 1968 and the program for two missions was designated as Pioneer F and G. Their objectives 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 passes within 100,000 miles of Jupiter, instruments will measure the magnetic fields, electromagnetic emissions, charged particles and thermal balance associated with this largest planet of the solar system.

Spacecraft. FY 1972 funds are used for the completion of manufacture and the necessary acceptance testing of the Pioneer F scheduled for launch in late February 1972, and the continued manufacture and testing of Pioneer G. During FY 1973, the Pioneer G will be completed and the acceptance testing will be conducted. Funds are also provided for the reimbursement to the AEC for the Pioneer G Radioisotope Thermoelectric Generators (RTGs).

Science. In FY 1972, the science subsystems were built, tested, and delivered for Pioneer F and made ready for Pioneer G. During FY 1973, the science instruments will be integrated with the Pioneer G spacecraft and acceptance-tested prior to launch. Each of the thirteen science experimenters will be provided funds for the analysis of their data collected during most of the cruise phase of Pioneer F, and the first few months of the Pioneer G mission.

Operations. FY 1972 funds support the preparation and launch of Pioneer F plus four months of inflight operations. Flight operations of Pioneer F will be supported by FY 1973 funds. This effort includes the collection of the data on magnetic tapes. Also provided for is the effort associated with the ground operations necessary in preparation for the Pioneer G launch such as RF compatibility testing, mission simulation and operational readiness training and testing.

Helios A and B

The Helios project is an international cooperative project between the governments of the United States and West Germany. Its scientific objectives are to investigate the properties of and processes in interplanetary space in the direction of and close to the sun at about 0.3 AU or within the orbit of Mercury. The spacecraft will be developed and built in West Germany utilizing consultants from the United States, and will weigh about 620 pounds and carry about 120 pounds 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 systems for the first phase of the mission. The West German technical personnel will control the spacecraft operations and operate the tracking systems and acquire the data during the later mission phases.

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Spacecraft. The Federal Republic of Germany is responsible for funding this effort.

Science. FY 1972 funds were utilized in continuing the fabrication and testing of three U.S. experiments. During FY 1973, the U.S. teams will be provided funds to fabricate and functionally test the prototype and flight models. They will participate in the associated prototype spacecraft/experiment integration effort in Germany. NASA will conduct the qualification and systems test for the U.S. experiments using a spacecraft simulator built for this purpose.

Operations. During FY 1973, as in FY 1972, computer software development will be funded, as well as documentation at JPL of Helios program and support instrumentation requirements, plus spacecraft and training simulation software requirements.

Supporting Research and Technology/Advanced Studies

	1971	1972	1973
Lunar science.....	$6,000,000	$2,200,000	$2,900,000
Planetary science.....	4,660,000	4,936,000	4,700,000
Planetary advance technical development.....	6,145,000	6,000,000	6,000,000
Planetary advance studies.....	1,200,000	1,200,000	1,200,000
Exobiology*.....	---	3,900,000	3,900,000
Total.....	$18,005,000	$18,236,000	$18,700,000

*The exobiology project was, in FY 1971, part of the Bioscience program.

Supporting Research and Technology and Advanced Studies projects are the research activities which provide support to the flight missions by providing the base for defining the scientific objectives of future missions, and establishing the scientific capabilities essential to the performance of these missions.

Lunar Science

In FY 1973, lunar science effort will be to interpret the large and growing amount of data acquired by lunar missions, and to incorporate these results in the knowledge of the characteristics and history of the moon. These efforts will include the appraisal of automated instrument concepts for physical and chemical analysis by remote sensing from lunar orbit and surface rovers. Laser ranging from earth telescopes to corner reflectors on the lunar surface is continuing to determine the relative motions of the earth-moon system to improve determination of absolute distance between points on the earth's surface, and to provide better understanding of the structure and dynamics of the earth.

Planetary Science

The Planetary Supporting Research and Technology/Planetary Atmospheres program supports research in atmospheric phenomena of the planets including the earth's upper atmosphere, and of the gaseous phenomena associated with comets. In FY 1973, emphasis will be placed on developing experiments for spacecraft exploration of the outer planets and the laboratory and theoretical studies required to support the flight experiments. Work under way directed at the direct entry probe investigation of the atmosphere of Venus and its clouds will be continued.

Another area financed under Planetary Supporting Research and Technology is the Planetology project which supports research in the increasingly important field of planetary geology including geochemistry, geophysics and photogeology. As the planetary program progresses from earth based observational data to flyby and orbiter data, and in 1975 to data from Mars landers, planetology research will play a more important role in determining the nature and properties of the planets. In FY 1973 the emphasis will be on the development of instrumentation for remote sensing geological, geochemical and geophysical studies of Mars and the outer planets.

Planetary/Advanced Technical Development (ATD)

These funds are used to assure technological readiness and perform detailed advance planning for candidate planetary missions. It is closely keyed to project start schedules and to advanced studies for identification of long-lead critical technologies. Timely identification and advance development of critical technologies to foreseeable mission requirements allows more efficient later use of project funds.

Major emphasis in FY 1972 has been on critical technologies required for entry probes into the atmospheres of Venus and Jupiter. Particularly for Jupiter, severe problems are encountered in entry heating and in communication through the dense atmosphere. Plans for ATD in FY 1973 are to continue this emphasis and in addition to develop in substantial depth a technological base for future low cost Mariner or Pioneer-class missions to both of these planets and to Saturn.

Planetary Advanced Studies

In the Planetary Advanced Studies project, the feasibility of potential future scientific missions is evaluated and an up to date catalogue of mission opportunities is developed. In FY 1972, studies are being conducted on: (1) solar electric missions; (2) outer planet orbiter and probe missions; (3) radar mapping spacecraft for Venus; (4) Mercury orbiter mission; (5) comet and asteroid missions; (6) nuclear electric missions; and (7) a rendezvous and/or sample return mission to Deimos/Phobos, the two moons of Mars. In FY 1973 it is planned to continue the

investigation of outer planet probe and orbiter missions and flyby and rendezvous/docking missions to comets and asteroids. Additional study candidates for FY 1973 include: (1) Mars surface roving vehicle missions; (2) outer planet satellite orbiter and/or lander mission; and (3) Venus buoyant station and atmosphere mobile vehicle mission.

Exobiology

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

Planetary Astronomy

	1971	1972	1973
Planetary astronomy.....	$4,800,000	$4,800,000	$4,800,000
Total.....	$4,800,000	$4,800,000	$4,800,000

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

The objectives of the program are accomplished through research programs which are carried out by astronomers and other scientists located at NASA centers, universities, observatories, and other organizations. In FY 1973, approximately 40 research programs will be supported, about 10

of which will be carried out at NASA centers and the Jet Propulsion Laboratory.

The programs range in size from single investigator to a large multi-faceted research program at major observatories including McDonald, Mauna Kea, Lowell and Catalina observatories. Supported programs will also include infrared, radio, and radar planetary studies.

Major emphasis will be directed toward studies of the planet Mercury and the outer planets from Jupiter through Pluto. The change in emphasis reflects our increased knowledge of Venus and Mars and a need for additional information on the other planets to support the upcoming flight programs. Included will be photography of the planets to study atmospheric dynamics, spectroscopic studies to search for trace chemical elements in planetary atmospheres and to study the physical properties of the atmospheres, infrared observations to determine the planet's thermal balance, and radio observations to determine the magnitude and variation of planetary temperatures and the existance and cause of non-thermal emissions. The relatively new discipline of planetary radar will be supported to obtain radar maps of the planets as well as properties of their surfaces such as roughness and dielectric constant.

In the area of instrument development, the planetary astronomy budget for FY 1973 contains the third installment, $1 million, towards the addition of a high power radar system at the National Astronomy and Ionosphere Center at Arecibo, Puerto Rico, a National Science Foundation (NSF) facility operated by Cornell University. This program, which satisfies a NASA program requirement, is being carried out in conjunction with NSF. Completion of the radar system will increase the planetary astronomy radar capability to the point where scientists will be able to obtain a radar "picture" of the surface of Venus with a resolution of 2 to 5 kilometers. This will make possible the mapping of the entire cloud covered surface of Venus at sufficient resolution to observe in some detail features such as mountains, craters, etc. The increased radar capability will also permit the study of surface properties of several of the satellites of Jupiter as well as "mapping" Mars and Mercury in considerably more detail than presently possible.

Data Analysis

	1971	1972	1973
Lunar data analysis.....	$2,000,000	$1,800,000	$2,100,000
Planetary data analysis.....	1,580,000	1,400,000	1,400,000
Total.....	$3,580,000	$3,200,000	$3,500,000

The Data Analysis project provides for the support of scientists analyzing the results of flight experiments after the initial period of funding provided 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 incorporate the results in the growing body of knowledge of the characteristics and history of the moon and planets.

Lunar Data Analysis. The analysis of Apollo scientific data, other than done initially by the principal investigators, will consume the majority of the FY 1972 Lunar Data Analysis project. This is expected to continue at an increased rate in FY 1973 as a result of the upcoming Apollo flights.

Planetary Data Analysis. In FY 1973 as in FY 1972, the Planetary Data Analysis project will provide for reduction of data from earlier Mariner missions to Mars and Venus and in particular from the Mariner orbiter 1971 mission, the Pioneer missions in interplanetary space, and earth satellite and sounding rocket missions pertinent to scientific exploration of the earth's upper atmosphere.

Planetary Quarantine

	1971	1972	1973
Planetary quarantine*.....	---	$2,200,000	$2,200,000
Total.....	---	$2,200,000	$2,200,000

*In prior years, the Planetary Quarantine project was part of the Bioscience program.

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

Research has developed measures for the assay, control and destruction of microbial life in spacecraft hardware prior to launch from earth and techniques of maintaining sterility until the craft reaches deep space.

These measures, however, impose thermal or radiation stresses upon the spacecraft which add to the cost of the mission and increase the hazard of equipment failure.

The research in FY 1973 will turn to critical evaluation of the sterilization effects of forces in outer space that may sterilize the outer portions of spacecraft during passage through areas where these forces occur. The results of these studies will be particularly applicable to missions to the outer planets whose interplanetary cruise periods of two to eight years will take the spacecraft through regions where there will be exposure to forces that may achieve sterility without the application of heat before launch. Specifically the biological effects of proton radiation, not known at the present time, will be evaluated as will be the effects of bombardment of high energy electrons in the solar wind. The efficiency of long term exposure of contaminated spacecraft surfaces to ultraviolet irradiation will be studied as will be the lethality of reflected ultraviolet energy in the lethal range. The complex problem of kill of microbes in the interior of the spacecraft by heating during entry into the planet's atmosphere will be moved toward solution.

The trend that has begun to increase planetary quarantine operations will continue with a matching decrease in research. Thorough evaluation of the microbial population on all the space flight hardware of the Pioneer F and Mariner Venus-Mercury missions will be conducted while preliminary evaluations of the biological loading of Viking hardware will be begun. Detailed knowledge of the number and species of the microbes on and in spacecraft before sterilization or launch is essential to maximum economy in quarantine operations.

OFFICE OF SPACE SCIENCE — BIOSCIENCE PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

Effective at the beginning of Fiscal Year 1972, most of the life sciences activities of the agency were consolidated in the Office of Manned Space Flight under the Space Life Sciences program. The Planetary Biology effort in Exobiology and Planetary Quarantine remains in the Office of Space Science and the Aeronautics portion of the former Human Factor Systems program remains in the Office of Aeronautics and Space Technology.

SUMMARY OF RESOURCES REQUIREMENTS:

	1971	1972	1973
Planetary quarantine.....	$2,000,000	---	---
Biosatellite.....	332,000	---	---
Supporting research and technology/ advanced studies.....	10,566,000	---	---
Total.....	$12,898,000	---	---

Distribution of Program Amount by Installation:

Manned Spacecraft Center.....	$197,000	---	---
Marshall Space Flight Center....	85,000	---	---
Goddard Space Flight Center.....	100,000	---	---
Jet Propulsion Laboratory.....	1,502,000	---	---
Wallops Station.....	144,000	---	---
Ames Research Center.....	4,100,000	---	---
Langley Research Center.....	28,000	---	---
NASA Headquarters.....	6,742,000	---	---

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1973 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE — LAUNCH VEHICLE PROCUREMENT PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1971	1972	1973
Scout	$ 13,200,000	$ 16,500,000	$ 21,000,000
Centaur	66,000,000	82,200,000	106,500,000
Delta	37,500,000	39,200,000	41,900,000
Titan III C	4,100,000	9,400,000	18,200,000
Supporting research and technology/advanced studies	4,100,000	4,000,000	4,000,000
Total	$124,900,000	$151,300,000	$191,600,000

HIGHLIGHTS OF BUDGET PLAN

	1971	1972	1973
Scout	$ 13,200,000	$ 16,500,000	$ 21,000,000
Incremental funding of hardware procurement in support of SAS, UK, Meteoroid Technology, Air Density/Injun, German, and ANS Missions	1,800,000	5,200,000	8,900,000
Management and engineering support, test and checkout, launch operations, maintenance, and field support	10,025,000	10,050,000	10,000,000
Major improvements to the fourth stage guidance and upper stage motor	1,375,000	1,250,000	2,100,000
Centaur	$ 66,000,000	$ 82,200,000	$106,500,000
Incremental funding of hardware procurement in support of HEAO, Viking, Mariner Venus/Mercury 1973, and Helios missions	29,345,000	31,693,000	58,389,000

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	1971	1972	1973
Centaur (Cont'd.)			
Management and engineering support, test and checkout launch operations, maintenance, and field support.	$ 14,336,000	$ 16,137,000	$ 21,479,000
Major improvements encompassing the Improved Centaur, Titan Centaur integration and proof flight, and selective redundancy.....	22,319,000	34,370,000	26,632,000
Delta.....	$ 37,500,000	$ 39,200,000	$ 41,900,000
Incremental funding of hardware procurement in support of IMP, RAE, Atmosphere, ERTS, SMS, Nimbus, and GEOS missions.....	11,000,000	10,470,000	17,930,000
Management and engineering support, test and checkout, launch operations, maintenance, and field support.	14,990,000	14,280,000	19,570,000
Improvements to first and second stage pneumatics, second stage hydraulics and propellant feed, guidance components.....	11,510,000	14,450,000	4,400,000
Titan III C.....	$ 4,100,000	$ 9,400,000	$ 18,200,000
Incremental funding of hardware procurement and related services from USAF for ATS F&G missions.....	4,100,000	9,400,000	18,200,000
Supporting Research and Technology/Advanced Studies....	$ 4,100,000	$ 4,000,000	$ 4,000,000
Funding support for exploratory and applied research and specific studies in the following launch vehicle technological disciplines:			

	1971	1972	1973
Supporting Research and Technology/ Advanced Studies (Cont'd.)..			
Advanced studies.....	$ 1,341,000	$ 1,535,000	$ 1,535,000
Propulsion and energy conversion.....	1,280,000	1,128,000	1,250,000
Guidance, control, and navigation.....	1,030,000	862,000	815,000
Instrumentation and electronics.....	60,000	125,000	125,000
Structures and materials	344,000	350,000	275,000
Vehicle engineering.....	45,000	---	---

OFFICE OF SPACE SCIENCE

LAUNCH VEHICLE PROCUREMENT PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Launch Vehicle Procurement program provides for centralized procurement of launch vehicles and the operational support for launching NASA's automated spacecraft. Activities included are the procurement of vehicle hardware, launch services, engineering and maintenance support, and the necessary improvements of vehicle systems and ground support equipment. Also included is a Supporting Research and Technology/Advanced Studies effort to provide analysis of future requirements and to investigate new technology developments.

The Launch Vehicle Procurement program is subdivided into three major categories: First, launch vehicle hardware which is readily identifiable with each specific mission and includes such items as the solid rocket motors, boosters, upper stages, shrouds, interstage adapters, and mission-peculiar hardware. The second category, supporting activities, includes the necessary preparation of the vehicle for launching and covers launch services, guidance services, engineering analysis for preflight and postflight activity, transportation, propellants and other support efforts. This supporting activities effort, unlike the hardware category, is based on the establishment of a capability rather than a quantity of units produced. In the third category, product improvement, major work is dedicated to maintain and improve reliability and performance in support of spacecraft mission requirements.

SUMMARY OF RESOURCES REQUIREMENTS

	1971	1972	1973
Scout	$13,200,000	$16,500,000	$21,000,000
Delta	37,500,000	39,200,000	41,900,000
Centaur	66,000,000	82,200,000	106,500,000
Titan III C	4,100,000	9,400,000	18,200,000
Supporting research and technology/advanced studies	4,100,000	4,000,000	4,000,000
Total	$124,900,000	$151,300,000	$191,600,000

Distribution of Program Amount by Installation:

	1971	1972	1973
John F. Kennedy Space Center.....	$2,443,000	$3,343,000	$3,680,000
Marshall Space Flight Center.....	940,000	872,000	815,000
Goddard Space Flight Center.....	36,860,000	38,031,000	40,684,000
Jet Propulsion Laboratory.....	875,000	830,000	800,000
Langley Research Center.....	13,026,000	16,167,000	21,213,000
Lewis Research Center.....	64,634,000	80,435,000	104,160,000
NASA Headquarters.....	6,122,000	11,622,000	20,248,000

BASIS OF FUND REQUIREMENTS:

Scout

Hardware.....	$1,800,000	$5,200,000	$8,900,000
Supporting activities.....	10,025,000	10,050,000	10,000,000
Major improvements.....	1,375,000	1,250,000	2,100,000
Total.....	$13,200,000	$16,500,000	$21,000,000

The Scout is the smallest in the NASA launch vehicle family. It is a solid propellant, four stage booster system approximately 22 meters (73 feet) in length with a launch weight of approximately 18,100 kilogram (40,000 pounds). This vehicle is capable of placing a 145 kilogram (320 pound) payload in a 555 kilometer (300 nautical mile) orbit and it is used for launching small scientific satellites, space probes, and high speed re-entry experiments. Through Calendar Year 1971, this vehicle has successfully launched 65 satellites in 78 attempts, with 100% success in the last 23 launches.

Funds requested for FY 1973 will be used as follows:

Hardware - Funds will be utilized to initiate or continue hardware procurement for the Air Density, Injun, ANS, German, SAS, UK-5, and Meteoroid Technology missions.

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

Improvements - Performance improvement to an upper stage motor and the development of an improved guidance system for the fourth stage will be continued with FY 1973 funds.

Delta

	1971	1972	1973
Hardware.....	$11,000,000	$10,470,000	$17,930,000
Supporting activities.....	14,990,000	14,280,000	19,570,000
Major improvements.....	11,510,000	14,450,000	4,400,000
Total.....	$37,500,000	$39,200,000	$41,900,000

The Delta is the most versatile in the NASA launch vehicle family. The vehicle consists of three stages--the first stage Thor booster augmented by three, six or nine strap-on solid motors for additional boost capability; the Delta second stage; and a solid propellant motor third stage. Over the 11 year period of its existence, this vehicle has been employed in 86 launch attempts of which 78 have been successful. In its three stage configuration, the vehicle is approximately 35 meters (115 feet) high and has a diameter of 2.4 meters (8 feet). It is capable of placing a 908 kilogram (2,000 pound) payload into a 555 kilometer (300 nautical mile) orbit.

Funds requested for FY 1973 will be used as follows:

Hardware - Funds will be used to continue and/or initiate hardware procurement to support the IMP, OSO, RAE, Atmosphere Explorers, ERTS, SMS, Nimbus, CAS, and GEOS missions.

Supporting Activities - Funding will be utilized to procure necessary technical and engineering support, to sustain vehicle test and checkout and launch operations, and to support maintenance of launch facilities and ground equipment.

Work initiated in FY 1972 will continue in FY 1973 to implement the recommendations of the review committee established to investigate the ITOS-B vehicle failure and the OSO-7 vehicle anomaly. Following a thorough design review, changes in manufacturing techniques, hardware, and test and checkout procedures will be made to improve overall reliability of the Delta launch vehicle system.

Improvements - Reliability improvements will be undertaken in first and second stage pneumatics, second stage hydraulics, propellant feed, and separation systems, and in guidance components. Efforts will be completed on the new eight foot fairing and the H-1 engine adaption to Delta.

Centaur

	1971	1972	1973
Hardware.....	$29,345,000	$31,693,000	$58,389,000
Supporting activities.....	14,336,000	16,137,000	21,479,000
Major improvements.....	22,319,000	34,370,000	26,632,000
Total.....	$66,000,000	$82,200,000	$106,500,000

The Centaur vehicle is a high performance multipurpose launch vehicle. It is the most powerful vehicle currently used by NASA for automated spacecraft. The Centaur presently uses an Atlas booster as a first stage. In this configuration, the vehicle is 40 meters (131 feet) in length and has a diameter of 3.1 meters (10 feet). A new configuration, the Titan Centaur, is being developed to support the Viking mission and for other heavy payload missions beyond the lifting capability of Atlas Centaur. This configuration, planned for operational use in 1974, will be 49 meters (160 feet) high and will have a payload shroud diameter of 4.3 meters (14 feet).

Funds requested for FY 1973 will be used as follows:

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

Supporting Activities - Funding will be utilized to purchase management and engineering support, launch support operations, field services and to maintain facilities and ground equipment. Efforts undertaken during late FY 1972 to improve quality and workmanship in the manufacture and assembly of the Centaur will be continued with FY 1973 funding.

Improvements - The integration of the Centaur with the Titan III booster and the Improved Centaur program will be continued. The Improved Centaur features a new, solid state avionics system to improve reliability, flexibility, and performance. The integration with the Titan III booster is required to support high energy missions, such as Viking and Helios. To verify the Titan Centaur integration in a flight environment and to provide confidence for the Viking mission, a proof test flight, to be launched in early 1974, is also supported with these funds. Implementation of a selective redundancy program in the Titan and Centaur mechanical and hydraulic systems will be continued.

Titan III C

	1971	1972	1973
Hardware.....	$4,100,000	$9,400,000	$18,200,000
Total.....	$4,100,000	$9,400,000	$18,200,000

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

Funds requested for FY 1973 are required to complete the procurement of hardware and related services for the Titan III C vehicle in support of the ATS-F mission. In addition, hardware procurement in support of the ATS-G mission will be continued to support the scheduled launch in calendar year 1975. Both launch vehicles are procured through the USAF and the funding estimates are based on that agency's consolidated Titan III procurement and contractual requirements.

Supporting Research and Technology/Advanced Studies

	1971	1972	1973
Advanced studies.....	$1,341,000	$1,535,000	$1,535,000
Propulsion and energy conversion.	1,280,000	1,128,000	1,250,000
Guidance, control and navigation.	1,030,000	862,000	815,000
Instrumentation and electronics..	60,000	125,000	125,000
Structures and materials.....	344,000	350,000	275,000
Vehicle engineering.....	45,000	---	---
Total.....	$4,100,000	$4,000,000	$4,000,000

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

In FY 1972, new studies have been directed at determining the applicability of existing expendable launch vehicle upper stages for the space shuttle. Also included are studies to examine the capability and desirability of potential launch vehicle growth options for launching future planetary missions and to define a preliminary design of a hybrid upper stage for primary application to the Delta launch vehicle. An advanced study continuing from FY 1971 has as its objective definition of a solar electric propulsion stage for potential application to both expendable launch vehicles and the space shuttle.

Funds requested for FY 1973 will be utilized as follows:

Advanced Studies - Studies of optimum launch vehicle families, high energy stages, and low cost design concepts will be initiated or continued to identify future automated launch vehicle development required to maintain an economical and reliable transportation system. The most promising concepts identified in the FY 1972 study program will be investigated in greater depth. The application of chemical and nonchemical propulsion systems to launch vehicle upper stages will also be considered.

Propulsion and Energy Conversion - Research will be continued on hybrid rocket motors for launch vehicle and spacecraft applications. Design, fabrication, and test firing of a dual mode rocket motor capable of two different thrust levels by the use of monopropellant and bipropellant will be accomplished.

Guidance, Control and Navigation - Development, test, and evaluation of a modular strapdown guidance system will continue. Further research will be done in the area of astrionic-spacecraft interface.

Instrumentation and Electronics - Research will be conducted to develop non-destructive testing techniques for electro-explosive devices.

Structures and Materials - Development and evaluation of concepts to thermally decouple insulation penetrations in cryrogenic propellant tanks caused by valving and structural supports is planned.

Vehicle Engineering - No research is planned for this area during FY 1973.

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RESEARCH AND DEVELOPMENT

FISCAL YEAR 1973 ESTIMATES

BUDGET SUMMARY

OFFICE OF APPLICATIONS — SPACE APPLICATIONS PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1971	1972	1973
Earth resources survey	$66,735,000	$64,575,000	$48,400,000
Earth resources technology satellites	(55,750,000)	(52,225,000)	(35,400,000)
Aircraft program	(10,985,000)	(12,350,000)	(13,000,000)
Applications technology satellites	23,750,000	51,800,000	61,200,000
Nimbus	24,700,000	18,125,000	28,300,000
Synchronous meteorological satellites	8,850,000	15,000,000	11,500,000
Cooperative applications satellites	75,000	2,600,000	3,300,000
TIROS/TOS improvements	3,200,000	2,250,000	8,000,000
TOS improvements	(2,559,000)	(2,048,000)	(2,200,000)
TIROS-M	(641,000)	(202,000)	(---)
TIROS-N	(---)	(---)	(5,800,000)
Geodetic satellites	2,806,000	3,500,000	5,000,000
Global atmospheric research program	1,000,000	2,250,000	4,500,000
Meteorological soundings	3,100,000	1,500,000	1,500,000
Supporting research and technology/ advanced studies	28,744,000	23,300,000	22,000,000
Earth observatory satellite studies	---	1,000,000	1,000,000
Radio interference and propagation program	1,000,000	1,600,000	---
Air traffic control studies	3,000,000	---	---
Total	$166,960,000	$187,500,000	$194,700,000

HIGHLIGHTS OF BUDGET PLAN

	1971	1972	1973
Earth Resources Survey	$66,735,000	$64,575,000	$48,400,000
Earth Resources Technology Satellites	$55,750,000	$52,225,000	$35,400,000
Spacecraft design, development and test leading to the launch of one spacecraft in 1972 and one in 1973	21,921,000	19,245,000	9,800,000

	1971	1972	1973
Sensor development to provide imagery and other data about earth resources in agriculture, geology, hydrology, oceanography and geography.....	$21,343,000	$15,980,000	$2,200,000
Ground data handling system development and installation in preparation for mission operations and generation of image products beginning in 1972.....	12,486,000	15,000,000	2,500,000
Support of investigators who will use the data to conduct experiments and develop techniques to determine the usefulness of the information...	---	2,000,000	20,900,000
Delta (Launch Vehicle Procurement)	(1,800,000)	(800,000)	(2,300,000)
Aircraft Program.....	$10,985,000	$12,350,000	$13,000,000
Aircraft operations and logistics support.....	4,780,000	5,540,000	6,710,000
Sensor development and procurement	2,880,000	1,790,000	1,100,000
Equipment maintenance and modification.....	2,562,000	2,725,000	3,050,000
Data handling and processing....	763,000	2,295,000	2,140,000
Applications Technology Satellites..	$23,750,000	$51,800,000	$61,200,000
ATS 1-5: Continued Operations and data analysis.....	3,205,000	1,750,000	1,200,000
ATS F&G:			
Spacecraft design, development and test leading to delivery of two spacecraft to KSC, one in 1973 and one in 1975.....	1,049,000	32,347,000	25,250,000
Experiments in communications, meteorology, applications technology and traffic management flight tested at synchronous altitude; advanced applications experiments for future missions.....	16,985,000	13,758,000	33,250,000

	1971	1972	1973
Procurement and modification of ground station equipment at Rosman, NC and Mojave stations and for a transportable station.....	$2,511,000	$3,945,000	$1,500,000
Titan III-c (Launch Vehicle Procurement).....	(4,100,000)	(9,400,000)	(18,200,000)
Nimbus.....	$24,700,000	$18,125,000	$28,300,000
Spacecraft design, fabrication and test leading to the launch of one spacecraft in 1972 and one in 1974..	18,001,000	10,801,000	15,310,000
Experiments using advanced infrared microwave instruments designed to allow determination of the vertical structure of the atmosphere in cloudy areas and to higher altitudes.....	5,691,000	6,288,000	11,226,000
Ground operations preparations for mission beginning in late 1972.....	1,008,000	1,036,000	1,764,000
Thrust Augmented Delta (Launch Vehicle Procurement).....	(1,985,000)	(1,315,000)	(2,000,000)
Synchronous Meteorological Satellites	$8,850,000	$15,000,000	$11,500,000
Spacecraft design, development and test leading to launch of one spacecraft in 1972 and one in 1973.....	7,205,000	10,454,000	8,947,000
Sensors to provide continuous infrared and high resolution visible cloud cover data.....	700,000	2,905,000	1,544,000
Fabrication and installation of ground station equipment.....	945,000	1,641,000	1,009,000
Delta (Launch Vehicle Procurement)	(1,745,000)	(2,655,000)	(2,300,000)
Cooperative Applications Satellites.	$75,000	$2,600,000	$3,300,000
CAS-A: Data analysis and project support in post launch support of CAS-A launch in August 1971.....	75,000	100,000	100,000

	1971	1972	1973
CAS-C:			
Spacecraft studies.....	---	---	$470,000
Development of technology experiments primarily high power tube and related components.....	---	$2,500,000	2,530,000
Ground System Studies.....	---	---	200,000
Scout (CAS-A Launch Vehicle Procurement).....	(---)	(1,250,000)	(---)
Delta (CAS-C Launch Vehicle Procurement).....	(---)	(---)	(1,900,000)
TIROS/TOS Improvements.....	$3,200,000	$2,250,000	$8,000,000
Advanced sensor design work and studies to improve subsystem and operational procedures for TIROS Operational System.....	2,559,000	2,048,000	2,200,000
Post-launch support for TIROS-M mission.....	641,000	202,000	---
Initiation of spacecraft system design for TIROS-N.....	---	---	5,800,000
Geodetic Satellites.....	$2,806,000	$3,500,000	$5,000,000
GEOS-1&2: Extended operations and data reduction and analysis.....	1,640,000	600,000	600,000
GEOS-C:			
Spacecraft design, development and test leading to delivery of one spacecraft to KSC in 1973.....	1,166,000	1,700,000	2,400,000
Experiments and instrumentation including radar altimeter, C-band and S-band communications and laser retroreflectors.....	---	1,200,000	1,800,000
Preparation for mission beginning in late 1973.....	---	---	200,000
Delta (Launch Vehicle Procurement)...	(470,000)	(1,100,000)	(2,230,000)

	1971	1972	1973
Global Atmospheric Research Program (GARP)	$1,000,000	$2,250,000	$4,500,000
Data systems test support	---	150,000	1,700,000
Simulation studies	900,000	1,100,000	1,630,000
GARP Atlantic tropical experiment support	---	---	200,000
Technology development	100,000	1,000,000	970,000
Meteorological Soundings	$3,100,000	$1,500,000	$1,500,000
Procurement and launch of research sounding rockets	2,137,000	700,000	200,000
Development of sounding rocket systems	515,000	350,000	300,000
Field experiment support	448,000	450,000	1,000,000
Supporting Research and Technology/ Advanced Studies	$28,744,000	$23,300,000	$22,000,000
Basic and applied research and studies in the following space applications disciplines:			
Applications technology	4,248,000	3,335,000	3,500,000
Communications	3,377,000	3,080,000	3,400,000
Earth resources	11,522,000	8,865,000	6,800,000
Geodesy/earth physics	1,883,000	1,466,000	1,300,000
Meteorology	2,656,000	2,100,000	2,500,000
Traffic management	1,338,000	980,000	900,000
Interdisciplinary applications	3,720,000	3,474,000	3,600,000
Earth Observatory Satellite Studies	---	$1,000,000	$1,000,000
Radio Interference and Propagation Program	$1,000,000	$1,600,000	---
Air Traffic Control Satellite Studies - Studies in support of DOT/FAA	$3,000,000	---	---

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1973 ESTIMATES

OFFICE OF APPLICATIONS — SPACE APPLICATIONS PROGRAM

FLIGHT SCHEDULE

PROJECT	MISSION	CALENDAR YEAR
Earth Resources Technology Satellites	Launch of ERTS-A	1972
	Launch of ERTS-B	1973
Applications Technology Satellites	Launch of ATS-F	1973
	Launch of ATS-G	1975
Nimbus	Launch of Nimbus E	1972
	Launch of Nimbus F	1974
Synchronous Meteorological Satellites	Launch of SMS-A	1972
	Launch of SMS-B	1973
	Launch of SMS-C/GOES-A*	(Subject to call-up by NOAA)
Cooperative Applications Satellites	Launch of CAS-C	1975
TIROS	Launch of TIROS-N	1976
Geodetic Satellite	Launch of GEOS-C	1973
Meteorological Soundings	Launch about 200 annually	----
INTELSAT**	Launch of INTELSAT-IV series	1972-1975 (Subject to call-up by COMSAT)
ITOS*	Launch of ITOS-C-G	1972-1974 (Subject to call-up by NOAA)

*NOAA Funded
**COMSAT Funded

OFFICE OF APPLICATIONS SPACE APPLICATIONS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objectives of the Space Applications program are to: (1) conduct a broad program of research and technical development leading to the application of space techniques for the benefit of mankind; (2) cooperate with government agencies and other organizations involved in space related activities in the applications technology, communications, earth resources, geodesy/earth physics, traffic management, environmental and meteorology disciplines, and special applications such as space processing; (3) develop and test procedures, instruments, subsystems, spacecraft, and interpretive techniques for various applications; (4) expand our knowledge of the atmosphere, earth, oceans, and space; (5) develop and implement the operational meteorological satellite system for the National Oceanic and Atmospheric Administration (NOAA), Department of Commerce; (6) fulfill NASA's responsibilities under the Communications Satellite Act of 1962; and (7) cooperate to the extent possible with foreign countries in the advancement and utilization of space related technology.

Within the Space Applications program, a number of goals have been established which should be achieved in the near future.

In the area of Earth Resources Survey from space, three goals have been established: (1) develop technology and capability for remote sensing of the earth from aircraft and space for resources, ecological and environmental surveys of the earth; (2) develop applications of this new technology to meet user requirements in agriculture, forestry, oceanography, geology, hydrology, geography, and cartography; and (3) develop technology for handling large quantities of remotely sensed data including the transmission, reduction, processing, storage and retrieval, and dissemination of the data.

In Communications and Applications Technology, the endeavors are to: (1) provide a capability for conducting space communications investigations in promising applications and to develop critical technologies in such areas as stabilization and pointing of large space erectable antennas, multi-beam antennas with pattern shaping, data relay systems, laser communications, data collection systems and television transmissions to low cost ground terminals; (2) provide opportunities to the user community to experiment with communications satellites in development of potential

applications; (3) study information network requirements and systems to meet user agency requirements in such areas as education, medical, law enforcement, and disaster warning; (4) study the factors which affect efficient use of communications frequencies, identify interference problems, and obtain greater utilization of the frequency spectrum; and (5) cooperate with other nations in joint communications and technological satellite missions.

In metecrology the goals are: (1) improve and extend the capability for infrared sounding to higher altitude regions with greater spatial and spectral resolution; (2) develop and flight test a prototype operational Synchronous Meteorological Satellite for the continuous viewing of the atmosphere and weather conditions; and (3) develop advanced operational meteorological satellite instrumentation having the ability to measure the vertical temperature structure and water vapor content of the atmosphere to the accuracy required for numerical weather prediction. The achievement of these goals will provide three dimensional meteorological measurements and the temporal variation which can be used to obtain a fuller understanding of the meteorological processes. This understanding is a prerequisite to long range forecasting utilizing numerical models of the atmosphere. The continuous viewing of short term severe atmospheric disturbances such as thunderstorms and tornadoes and the monitoring of the tropic areas to detect tropical disturbances and hurricanes will assist the improvement of short term prediction.

In Geodesy and Earth Physics the objectives are to apply space technology and related precision measurement techniques, such as laser satellite tracking and very long baseline radio interferometry techniques to: (1) measurements of the dynamics of the solid earth and the oceans; (2) measurements of the spectral and time variations of the gravity field and magnetic field of the earth; (3) establishment of marine geodetic control points in the open ocean; (4) measurements of surface topography of oceans to contribute to mathematical descriptions of ocean circulations and the effect of these circulations on the possible spread of pollution; and (5) achievement of the objectives of the National Geodetic Satellite program with respect to accurate determination of the size and shape of the earth. The accomplishment of these objectives will contribute to a better understanding of earthquake causes and potentially to improved earthquake forecasting techniques, contribute to greater understanding of volcano eruption, permit global mapping of gravity and magnetic field anomalies, and make it possible to prepare accurate maps of geological features and mineral deposits on and beneath the ocean floor.

In traffic management, the goals are to understand: (1) the needs for better aircraft and ship position determination, communications, and traffic control; and (2) the various satellite designs and technical systems which would best meet the requirements of the maritime and

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aviation communities. NASA is cooperating with Department of Transportation, including the U.S. Coast Guard and Federal Aviation Administration (FAA), Maritime Administration, Department of the Navy, Atomic Energy Commission, and the aviation and maritime industries in navigation, search and rescue, communications, and traffic control satellite experiments, as related to aircraft, maritime, and land transportation activities.

SUMMARY OF RESOURCES REQUIREMENTS:

Space Applications

	1971	1972	1973
Earth resources survey.....	$66,735,000	$64,575,000	$48,400,000
Earth resources technology satellites.....	(55,750,000)	(52,225,000)	(35,400,000)
Aircraft program.....	(10,985,000)	(12,350,000)	(13,000,000)
Applications technology satellites.....	23,750,000	51,800,000	61,200,000
Nimbus.....	24,700,000	18,125,000	28,300,000
Synchronous meteorological satellites.....	8,850,000	15,000,000	11,500,000
Cooperative applications satellites.....	75,000	2,600,000	3,300,000
TIROS/TOS improvements.....	3,200,000	2,250,000	8,000,000
TOS improvements.....	(2,559,000)	(2,048,000)	(2,200,000)
TIROS-M.....	(641,000)	(202,000)	(---)
TIROS-N.....	(---)	(---)	(5,800,000)
Geodetic satellites.....	2,806,000	3,500,000	5,000,000
Global atmospheric research program.....	1,000,000	2,250,000	4,500,000
Meteorological soundings.....	3,100,000	1,500,000	1,500,000
Supporting research and technology/advanced studies..	28,744,000	23,300,000	22,000,000
Earth observatory satellite studies.....	---	1,000,000	1,000,000
Radio interference and propagation program.....	1,000,000	1,600,000	---
Air traffic control studies....	3,000,000	---	---
Total.....	$166,960,000	$187,500,000	$194,700,000

Distribution of Program Amount by Installation:

	1971	1972	1973
John F. Kennedy Space Center, NASA	---	$25,000	$50,000
Manned Spacecraft Center	$13,045,000	12,565,000	13,925,000
Marshall Space Flight Center	330,000	300,000	300,000
Goddard Space Flight Center	129,220,000	150,393,000	153,155,000
Jet Propulsion Laboratory	1,397,000	1,100,000	1,000,000
Wallops Station	2,498,000	3,655,000	5,790,000
Ames Research Center	765,000	1,470,000	3,575,000
Langley Research Center	5,715,000	4,280,000	6,425,000
Lewis Research Center	1,680,000	3,620,000	4,575,000
NASA Headquarters	12,310,000	10,092,000	5,905,000

BASIS OF FUND REQUIREMENTS:

Earth Resources Survey

Earth resources technology satellites:			
Spacecraft	$21,921,000	$19,245,000	$9,800,000
Sensors	21,343,000	15,980,000	2,200,000
Ground operations	12,486,000	15,000,000	2,500,000
Investigations	---	2,000,000	20,900,000
Total, Earth resources technology satellites	$55,750,000	$52,225,000	$35,400,000
Delta (Launch Vehicle Procurement Program)	($1,800,000)	($800,000)	($2,300,000)
Subtotal (including launch vehicles)	($57,550,000)	($53,025,000)	($37,700,000)
Earth resources survey aircraft program:			
Aircraft operations and support	$4,780,000	$5,540,000	$6,710,000
Sensor development and procurement	2,880,000	1,790,000	1,100,000
Equipment maintenance and modification	2,562,000	2,725,000	3,050,000
Data handling and processing	763,000	2,295,000	2,140,000
Subtotal, earth resources survey aircraft program	$10,985,000	$12,350,000	$13,000,000
Total, Earth Resources Survey (including launch vehicles)	($68,535,000)	($65,375,000)	($50,700,000)

Earth Resources Technology Satellites

The objectives of the Earth Resources Technology Satellite (ERTS) program are to design, develop, and launch two spacecraft (ERTS-A and -B) into medium-altitude, near-polar orbits, to develop a ground data handling system for processing the data, and to conduct a wide range of investigations in the earth resources areas relating to agriculture, forestry, geology, hydrology, cartography, geography, and oceanography, and environmental quality. The mission objectives include obtaining a large volume of repetitive earth surface imagery over a period of several seasons and verifying that useful information about earth resources and changing conditions on the earth's surface can be extracted from the data acquired. A long term goal of the ERTS-A and -B missions is to obtain the needed practical experience, engineering, and management data to provide a basis for decisions as to the feasibility and desirability of the design and development of operational earth resources survey systems.

The first satellite, ERTS-A, is scheduled to be launched in May 1972 and is to be followed by the launch of ERTS-B in November 1973. Investigations using the data from ERTS-A will begin with the launch of the satellite and continue during its expected useful life of one year or more. Supplementary data will be provided by the Earth Resources Aircraft program prior to and during the missions of ERTS-A and -B.

Spacecraft

During FY 1972 funds provide for completion of the development and fabrication of the ERTS-A spacecraft. Sensor bench integration and spacecraft integration of the payload will be accomplished. Final integration and tests will be accomplished and launch operations conducted. In FY 1973 funds will provide for continued development and fabrication of the ERTS-B flight spacecraft and integration of the flight sensors.

Sensors

During FY 1972 the engineering models of the Multispectral Scanner (MSS), the Return Beam Vidicon (RBV) Camera System, and the Wide Band Tape Recorder (WBTR) underwent bench integration tests at the prime contractor plants; flight models of these instruments and the Data Collection System (DCS) completed development and were installed in the spacecraft for integration, test, and launch. In FY 1973 the ERTS-B 5-Band Multispectral Scanner will undergo hardware development and fabrication. The ERTS-B flight models of the MSS, RBV, DCS, and WBTR will be installed in the flight spacecraft.

Ground Operations

During FY 1972 the Ground Data Handling System (GDHS) and Operations Control Center (OCC) completed development and have been installed and checked out in support of the ERTS-A launch. In FY 1973 operation of the GDHS and the OCC will continue in support of the ERTS-A mission and the production of photographic products and computer tapes for ERTS data users.

Investigations

During FY 1972 proposals were received, evaluated, and investigators selected to conduct ERTS-A data use investigations. Aircraft data were supplied to selected investigators to initiate effort prior to launch. In FY 1973 approximately 300 domestic investigators will be under contract for ERTS-A investigations and ERTS-B proposals will be evaluated and investigators selected.

Earth Resources Survey Aircraft

NASA's Earth Resources Survey Aircraft program is being used to conduct tests and experiments with instruments analogous to those being considered for the spacecraft systems, to explore data management problems that will be a part of the total system operation, and to provide data and test support to the earth resources supporting research and technology effort. With the advent of earth resources space platforms, the aircraft program will respond to the additional data support requirements imposed by the many investigators associated with ERTS and the Skylab Earth Resources Experiment Package (EREP). These new requirements led to the acquisition of additional aircraft and sensor capabilities in FY 1972.

Aircraft Operations and Support

Funding for aircraft operations and logistic support provides for the continued operation of the Manned Spacecraft Center's (MSC) aircraft, the University of Michigan contract aircraft, and reflects the addition of two surplus U.S. Air Force U-2 aircraft stationed at the Ames Research Center (ARC).

Funding in FY 1973 reflects an across the board increase in aircraft utilization in supporting ERTS-A investigators and EREP prelaunch survey requirements.

Sensor Development and Procurement

Several substantial additions to the aircraft instrumentation capability are being made in FY 1972. The 24 channel line scanner covering a broad visible and infrared spectrum, the passive microwave imaging system, and

the scanning imaging spectroradiometer will provide a much improved capability for experimentation and for use on a combined mission basis with the ERTS flights.

Increases in this category also reflect the costs of installing a multi-spectral scanner and acquiring additional camera systems for the U-2 aircraft in preparation for the ERTS and EREP support missions.

Equipment Maintenance and Modifications

Increases in FY 1972 and FY 1973 reflect sensor interface modifications to the U-2 in preparation for ERTS-EREP support missions and aircraft modifications associated with the new sensors presently being installed in three MSC aircraft.

Data Handling and Processing

This item covers continuing data processing and handling activities at MSC. Increases associated with the new ARC facility plus the expected demands **are attributed to increased mission activities and new sensor systems.**

Applications Technology Satellites (ATS)

	1971	1972	1973
Extended operations (ATS 1-5).	$3,205,000	$1,750,000	$1,200,000
Spacecraft.....	1,049,000	32,347,000	25,250,000
Experiments.....	16,985,000	13,758,000	33,250,000
Operational **support**.....	2,511,000	3,945,000	1,500,000
Total.....	$23,750,000	$51,800,000	$61,200,000
Titan IIIC (Launch Vehicle Procurement Program).....	($4,100,000)	($9,400,000)	($18,200,000)
Total (including launch vehicles).....	($27,850,000)	($61,200,000)	($79,400,000)

The objective of the ATS program is to design, develop and launch a series of spacecraft into orbit and to test advanced technologies and conduct specific applications and science experiments. Five spacecraft have been launched to date, of which ATS 1, 3, and 5 are still operative. Two spacecraft, ATS F&G,

are presently under development by Fairchild Industries. These two spacecraft will contain both applications and science experiments and will be launched into synchronous orbit in 1973 (ATS F) and 1975 (ATS G). Three communications ground stations will be used, two located at Rosman, North Carolina and Mojave, California, and a transportable station to be located in Europe. In addition, development of promising advanced applications flight experiments will continue for flight test on future missions.

Extended Operations

During FY 1972 and FY 1973 ATS 1, 3, and 5 communications, meteorological, and science experiments will continue and data reduced and analyzed. Ground operational support will continue for these three spacecraft and a final report will be completed on the ATS 1-5 series.

Spacecraft

The significant spacecraft technologies to be demonstrated by the ATS F&G flights are: the thirty (30) foot space erectable antenna; high pointing accuracy; interferometer performance; station keeping; and solar array technology. In FY 1972 and FY 1973 design and development of the ATS F&G spacecraft will continue. In FY 1972 the thermal structure for the spacecraft was completed and in FY 1973 the prototype model and flight model will be completed. In addition, FY 1973 funds will be utilized for ATS F pre- and postlaunch support.

Experiments

During FY 1972 and FY 1973 ATS 1, 3, and 5 will continue to furnish applications and science experimental data. ATS 1 continues to furnish real time solar and geomagnetic data to the National Oceanic and Atmospheric Administration for their use in supporting national and international space programs. It will also be used to support an educational TV experiment with Alaska and an experiment with the National Public Radio and the Department of Health, Education and Welfare, thus offering communications in education, medicine and environmental areas. A law enforcement experiment utilizing ATS 1 is planned in FY 1973 consisting of transmission and relay of voice data and facsimile transmission of fingerprints. ATS 1 and 3 continue to furnish meteorological data. ATS 5 has been furnishing useful L-band ranging and multipath data utilizing this spacecraft and high flying aircraft.

The experiments for ATS F and G are in the areas of communications, meteorology, earth resources, geodesy and earth physics, traffic management, particles and fields, and ionospheres/radio physics. Development of ATS F applications and science experiments will continue into FY 1973, with few

changes made since initial selection. The Indian Government is equipping approximately 5,000 villages with TV receivers capable of receiving program material directly from ATS F or through a retransmitting station. The final selection of ATS G experiments is planned to be made early in 1972. During FY 1973 effort will continue on the development of promising advanced applications flight experiments through engineering model stage, which have been defined but not yet assigned to specific flight missions.

Operational Support

During FY 1973 effort will continue in the procurement and modification of equipment in the Rosman, Mojave and transportable ground stations to be compatible with the frequencies of the ATS F&G satellites. Hughes Aircraft Company is the contractor for the transportable ground station. In addition, ground station integration, system engineering, repairs, and spare parts will be funded.

Nimbus

	1971	1972	1973
Spacecraft	$18,001,000	$10,801,000	$15,310,000
Experiments	5,691,000	6,288,000	11,226,000
Ground operations and support	1,008,000	1,036,000	1,764,000
Total	$24,700,000	$18,125,000	$28,300,000
Thrust Augmented Delta (Launch Vehicle Procurement Program)	($1,985,000)	($1,315,000)	($2,000,000)
Total (including launch vehicles)	($26,685,000)	($19,440,000)	($30,300,000)

The objectives of this project are to develop spacecraft with emphasis on meteorology to provide research data for use by the scientific community; to carry out flights tests to prove the applicability of new instrumentation; and to provide the basis for further significant technological advances in meteorological satellites for operational as well as research scientific use. The objectives for the Nimbus E and F include testing instrumentation to expand atmospheric remote sensing to cloudy regions, higher altitudes, and new regions of the electromagnetic spectrum. Extended altitude remote sensing and atmospheric soundings in the presence of clouds are needed to improve the accuracy and time extension of weather forecasts.

The Nimbus F sounding experiments and specifically the Tropical Wind, Energy Conversion and Reference Level Experiment (TWERLE) are expected to provide important environmental spaceborne inputs for the GARP Atlantic Tropical Experiment (GATE) of the Global Atmospheric Research program (GARP) and for the data system test for GARP planned subsequent to the launch of Nimbus F.

Spacecraft

FY 1972 funds provide for integration of the Nimbus E spacecraft systems and experiments. FY 1973 funds will be used to complete the integration and test of the Nimbus E spacecraft systems and experiments leading to a launch in November 1972. Development, assembly, and test of the Nimbus F spacecraft will be initiated in FY 1973.

Experiments

FY 1972 funds are being used for the completion and checkout of the Nimbus E experiment package and to initiate development of the Nimbus F experiments. During FY 1973 emphasis will be on the continued development of the Nimbus F experiments leading to integration with the spacecraft late in Calendar Year 1973.

Ground Operations and Support

FY 1972 funds are required for continued acquisition and analysis of data from the Nimbus 3 and 4 spacecraft and to initiate procurement of ground equipment needed for the Nimbus E mission. Procurement of this equipment will be completed and mission operations activities will be initiated during FY 1973.

Synchronous Meteorological Satellite

	1971	1972	1973
Spacecraft	$7,205,000	$10,454,000	$8,947,000
Sensors	700,000	2,905,000	1,544,000
Ground operations	945,000	1,641,000	1,009,000
Total	$8,850,000	$15,000,000	$11,500,000
Delta (Launch Vehicle Procurement Program)	($1,745,000)	($2,655,000)	($2,300,000)
Total (including launch vehicles)	($10,595,000)	($17,655,000)	($13,800,000)

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The objectives of the Synchronous Meteorological Satellite (SMS) are to demonstrate a prototype operational system which will meet the requirements of the National Oceanic and Atmospheric Administration (NOAA) to: (1) permit continuous observation of major weather systems routinely, thus enhancing the ability to predict and locate severe short-lived storms; (2) derive important wind field data over large areas and in much less time than heretofore possible; and (3) provide capability for rapid dissemination of processed meteorological data to local meteorologists.

The spacecraft will be spin stabilized and will contain a Visible and Infrared Spin-Scan Radiometer (VISSR) system for both IR and high resolution visible photography, a communications system for data collection and distribution, and a space environment monitoring system. The spacecraft will be sized to permit launch into synchronous orbit by the Delta launch vehicle.

Spacecraft

In FY 1972, the design and breadboard effort of all spacecraft subsystems will be completed. The subsystems for SMS-A will be fabricated and tested and the spacecraft will be assembled and integrated.

FY 1973 funds will be used to complete test and integration of the SMS-A spacecraft leading to a launch in late 1972. The subsystems of SMS-B will be fabricated and tested. The SMS-B spacecraft will be assembled and integrated and the testing of these two spacecraft will be initiated. Simultaneously with work on SMS-B, reimbursable work for NOAA will be in progress on a third SMS to be designated Geosynchronous Operational Environmental Satellite (GOES).

Sensors

In FY 1972, the VISSR engineering model will be tested and calibrated. The prototype model will be fabricated, tested, and calibrated. The flight model for SMS-A will be fabricated.

In FY 1973, the flight model for SMS-A will be tested, calibrated, and integrated into the spacecraft. The flight model for SMS-B will be fabricated, tested, calibrated, and integrated into its spacecraft. The fabrication for the GOES-A spacecraft will be initiated.

Ground Operations

In FY 1972, the Range and Range Rate (R&RR) equipment will be fabricated and delivered. The Station Integration and Interface (SI&I) equipment will be fabricated and delivered.

In FY 1973, the R&RR equipment will be installed and checked out. The SI&I equipment will be installed, checked out, and integrated into the ground station. Upon launch, the SMS-A spacecraft will be operated in its postlaunch engineering evaluation and check out phase.

Cooperative Applications Satellites

	1971	1972	1973
CAS-A			
Project support and data analysis.....	$75,000	$100,000	$100,000
CAS-C			
Spacecraft.....	---	---	470,000
Experiments.....	---	2,500,000	2,530,000
Operational support.....	---	---	200,000
Subtotal, CAS-C.....	---	$2,500,000	$3,200,000
Total, CAS-A&C.....	$75,000	$2,600,000	$3,300,000
Scout (CAS-A) (Launch Vehicle Procurement Program).....	(---)	($1,250,000)	(---)
Delta (CAS-C) (Launch Vehicle Procurement Program).....	(---)	(---)	($1,900,000)
Total (including launch vehicles).....	($75,000)	($3,850,000)	($5,200,000)

CAS-A

CAS-A is a joint satellite project of the National Aeronautics and Space Administration (NASA) and the French Space Agency (CNES) to develop meteorology and position location instrumentation for use on free-drifting balloons designed to operate with an earth-orbiting satellite. It was successfully launched on August 16, 1971, by NASA from Wallops Station. Instrument data is utilized by U.S. and French scientists to improve the understanding of the atmospheric structure and to extend weather forecasting capabilities. CNES launched about 500 scientific balloons from three sites in Argentina to an altitude of about 12 kilometers in the Southern Hemisphere. The satellite tracks and obtains meteorological data from the balloons and transmits it to earth stations. During FY 1972 and continuing

through FY 1973, fund requirements are to support U.S. investigators to analyze the meteorological data and for project support.

CAS-C

The Canadian Department of Communications (DoC) and NASA entered into a Memorandum of Understanding in April 1971 to launch a Canadian Cooperative Applications Satellite (CAS-C) in early 1975 to flight test certain advanced communications technologies. The overall objective of the project is to advance the state of the art in spacecraft and related ground based technologies relevant to future communications and other satellite applications systems. Canada will provide funding support for the spacecraft development. NASA's prime responsibility is for development of the high power tube and launch of the spacecraft. After the satellite is placed in geostationary orbit, NASA and DoC will conduct communications experiments, sharing the high power 12 GHz spacecraft transponder equally.

Spacecraft

The spacecraft is basically designed for experimental communications experiments with small terminals at the 12/14 GHz frequency bands allocated for these purposes at the World Administrative Radio Conference in 1971. FY 1973 NASA funding includes spacecraft studies.

Experiments

In addition to the experiments described above, this spacecraft will conduct flight tests of technology experiments including:

(1) extendable solar power panel arrays of 1 KW capability,

(2) altitude control of a satellite with large flexible appendages (the solar arrays),

(3) the use of electric propulsion for station keeping,

(4) liquid metal slip rings for power transfer across a rotary joint, and

(5) efficient (50%), high power (200w) transmitter at 12 GHz.

FY 1972 funds are being utilized for the high power tube development. This effort will continue in FY 1973.

Operational Support

The operational support will include planning and procurement of the ground station system and provide for required modifications and spare parts. FY 1973 effort includes initiation of ground system planning and procurement.

TIROS/TOS Improvements

	1971	1972	1973
TOS improvements.....	$2,559,000	$2,048,000	$2,200,000
TIROS-M.....	641,000	202,000	---
TIROS-N.....	---	---	5,800,000
Total.....	$3,200,000	$2,250,000	$8,000,000

The objectives of this project are to provide research and development toward advanced operational meteorological satellite systems, in support of the National Operational Meteorological Satellite System (NOMSS). These objectives are being met by conducting an improvement program wherein sensors and subsystems to be incorporated into future operational satellites are developed, and through the development of prototype operational spacecraft for major advancements of the overall system.

TOS Improvements

In FY 1972, developmental effort on advanced sensors and ground hardware for ITOS-D to be launched in 1972 is being continued. In addition, effort on a new advanced sounder, and an advanced very high resolution radiometer for future missions was initiated. FY 1973 funds will be used to perform systems analysis studies as necessary to evaluate and upgrade subsystems and operational procedures of the operational system.

TIROS-M

In FY 1972, spacecraft funds were used to complete the funding to the prime contractor for TIROS-M.

TIROS-N

The TIROS Operational Satellite (TOS) program, based on the technology developed in the TIROS, Nimbus, and the SR&T programs, is an evolutionary program that has led to spacecraft and subsystems, including tracking and data acquisition systems and equipment, having an extremely high

level of performance and reliability. The results of this program have made it possible to incorporate major changes in the national operational system about every fifth year. In this way, the initial TIROS system operated from 1960 to 1965, the TOS system operated from 1965 to 1971, and the present ITOS series is expected to fulfill operational requirements until 1976.

The next major change will be TIROS-N which will be the forerunner of the advanced operational spacecraft needed to meet the advanced technology requirements of the national operational system and the Global Atmospheric Research Program (GARP) starting in the mid-1970's time frame. With TIROS-N, the emphasis will shift from the imaging of cloud cover to the quantitative measurement of the vertical structure of the atmosphere which is needed for improvements in numerical weather prediction. The attainment of the goal of accurate weather forecasts through numerical weather prediction is absolutely dependent upon the availability of quantitative atmospheric data on a global scale.

In FY 1973, a spacecraft contractor will be selected for the hardware phase and detailed design work will be initiated.

Geodetic Satellites

	1971	1972	1973
GEOS - 1&2			
Extended support.....	$1,640,000	$600,000	$600,000
GEOS-C			
Spacecraft.....	1,166,000	1,700,000	2,400,000
Experiments.....	---	1,200,000	1,800,000
Operational support.....	---	---	200,000
Total.....	$2,806,000	$3,500,000	$5,000,000
Delta (Launch Vehicle Procurement Program).....	(470,000)	(1,100,000)	(2,230,000)
Total (including launch vehicles).....	($3,276,000)	($4,600,000)	($7,230,000)

The objectives of this project are to design, develop, and launch geodetic satellites capable of performing experiments in support of: (1) the National Geodetic Satellite Program (NGSP), a joint NASA/DoD/DoC program

under NASA management; and (2) application of geodetic satellite techniques to solid earth geophysics and oceanography. Three satellites have been launched to date; namely, Pageos 1, GEOS 1, and GEOS 2, of which GEOS 1 and 2 are still being utilized. A fourth mission, GEOS-C, is being developed and is scheduled for launch in late Calendar Year 1973. The GEOS-C mission will: (1) perform an in-orbit satellite altimeter experiment to determine and demonstrate the feasibility of utilizing an altimeter to measure the distance between the satellite and the ocean surface with a precision of 5 meters or better; (2) perform satellite-to-satellite tracking of the GEOS-C spacecraft through the geosynchronous satellite, ATS-F, to measure directly the short period wavelengths in the earth's gravity field; (3) support the calibration of the USAF Western Test Range C-band radars by carrying coherent C-band transponder systems, and assist in locating these stations in a unified world reference grid; (4) support the refinement in the determination of the large scale terms in the earth's gravity field by acquiring data from a satellite equipped with precision geodetic instrumentation; and (5) support the intercomparison of candidate geodetic instrumentation systems such as: the radar altimeter, satellite-to-satellite tracking, the Manned Space Flight Unified S-band system, and the NASA and Smithsonian Astrophysical Observatory laser tracking systems.

Extended Support

During FY 1972 and FY 1973, data will continue to be received from GEOS 1 and 2. In addition, data reduction and analysis will continue on the data already obtained.

Spacecraft

During FY 1972, the prototype spacecraft of GEOS 2 was selected as the one for development as the GEOS-C flight model. Development of GEOS-C will continue in FY 1973 with a launch scheduled for late 1973. The Applied Physics Laboratory, Johns Hopkins University is the spacecraft contractor.

Experiments

New instrumentation being developed for flight test on GEOS-C are the radar altimeter, the components for the satellite-to-satellite tracking equipment, and the coherent C-band radar transponders. GEOS-C will also carry laser retroreflectors, two Doppler beacons, Unified S-Band transponder, and, tentatively, optical beacons. During FY 1972 and FY 1973, development of the radar altimeter, C-band and S-band communication experiments will continue. During FY 1973 effort on the laser and beacon experiments will be initiated.

Operational Support

During FY 1973, operational support will be in the areas of pre-and postlaunch support of the GEOS-C.

Global Atmospheric Research Program (GARP)

	1971	1972	1973
Data systems test support.....	---	$150,000	$1,700,000
Simulations studies.....	$900,000	1,100,000	1,630,000
GARP atlantic tropical experiment support.....	---	---	200,000
Technology development.....	100,000	1,000,000	970,000
Total.....	$1,000,000	$2,250,000	$4,500,000

The Global Atmospheric Research Program (GARP) is an international cooperative program designed to increase our understanding of the general circulation of the atmosphere and to establish the mathematical and physical basis for methods of long range weather prediction. GARP is directed jointly by the governments of interested nations through the World Meteorological Organization (WMO) and by the world scientific community through the International Council of Scientific Unions (ICSU). National and international organizations have been established to plan and execute the program.

Two major experiments are planned: a tropical experiment in the tropical Atlantic Ocean area in the summer of 1974 and a First GARP Global Experiment (FGGE) during the period 1976/1977. Operational and experimental satellites of the United States, U.S.S.R., and France have been identified as essential to the GARP experiments. The studies and analyses of proposed operational meteorological satellite systems are being continued in FY 1972 to define the optimum global observing system responsive to GARP requirements, and to optimize the extraction of meteorological information from spaceborne sensors.

Data Systems Test Support

During FY 1973, a transition occurs from planning to implementation of the GARP field exercises. The most significant increase will be required for the design and implementation of the Data Systems Test, for which NASA has been assigned primary responsibility. This is conceived as a complete system test simulating the First GARP Global Experiment (FGGE) to determine the suitability of the components. Design of the Data Systems Test (DST)

will also provide facilities and techniques for the employment of the test data sets in simulation experiments and prediction models, providing for analysis and feedback of the suitability of the data management components of the total system.

Simulations Studies

During FY 1973, work conducted by the Goddard Institute for Space Studies will concentrate on the assimilation of asynoptic satellite data in general circulation models and operational forecast models and will test the effectiveness of combinations of satellite and conventional data, with specific application to the Data Systems Test and the First GARP Global Experiment.

GARP Atlantic Tropical Experiment Support

NASA will provide observational support to the GARP Atlantic Tropical Experiment during June-August 1974. Meteorological data from the geostationary SMS satellite will provide essential data both for research purposes and for the operational deployment of project ships and aircraft during the conduct of the experiment. NASA will also provide aircraft for *in situ* observations in support of the GARP Atlantic Tropical Experiment.

Technology Development

Technology development during FY 1973 will concentrate on the establishment of a reference level in the southern hemisphere and the determination of wind profiles in the tropics. The TWERLE experiment on Nimbus F is the most promising method for obtaining southern hemisphere reference level data. Development of a satellite-carrier balloon subsystem, for the measurement of wind profiles in the tropical regions, will be continued with the National Center for Atmospheric Research.

Meteorological Soundings

	1971	1972	1973
Research sounding rockets.....	$2,137,000	$700,000	$200,000
Sounding rocket systems.....	515,000	350,000	300,000
Field experiment support.....	448,000	450,000	1,000,000
Total.....	$3,100,000	$1,500,000	$1,500,000

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The objectives are to measure with present meteorological sounding rockets the structure, characteristics, composition and chemical reactions of the atmosphere within the region 30 to 100km and to develop an economical meteorological sounding rocket system to meet research, range support, and routine operational requirements.

Research Sounding Rockets

Research meteorological rockets of various types are used for the exploration and study of the atmospheric composition and chemical reactions as they relate to the structure, dynamics, and gaseous constitutents within the 30 to 100km region.

In FY 1972, about 30 Nike Cajun type rockets will be launched from Wallops Station, Va., Point Barrow, Alaska, and foreign sites. In FY 1973, about 10 Arcas type rockets will be launched from Wallops Station and foreign sites.

Sounding Rocket Systems

A small meteorological sounding rocket system for economical atmospheric measurements in the region 30 to 75km is being developed. This system will be capable of launching reliable, inexpensive operational sounding rockets amenable to the requirements for range support, atmospheric research, and network operations.

In FY 1972, prototype thin film temperature sensors and prototype solid state pressure transducers will be delivered and tested on balloons. Lightweight decelerators, payloads, and the tracking system will receive initial flight tests. About 15 Arcas type rockets will be launched from Wallops Station, Va.

In FY 1973, thin film temperature sensors, decelerators, payloads and the tracking system will be flight tested. User flight tests of rocket motors will be completed. About 35 rockets will be launched from Wallops Station.

Field Experiment Support

The field experiment support program provides, through cooperation with other countries, for the establishment of self-sustaining capabilities for coordinated meteorological sounding rocket launches from sites that will contribute mutually valuable atmospheric data. Also, through international cooperation, is the establishment of a Western Hemisphere international meridional network for exchange of data with an Eastern Hemisphere network.

In FY 1972, about 180 Arcas and Boosted Dart type rockets will be launched to continue field experiment projects. In FY 1973, funds are required to continue field experiment projects with other cooperating countries, to obtain additional atmospheric research data, to train foreign nationals for cooperative programs, to conduct international rocket comparisons, to conduct rocket-satellite sounding comparisons and to initiate the establishment of an international Western Hemisphere meridional rocket network that will be part of the U.S.-U.S.S.R. agreement for space cooperation. About 215 rockets of the Arcas and Boosted Dart type will be launched from Wallops Station and foreign sites. Implementation of the international cooperative program to establish a Western Hemisphere meridional rocket network will require establishing new sites and increasing the number of launches.

Supporting Research and Technology

	1971	1972	1973
Applications technology.....	$4,248,000	$3,335,000	$3,500,000
Communications.....	3,377,000	3,080,000	3,400,000
Earth resources.....	11,522,000	8,865,000	6,800,000
Geodesy/earth physics.....	1,883,000	1,466,000	1,300,000
Meteorology.....	2,656,000	2,100,000	2,500,000
Traffic management.....	1,338,000	980,000	900,000
Interdisciplinary applications	3,720,000	3,474,000	3,600,000
Total.....	$28,744,000	$23,300,000	$22,000,000

Nearly every technique and space system in Space Applications must be preceded by Supporting Research and Technology (SR&T)/Advanced Studies. This effort includes supporting activities in all disciplines (Applications Technology, Communications, Earth Resources, Geodesy/Earth Physics, Meteorology, Traffic Management) and a number of interdisciplinary activities.

Applications Technology efforts will include studies of problems and technology for synchronous orbit spacecraft; synchronous orbit apogee motor technology and reliability; and characteristics of rendezvous techniques with applications spacecraft. Work continues to develop cost trade offs and establish design flexibility, reliability, and mechanical integrity of optimized graphite/epoxy apogee kick motor designs. Propulsion thruster trade-off studies will continue along with comparisons of chemical and electrical thruster systems. Systems studies in Small Applications Technology Satellites will be continued. The sensor and instrumentation development includes sensors across the complete electromagnetic spectrum. Models of both mechanical and

electronic multispectral line scanners will be developed. Work is under way in advanced tape recorders and general data storage media, and active and passive spaceborne cryogenic units. In the data management area special attention is given to multispectral correlation schemes and to on-board data reduction techniques.

In communications, effort will be conducted in the areas of advanced systems, user requirements, and communications technology. Advanced systems effort is planned in the areas of communications systems analysis, information network system concepts, communications satellite repeater configuration studies, optimum signal detection techniques, communications satellite systems for Alaska, and bandwidth compression techniques for two dimensional data. User requirements are pursued in biomedical communications network, law enforcement information network, educational communications systems, disaster warning satellite systems, and educational television. Efforts conducted in communications technology are: (1) continuing effort in communications satellite microwave power research including ground receiver systems, high power microwave components, high power tube technology and component evaluation; (2) developing multiple narrow beam-shaped and contoured beam pattern antenna technology; (3) continuing studies of the efficient use of the frequency spectrum and orbit utilization; (4) conducting research and development in the area of laser communications; (5) investigation of manned communication systems technology; and (6) continuing systems studies in tracking and data relay.

In FY 1972, in earth resources activities, a significant start was made in cooperative regional activities by NASA Centers with local, state, and federal agencies. Many problems are under study from the space applications point of view. We are stressing the importance of measurements and analysis of data in evaluating the feasibility of potential applications.

In FY 1973, emerging multidisciplinary applications will be strengthened at Wallops Station and Langley Research Center, Virginia, in Chesapeake Bay studies; at Lewis Research Center, Ohio, in Midwest and Great Lakes studies; at Marshall Space Flight Center in Alabama studies; at Mississippi Test Facility in tri-state studies involving Arkansas, Louisiana, and the Mississippi Gulf Coast; at Manned Spacecraft Center in studies of the 18 county Houston area; and in California at Ames Research Center near San Francisco. Intensive efforts will continue correlating the Earth Resources Survey flight investigations of ERTS and Skylab with the SR&T applications investigations programs.

The Geodesy/Earth Physics activities in FY 1973 will include: (1) the use of improved laser satellite tracking systems in an experiment to measure crustal mass displacement rates across the San Andreas fault; (2)

the use of laser satellite tracking systems and the Very Long Baseline Radio Interferometry (VLBI) technique in separate experiments to measure polar motion and variations in the rate of rotation of the earth about its axis; (3) the initiation of a long term VLBI experiment to detect and monitor continental drift; (4) continued support of the development of laser satellite tracking systems having very high accuracies of the order of 5 centimeters; (6) a high accuracy (10 centimeter) satellite altimeter development effort to provide the capability of obtaining global synoptic measurements of the spatial and time variations of the ocean surface geometry that can be related to oceanic circulation patterns, tides, storm surges, and sea state conditions; (7) the development of improved techniques and procedures for the reduction, analysis, and interpretation of data to be derived from the laser and VLBI solid earth dynamics experiments and from satellite altimeter experiments; (8) the conduct of earth physics satellite advanced mission studies; and (9) the conduct of studies to identify specific requirements for and uses of accurate maps of the ocean floor.

Meteorological research will continue in the development, optimization, and application of remote sensing techniques. This includes: (1) analysis and interpretation of satellite data for the improvements and optimization of sensing techniques to provide quantitative measurements of atmospheric structure, composition, dynamics, and related phenomena; (2) development and analysis of radiation transfer models to improve the accuracy and design of remote sensing instrumentation; (3) development of techniques for the improvement, calibration, and test of satellite instrumentation; (4) aircraft and balloon flight tests of satellite sensors to verify their performance and to develop methods for the interpretation of the measurements; (5) determining the effect of atmospheric spectral transmission and variability upon the quantitative interpretation of radiation signatures; (6) development of climatological-statistical models of the atmosphere for the assessment of atmospheric effects on spectral transmission in various geographic regions; and (7) study and development of sensors to measure the atmospheric constituents of the stratosphere and their photochemical reactions along with numerical models of the composition and processes.

In Traffic Management we will study over ocean traffic control techniques, ship collision avoidance, and evaluate ground-based navigation systems as they apply to ships at sea. Data collection will be pursued in such areas as platform conceptual studies, satellite onboard data processing, component technology effort, and advanced position location technology.

In Interdisciplinary Applications, studies and research relating to several of the applications disciplines are conducted. In addition, development and support of multidisciplinary centers such as the University of Wisconsin and the Goddard Institute of Space Studies are continued.

Earth Observatory Satellite Studies

	1971	1972	1973
Phase B studies.....	---	$1,000,000	$1,000,000
Total.....	---	$1,000,000	$1,000,000

The Earth Observatory Satellite (EOS) is envisioned as a series of orbital platforms for the conduct of research leading to the development of remote sensing devices and techniques applicable to the Earth Observations disciplines. The EOS will be capable of continuing, late into this decade, the research now conducted with the ERTS and Nimbus series of spacecraft. To support oceanographic and meteorological investigations, including studies of air-sea interaction, it is planned to fly a passive multifrequency microwave system on an EOS mission. This system is essential to the eventual development of an "all weather" remote sensing system. To meet requirements for terrestrial survey and environmental quality/ecology disciplines, high resolution mapping and scanning sensors are planned. Other candidate sensors including instruments for indicating sea surface temperature, ocean color, cloud characteristics, atmosphere gaseous pollutants, atmosphere particulate pollution, and atmospheric temperature.

FY 1972 funds have been used to initiate design studies for several of the advanced sensor and subsystem concepts proposed for EOS missions.

Funds requested in FY 1973 will be used to continue these design studies and to support additional studies of spacecraft and ground data handling approaches.

Radio Interference and Propagation Program

	1971	1972	1973
Studies and experimentation.....	$1,000,000	$1,600,000	---
Total.....	$1,000,000	$1,600,000	---

The basic program was developed as a jointly supported activity of NASA, Federal Communications Commission (FCC), Department of Commerce (DoC), Office of Telecommunications Management (now Office of Telecommunications Policy, OTP) in 1969. The objectives are to conduct radio interference and propagation experiments and analyze the data from these and related measurements so that analytical models of propagation phenomena can be constructed. The initial phase of the program was completed in September

1971 in the measurement of ground-to-ground radio interference below 10 GHz caused by propagation phenomena and man made noise. Experiment data was acquired from site operations mainly at Langley, Virginia; Westford, Massachusetts and Ohio State University. Experiment data was vital in preparing the U.S. technical positions for the World Administrative Radio Conference (WARC) in 1971 and in preparatory meetings for the WARC. The data is also utilized by FCC and OTP in their deliberations on the proposed U.S. domestic satellite systems. Areas requiring additional experimental effort and investigations are satellite-to-ground, ground-to-satellite, and satellite-to-satellite interference and orbit utilization problems, and the use of frequencies above 10 GHz. Emphasis in FY 1972 and prior years was placed on acquiring data in support of U.S. positions on interference between satellite earth stations and microwave relay links at frequencies below 10 GHz. No FY 1973 funds are being requested for this project.

Air Traffic Control Satellite Studies

	1971	1972	1973
Studies and support.....	$3,000,000	---	---
Total.....	$3,000,000	---	---

Studies are being conducted and technology developments are initiated in coordination with the Department of Transportation (DoT)/Federal Aviation Administration to meet the needs of the most effective operational systems for air traffic control and communications services for the early 1980 period. These efforts are being conducted utilizing FY 1971 funds. No additional funds for FY 1972 and 1973 are requested by NASA for this project.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1973 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR

AERONAUTICS AND SPACE TECHNOLOGY PROGRAMS

Program	1971	1972	1973
Aeronautical research and technology.....	$100,132,000	$110,000,000	$163,440,000
Space research and technology	105,004,000	75,105,000	64,760,000
Nuclear power and propulsion.	55,200,000	27,720,000	21,100,000
Total.....	$260,336,000	$212,825,000	$249,300,000

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1973 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY — AERONAUTICAL RESEARCH AND TECHNOLOGY PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1971	1972	1973
Research and technology base.....	$74,109,000	$70,076,000	$90,640,000
Systems and design studies.....	5,143,000	8,094,000	7,000,000
Systems and experimental programs...	20,880,000	31,830,000	65,800,000
Total.....	$100,132,000	$110,000,000	$163,440,000

HIGHLIGHTS OF BUDGET PLAN

	1971	1972	1973
Research and Technology Base.....	$74,109,000	$70,076,000	$90,640,000
Materials - Basic research and development studies on metals, ceramics, polymers and composites of those materials that will lead to improved high temperature properties and reliability.....	4,216,000	5,800,000	7,200,000
Structures - Advancement of technology for future short and long haul transportation systems and air defense systems in areas of high temperature structures, composite structures, analysis and design, and structural dynamics.....	3,150,000	3,776,000	8,070,000
Avionics - Application of advanced theory to avionic systems design; develop technology for VTOL automated flight, pilot warning, control and display for improving general aviation aircraft safety; application of active control technology to advanced transport aircraft design..	3,885,000	2,543,000	5,350,000

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	1971	1972	1973
Propulsion - Efforts supporting engine, engine components, and nacelle improvements aimed at improved performance, pollution reduction, and weight and cost reduction..	$17,051,000	$20,005,000	$26,900,000
Aerodynamics - Programs to increase understanding and predictability of complicated aerodynamic and flight dynamic phenomena to provide improved vehicle design criteria.....	13,702,000	12,922,000	10,170,000
Configurations - Vehicle configuration programs to provide technology base for general aviation aircraft with improved safety and flight characteristics; for STOL, VTOL, and rotocraft vehicles with improved capability for short haul applications; for long haul transports; and for military fighter, bomber, and missile systems.....	23,828,000	18,930,000	25,300,000
Life Sciences - Research and technology relative to the relationship between man and advanced aeronautical systems.....	2,100,000	3,100,000	3,050,000
Aircraft Operations - Development of refined knowledge of the atmosphere (low level winds, high altitudes, turbulence) for improved vehicle design and operating procedures and develop solutions to problems spawned by current aircraft operations (slippery runways, lightning effects, turbulence detection, fire, crash) in the flight and runway environments.....	5,277,000	2,100,000	3,700,000
Technical Assistance to DOD Development Programs - Specialized models, computer time, specialized instrumentation and test gases supporting Air Force F-15, B-1 and AX airplane development and the Navy F-14 program.....	900,000	900,000	900,000

	1971	1972	1973
Systems and Design Studies.....	$5,143,000	$8,094,000	$7,000,000
Systems Studies - Examination and analysis of new ideas for aeronautical missions and systems. Focus in FY 1973 is on low density short haul air transportation service and advanced fighters.....	993,000	1,594,000	2,200,000
Experimental Design Studies - Efforts focused on conventional take-off and landing (CTOL) MKII Experiment Quiet Engine to optimize configuration of this engine, Advanced Technology Experimental Fighter to investigate potential of integrating all new technology innovations, lift-fan research aircraft to define near term research airplane program, and advanced technology transport to determine technology requirement that require additional in-depth study.....	4,150,000	6,500,000	4,800,000
Systems and Experimental Programs...	$20,880,000	$31,830,000	$65,800,000
Experimental Engine Programs.....	$8,054,000	$5,000,000	$12,000,000
Experimental Quiet Engine for Conventional Take-Off and Landing Aircraft - Completion of test program aimed at noise reduction via design considerations and acoustical treatment of Nacelle.....	8,054,000	5,000,000	1,000,000
Short Take-Off and Landing (STOL) Experimental Quiet Engine - Initiation of three year effort to develop and demonstrate noise levels of 95 EPNdB at 500 feet.....	---	---	2,000,000
JT3D/JT8D Engine Quieting - Initiation of effort to investigate and demonstrate noise reduction modifications that are retrofittable to current jet aircraft.....	---	---	9,000,000

	1971	1972	1973
Flight Experiments Programs.....	$9,176,000	$9,200,000	$12,700,000
C-8 Augmentor Wing Research Aircraft - Proof-of-concept flight tests of augmentor wing powered-lift concept to provide technology base developing design and certification criteria, and operational procedures for turbofan STOL transports.....	2,971,000	2,200,000	1,500,000
Transport Technology (F-8) Flight Research - Continuation of proof-of-concept tests of a supercritical wing for transonic aircraft and the initiation of the design of hardware for a follow-on flight program.....	780,000	1,000,000	2,500,000
YF-12 Research Aircraft Technology Program - A joint USAF/NASA flight test program to investigate prediction techniques and problems of civil and military long range aircraft in regimes of structures, propulsion systems, and aerodynamics, with emphasis on the latter two in FY 1973	4,900,000	2,900,000	4,700,000
F-111 Transonic Aircraft Technology (TACT) - A joint NASA/Air Force program to determine the applicability of the supercritical wing concept to a swept wing aircraft. The aircraft will be first flown in its normal Air Force mode for baseline information and again after being retrofitted with a supercritical wing.....	---	100,000	200,000
Fly-By-Wire Experimental Program - Development and experimental flight test of reliable cost-effective digital electronic flight control systems for advanced aircraft.....	525,000	1,000,000	1,700,000
Composite Structures Flight Experiment - Will provide actual flight service experience concerning fatigue behavior, maintenance requirements, and inspectibility of selective composite reinforcement of metal aircraft structures using the USAF C-130 airplane and the Army CH-54 helicopter..	---	2,000,000	2,100,000

	1971	1972	1973
Research/Experimental Vehicle Program	$1,150,000	$13,340,000	$30,500,000
Rotor System Test Vehicle Research Aircraft - Definition, detailed design, initiate procurement of Research Aircraft, (a joint Army/NASA program) Acquisition of the new type aircraft will allow flight tests to demonstrate its flight applicability from hovering to fast conventional flight.....	---	740,000	1,500,000
Tilt Rotor Research Aircraft - Define vehicle based on research data. Design and fabricate research vehicle (Joint Army/NASA program).....	---	400,000	1,500,000
Quiet Experimental STOL Transport Research Airplane (QUESTOL) - Technology support and the initiation of final design and construction of two (2) experimental airplanes for development of detailed design operations, and certification criteria for turbofan augmented-lift STOL transports.....	1,150,000	12,200,000	27,500,000
Operating Systems Experiments Programs	$2,500,000	$4,290,000	$10,600,000
Noise Reduction Flight Procedures Experiments - Technology for and demonstration of noise abatement flight paths for existing jet transports and for advanced aircraft operating in an upgraded air traffic control system.....	---	300,000	3,400,000
Terminal Configured Vehicle Operations Experiments - The aeronautical aspects of an advanced ATC system by designing into future aircraft a new terminal capability to be compatible with the potential of the new FAA ATC ground automation.....	---	400,000	4,200,000

	1971	1972	1973
Vertical Take Off and Landing Operating Systems Experiments - Avionics technology and operating data peculiar to VTOL aircraft operating in an advanced air traffic control system with emphasis on automatic landing systems.....	---	300,000	500,000
Short Take Off and Landing Operating Systems Experiments - A joint DOT/NASA program to develop and conduct flight experiments with advanced navigation, guidance, and control concepts for all-weather STOL operations.....	2,500,000	3,290,000	2,500,000

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

AERONAUTICAL RESEARCH AND TECHNOLOGY PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The NASA FY 1973 Aeronautics program is based on direction, policy, and national agreement which is more encompassing than in previous years. The joint DOT/NASA Civil Aviation Research and Development (CARD) Study, the North East Corridor Transportation Policy, and joint program studies and plans with the U.S. Air Force, Army and Navy, provide specific directions upon which to base the FY 1973 aeronautics budget. A set of national needs and goals for aeronautics has been identified. They are the basis for selecting areas of technology emphasis for FY 1973. Furthermore, reviews currently under way within NASA, jointly with DOT, and under discussion with DOD insure improved planning for implementation of the FY 1973 program, and planning an FY 1974 program.

The overall thrust is to retain civil and military international technological superiority while providing (1) technology supporting improvement of our national air transportation systems to make them unobtrusive to the environment, competitive in all aspects of the aviation world market, safer and more reliable, and above all, make them relevant to this decade's air transportation demands, and (2) technology supporting the needs of the U.S. military aeronautical systems concepts evolving in the 1970's. To this end, the program places particular emphasis on the following: (a) Reduction of environmental pollution attributed to aircraft through the development of quiet, pollution-free engines, and propulsive lift systems, and refinement of aircraft operational procedures around terminal areas; (b) decreased air traffic congestion and delay time with increased safety through technology for improved airports, air traffic control systems, avionics, aircraft operating systems and procedures, and terminal configured vehicle concepts, including STOL propulsive lift; (c) a short-haul air system technology program that includes an experimental STOL aircraft, Short Take Off and Landing (STOL) quiet engine, jet lift Vertical and Short Take Off and Landing (V/STOL), rotor vehicles, advanced helicopter technology, and advanced systems for the STOL aircraft of the 80's; (d) a long haul transport technology program ranging from the transonic through hypersonic speed regime, involving continued work on the application of supercritical technology to air transports for more efficient and economical operation, supersonic propulsion and configuration investigations through wind tunnel and flight research, and design studies of supersonic and hypersonic vehicle configuration and propulsion systems; (e) assistance to the military through research and technology activities aimed at removing technological obstacles from current developments and at providing future options. Areas of special emphasis at this time are

rotor vehicles, including the tilt rotor, and the technology for an advanced fighter aircraft. Joint activity with DOD in these programs will continue.

In addition to these major technology efforts, OAST will continue vigorous pursuit of its fundamental role of conducting basic research and developing the technology for new capabilities and missions which are not presently amenable to more precise definition. The FY 1973 aeronautics program will be conducted within the context of three major program categories: Research and Technology Base; Systems and Design Studies; Systems and Experimental Programs.

Research and Technology Base

The Research and Technology Base is the basic research and the discipline research and technology that is forward looking in its potential application to the broad band of national needs and goals in aeronautics.

Within the federal government the development of the aviation research and technology base is the primary responsibility of NASA. The nation as a whole annually invests approximately 1/4 billion dollars on the national aviation technical base (federal and private funding). NASA, through its programs, provides slightly less than 1/2 of the total funding and performs approximately 1/3 of the nation's effort in its laboratories. The nation's resource investment in the research and technology base increased from 1961 to 1969 and has remained at essentially a constant level since 1970. The NASA FY 1973 programs provide some growth and aim at maintaining our strength in selected discipline areas. These are: materials, structures, avionics, controls, propulsion, aerodynamics, vehicle configurations, life sciences and aircraft operations.

Systems and Design Studies

This activity provides the necessary analytical results which permit the successful transfusion of the technology developed under the R&T Base into total systems for experimental programs. Elements of this analytical capability exist throughout all technical disciplines. Other objectives of this activity are to continuously re-examine program emphasis, confirm program relevance to needs, re-examine hypotheses and assumptions, and generally insure that NASA is working the "right problems". Although this activity is predominantly in-house, it is supported by some specific contractual activities that include: (a) An advanced conventional take-off and landing (CTOL) Quiet Engine Design Study of an advanced version of the current quiet engine which incorporates in a design concept the latest advances in engine technology and determines trade-offs between noise reduction mechanisms, engine performance and installed weight; (b) an Advanced Technology Experimental Fighter Study investigating the potential of integrating all the newest technologies into a superior fighter aircraft design; (c) Lift-Fan Research Aircraft Design Studies for the purpose of examining advanced lift-fan VTOL transport vehicles for the 1985 time period; (d) Advanced Transport Technology Systems Studies investigating the practical application of supercritical aerodynamics and related technologies into new subsonic/transonic civil and military transport designs; (e) STOL System and Design Studies aimed at furthering the understanding of short-haul STOL civil transport operations,

economics, and implementation needs as they affect the technical aspects of STOL transports.

Systems and Experimental Programs

This activity aims at verifying the technical readiness of technological concepts. It involves the design, fabrication and testing of specific experimental components, systems, or processes, to allow experimental testing and verification of a concept in a realistic environment. The return or payoff is the opportunity for an earlier application of the technology to a critical need in operational systems, or a significantly new perspective for the design of a future system. The thrust of this activity is to minimize technical and economic risk in the application of new technology to operational hardware and to decrease the very long time lag between the demonstration of technical feasibility and application. Experimental programs, as the final phase of technology development, are undertaken jointly, whenever possible, with other agencies. The FY 1973 programs are divided into four categories: Experimental Engines; Flight Experiments; Research and Experimental Vehicles; and Operating Systems Experiments. A total of sixteen individual projects are described in detail in the accompanying text. Of these sixteen, the Quiet Experimental STOL Transport Research Airplane, a FY 1972 new start, is the major project in terms of resources in FY 1973. It is proceeding according to plan. Significant new starts in FY 1973 include a STOL Experimental Quiet Engine, a JT3D/JT8D Engine Quieting Program, and a Rotor Test Vehicle and a Tilt Rotor Vehicle. Both the Rotor Test Vehicle and the Tilt Rotor Vehicle efforts are joint NASA/U.S. Army programs.

SUMMARY OF RESOURCES REQUIREMENTS:

	1971	1972	1973
Research and technology base.....	$74,109,000	$70,076,000	$90,640,000
Systems and design studies..	5,143,000	8,094,000	7,000,000
Systems and experimental programs.....	20,880,000	31,830,000	65,800,000
Total.....	$100,132,000	$110,000,000	$163,440,000

Distribution of Program Amount by Installation:

Manned Spacecraft Center..	---	---	$100,000
Marshall Space Flight Center.....	$1,299,000	$1,025,000	1,000,000
Jet Propulsion Laboratory.	594,000	1,160,000	1,300,000
Wallops Station.....	---	60,000	150,000
Ames Research Center.....	20,040,000	30,844,000	56,520,000
Flight Research Center....	9,552,000	10,047,000	12,375,000
Langley Research Center...	32,645,000	30,124,000	51,220,000
Lewis Research Center.....	31,049,000	29,941,000	39,350,000
Headquarters.....	4,953,000	6,799,000	1,425,000

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BASIS OF FUND REQUIREMENTS:

Research and Technology Base

	1971	1972	1973
Materials research and technology.....	$4,216,000	$5,800,000	$7,200,000
Structures research and technology.....	3,150,000	3,776,000	8,070,000
Avionics research and technology.....	3,885,000	2,543,000	5,350,000
Propulsion research and technology.....	17,051,000	20,005,000	26,900,000
Aerodynamics research and technology.....	13,702,000	12,922,000	10,170,000
Configuration research and technology.....	23,828,000	18,930,000	25,300,000
Life sciences research and technology.....	2,100,000	3,100,000	3,050,000
Operations research and technology.....	5,277,000	2,100,000	3,700,000
Technical assistance to DOD	900,000	900,000	900,000
Total.....	$74,109,000	$70,076,000	$90,640,000
Materials Research and Technology.....	$4,216,000	$5,800,000	$7,200,000

The ability to predict the onset of fracture and the fatigue life of aircraft structural and propulsion materials is becoming increasingly important as design procedures become more efficient. To achieve these objectives, basic research in FY 1973 will be aimed at developing new methods for determining the stress and strain distributions in the vicinity of flaws and the rate of growth of these flaws when advanced materials are subjected to loads under various environmental conditions, including hot salt stress corrosion, and under various cyclic loading programs.

Fundamental research at Lewis in the area of atomic structure and properties is concerned with relating microscopic and submicroscopic structure to the useful properties of metals, nonmetals and composite materials. Generally speaking it is long-range research and is intended to lead to reproducible high strength materials that will permit the design of safer military aircraft and civil transports. Emphasis today is on strengthening mechanisms of metal alloys, chemical structures of polymers and interfacial properties of composites. This research will be continued in FY 1973.

Long-range continuing disciplinary research at Lewis on materials for the hot sections of jet engines has been very successful in developing strong stable materials for increasingly higher temperatures. Further advances in

this direction now depend as much upon increasing the resistance to high--temperature oxidation as they do upon increasing the mechanical properties. Accordingly, research will be largely concentrated upon the study of oxidation mechanisms under service conditions and upon the development and evaluation of protective coatings for nickel-base alloys, cobalt-base alloys, dispersion-strengthened materials and refractory metals. New fabrication techniques, including processing of metal powders and directional solidification, will be explored to improve properties further and also to allow the use of complex air-cooled configurations. For the low temperature (compressor and fan) end of the engine, research will concentrate upon development of composite materials using graphite, boron or advanced glass fibers.

Improved polymers in the form of non-flammable foams and paints for aircraft insulation and protection have been developed and application studies are continuing. Emphasis in this area will be focused on nontoxic materials. The development of fuel tank sealants will be continued with specific attention to long lifetime elastomers to reduce maintenance costs. Studies on structural adhesives for stronger and safer aircraft will be initiated. Protective plastic coatings for metallic aircraft skins will be investigated.

Composites, because of their advantageous strength-to-weight ratio, are being investigated for numerous potential aircraft applications, such as vanes and blades in jet engines. In the case of polymeric composites both the organic matrix and the reinforcement have been improved for compressor blades. Polymers capable of operating at 600°F have been developed; however, continued study is required to attain the longer life-time and greater stability in the engine environment. Metal matrix composites are being developed for hot structural elements, turbine vanes, buckets and other components subjected to temperatures above 600°F. Effort will be expanded in three areas: matrix materials, reinforcing fibers and the assembled composites. Aluminum, titanium and nickel-alloy matrices will be used for progressively higher temperatures. The corresponding fibers will include carbon, oxides, carbides and refractory metal alloys. The chemical compatibility of various matrix-fiber combinations will be improved and their mechanical behavior will be studied in FY 1973.

	1971	1972	1973
Structures Research and Technology.....	$3,150,000	$3,776,000	$8,070,000

This program is aimed at providing the structures research and technology required to develop superior civil and military aircraft. Increased emphasis will be placed in FY 1973 on efforts supporting development of short haul and long haul civil transportation systems.

The elements of this program encompass high temperature structures technology, studies of the application of composites to structures, structural analysis and design, and structural dynamics. Recent studies have shown that significant potential payoffs may be possible by the introduction of composites in airframes and by the use of active controls to reduce loads and thereby save structural weight. The structures program is largely conducted at Langley.

The development of structures to withstand flight loads in the presence of severe surface heating and internal thermal stresses and still meet weight and lifetime requirements of very high speed transports is extremely challenging. Various structural concepts will be investigated in FY 1973 for application to critical temperature regions associated with cruise Mach numbers of eight or higher. Components embodying promising concepts will be subjected to representative conditions in hypersonic wind tunnels to investigate their capability to withstand surface temperatures of the order of 1100°C (2000°F) with the accompanying severe thermal gradient and stresses.

The composite materials technology investigations will be combined with the development of fabrication techniques. Large scale structures will be designed, built, and tested to evaluate the load carrying capability of such structures.

In the area of structural analysis and design, improvements in analytical capability for predicting the unsteady loads and deflections of wings and control surfaces are anticipated from current activities that are underway. Advanced aeroelastic analyses will be incorporated into the NASTRAN structural analysis program. The NASTRAN program was developed by NASA, and is now being used by engineers in the U.S. representing 13 different industries. Although NASTRAN has broad problem solving capability, the number of recommended improvements or additions to the program appears to be increasing with the number of users. It is planned to incorporate as many of these improvements as possible within the next several years.

A computer program called IPAD (Integrated Program for Aircraft Design) which will consider various disciplines such as performance, aerodynamics, aeroelasticity, structures, and propulsion, and then optimize the vehicle considering economic factors, has been under study for about two years. Development of a simple pilot model will be continued in FY 1973.

A means of realizing efficient solutions for such design problems as flutter, fatigue and gust loads is to reduce the modal response of elastic aircraft wings, fuselage, and tail surfaces. Advanced control systems that include active control surfaces can accomplish such reduction of elastic mode response. Both analytical and wind tunnel work on the effectiveness of leading edge and trailing edge controls to accomplish these structural improvements will continue in FY 1973.

Another program in structural dynamics is concerned with the investigation of fluctuating pressures in laminar, turbulent, and separated boundary layers, and in the region of shock waves on aircraft components. Analytical wind tunnel and flight tests to improve methods for calculating response of structures to these fluctuating pressures will be continued in FY 1973.

	1971	1972	1973
Avionics Research and Technology.....	$3,885,000	$2,543,000	$5,350,000

To evaluate and enhance the applicability of past control theory basic research to practical problems, an effort has been started at Ames to apply modern control theory to the modeling and design of a STOL automatic landing system. Demonstration of this concept as a software change in an airborne digital computer is planned by the end of FY 1973. The complex interactions of advanced aircraft, their avionic systems and the external operating environment require interdisciplinary research activities involving participants with broad technical background. To meet this need a cooperative university grant program in air transportation involving three universities with complementary research capabilities and the Langley Research Center has been recently initiated. The effort will be expanded in FY 1973 and a fourth university will be added.

Future short haul aircraft, particularly the VTOL, will have more complex operating modes (e.g. transition from horizontal to vertical flight) and will require tightly scheduled operations using economical, reliable systems under conditions of high pilot workload due to short flight stage lengths. Automated flight systems are necessary to make these operations practical. A program to develop advanced technology for automated VTOL avionic systems is being initiated at Langley. This effort will develop technology applicable to the unique requirements of VTOL aircraft including low speed airspeed and altitude sensors and control and display techniques for steep descent and takeoff.

Efforts on general aviation avionics will be continued with the objective of improving flight safety and allowing for increased participation of small aircraft in the air traffic control system. A principal effort at Langley is the development of random modulation CW doppler microwave techniques for a cooperative pilot warning system. Earlier efforts showed the feasibility of the technique and the current emphasis is on reducing the cost of the microwave hardware. Flight test of this system is planned to begin in the latter part of FY 1973.

The application of active control technology to advanced supersonic and subsonic/sonic aircraft can provide significant benefits in terms of improved economics and performance, improved ride qualities and more flexible flight path control to alleviate terminal area congestion and noise problems. An active control technology program being initiated at Langley in FY 1972 will be expanded in FY 1973. This program involves efforts to develop design criteria for application, formulate integrated design approaches and verify design procedures for typical advanced aircraft missions with emphasis on advanced supersonic aircraft. Supporting technology efforts in digital computer reliability and reliable inertial systems are key to the achievement of this objective.

	1971	1972	1973
Propulsion Research Technology.....	$17,051,000	$20,005,000	$26,900,000

Research during FY 1973 will continue to develop techniques for improving

the performance of all gas turbine engine components for both civil and military applications. Basic materials development, design theory, analysis and experimentation will be performed for extreme conditions with lubricants, bearings, gears, and seals to achieve efficient performance, reliability, and extended life. Approaches to reduce fan and compressor weight will be investigated. Stage pressure ratios will be increased as well as specific air flow rate. Blading will be tested at higher Mach numbers and higher levels of loading than before. Primary combustor research will establish the technology necessary for combustors having low pollutant emissions and good durability for operation at pressures up to 400 psia and outlet temperatures to 3000°F. A program will be started to study the problems of small annular combustors with air flow rates below ten pounds per second. Basic studies will also be conducted on combustor liner cooling, jet penetration and mixing, fuel injector design, and short diffusors with boundary layer control. Turbine research will include work on the interrelated problems of turbine aerodynamics, cooling, and life. A variety of advanced turbine blade designs will be investigated by Lewis Research Center.

A major research emphasis during FY 1973 will continue to be the reduction of the environmental impacts of aircraft propulsion systems, both noise and exhaust emission pollution. Analytical studies and experiments conducted mostly by Lewis Research Center will seek to establish noise reduction design principles for all major noise generating components including fans, compressors, turbines, and jet exhaust systems. Other work will seek to establish low noise design principles for acoustically treated nacelles. Special problems peculiar to CTOL, STOL, and VTOL aircraft systems will all be investigated.

Techniques for reducing pollutant emissions will be studied by Lewis Research Center in primary combustors and reheat burners. Principal attention during FY 1973 will be given to reducing emissions of nitric oxide at high power settings and carbon monoxide and hydrocarbons at engine idle. The concentrations of various particulates and gaseous pollutants in the atmosphere below 40,000 feet will be measured by sampling devices installed on commercial air transports. Upper atmospheric measurements will be made using a YF-12 or other high altitude aircraft. All measurements will be used to establish atmospheric contamination baseline data and the contribution to atmospheric pollution made by jet aircraft.

High performance variable geometry 2 dimensional and axisymmetric inlets for both military and civil applications will be investigated in wind tunnels. Representative inlets will also be flight tested to determine the effects of the aircraft flow fields on inlet operation. Inlet-nacelle investigations will determine minimum drag configurations for aircraft operating at transonic speeds. Tests to determine the effectiveness of inlet sonic choke for suppressing fan noise particularly for civil applications will be conducted. High performance variable geometry engine exhaust nozzle research will emphasize the interaction between aircraft flow fields and the nozzle. Plug and wedge nozzle configurations will provide information on cooling requirements and performance. Nozzles designed for reduced jet noise will be flight

tested for supersonic transport applications. The Lewis Research Center is responsible for the major portion of the propulsion research activity.

Research during FY 1973 on complete propulsion systems will explore optimum design characteristics for future transports and military aircraft. Systems test programs will be conducted to investigate dynamic interactions among propulsion system components.

The development of the low cost engine technology base will continue at Lewis Research Center during FY 1973. This work is directed primarily to turbojet and turbofan engines in the 500 and 1,000 lbs. thrust class which could be suitable for a wide range of non-recoverable missiles and drones and also to general aviation aircraft. The special problem of achieving high performance in advanced small gas turbine engines will also be investigated.

Advanced propulsion control system technology will be developed to provide optimum system performance throughout the entire operating envelope of high performance supersonic aircraft. A joint NASA/AF research program for an integrated propulsion control system has been initiated during FY 1972. It is estimated that the joint program will be completed during FY 1975.

Efforts are underway to develop the technology for propulsion components and systems meeting STOL application requirements with respect to noise, pollution, and performance, and which minimizes the performance, weight, and cost penalties associated with these requirements. Specific attention will be given during FY 1973 towards determining experimentally, the unsuppressed and suppressed noise and performance characteristics of fans whose design parameters are in the range of applicability for externally blown flap aircraft concepts. Additional efforts on FY 1973 will be directed towards determining the effect of flow distortion due to inlet sonic choking on the aerodynamic performance of fans, and to determine the acoustic performance of wing slot and flap noise reduction techniques, sonic inlets, and fan/sonic inlet systems in the range of applicability for augmentor wing aircraft concepts. Installed performance of these systems during cruise and low speed operations will be determined by wind tunnel tests with small scale engine simulators. The Lewis Research Center has prime responsibility for the STOL propulsion research.

VTOL engine technology investigations include lift engine components, system integration of the engine components, engine installation effects, and engine noise generation and suppression. This work is conducted primarily at the Lewis Research Center and full utilization of the new Vertical Lift Engine Test facility is expected during FY 1973.

Analytical studies supported by limited experimental research will be conducted by Lewis Research Center during FY 1973, to assess the feasibility and safety of operation of nuclear propulsion systems for very large advanced subsonic aircraft and air cushion vehicles. The work will be concentrated on safety, fission-product containment, and integrated aircraft-engine reactor design analysis.

The technical feasibility of advanced future aircraft and their associated propulsion systems will be studied. The comparative merits of alternative engines and promising areas of research will be determined.

The performance model of the Hypersonic Research Engine will be tested during FY 1973 in the Lewis Plum Brook Hypersonic Propulsion facility at Mach numbers of 5, 6, and 7. Tests previously conducted in the Langley hypersonic tunnel with vitiated air at Mach 8 have demonstrated the practicality of hydrogen fuel regeneratively cooled structures. Investigations of components of advanced hypersonic propulsion system concepts which may appreciably reduce cooling requirements of the engine and improve system performance will be continued during FY 1973. The Langley Research Center is responsible for the Hypersonic Research Engine program.

	1971	1972	1973
Aerodynamics Research and Technology.....	$13,702,000	$12,922,000	$10,170,000

Aerodynamic Prediction and Simulation

Increased capability in understanding and predicting complicated aerodynamic phenomena, such as three-dimensional transonic flows, will be pursued in FY 1973 by taking advantage of the cost effectiveness of computer flow simulation. Computational procedures will be developed also at Ames and Langley Research Centers to optimize airfoil and wing-body designs for military and commercial aircraft over the complete speed range. Concurrent experimental studies will be carried out at Ames Research Center to provide empirical inputs to the computational procedures (particularly with respect to viscous effects), to guide and check the validity of the analyses, and to study flows which are too complicated to be handled as yet by the computer. At Langley Research Center, some of the computational and experimental efforts in the coming year will be devoted to determining sonic boom shapes and overpressures in atmospheric and flight conditions conducive to the production of "superbooms" at hypersonic flight speeds and to defining configurations which minimize sonic boom effects.

Experimental investigations of aerodynamic phenomena are often handicapped by the less than perfect flow simulation provided by existing wind tunnels and test procedures. Improved simulation is needed particularly in the high Reynolds number transonic test regime. Critical experiments will be carried out at Ames Research Center and Jet Propulsion Laboratory in FY 1973 to investigate tunnel-induced and test procedure aberrations in the transonic range. At Langley Research Center, new design concepts will be sought to suppress such effects, as well as the influence of the tunnel environment on boundary layer transition at higher flight speeds. In conjunction with research on improved tunnel test and design techniques, advanced procedures for measuring flow quantities, such as the use of Doppler velocimeters, will be pursued.

Flight Mechanics

Programs to predict aircraft dynamic response behavior as a function of atmospheric disturbances and pilot command require increased emphasis in order to provide meaningful design criteria for assuring satisfactory flying and ride qualities in future aircraft. In FY 1973, studies will be made to define improved techniques for calculating dynamic response from static measurements (including effects of structural flexibility, turbulence and flight at or beyond the stall), on factors affecting spin modes including the entry and recovery phases, and on defining more realistic handling qualities criteria for vehicles with control systems that employ a high degree of augmentation. The spin research will be conducted primarily at the Langley Research Center utilizing the spin tunnel and airborne drop-model techniques. In line with such studies, a thorough analysis will also be made of the potential benefits, such as the alleviation of adverse vehicle response during flight in turbulence and at or beyond the stall, from aerodynamic configurations designed to take full advantage of "fly-by-wire" control system technology. The advanced ground simulators, flight vehicles, and specialized wind tunnels equipment necessary to carry out such research will be maintained and updated on a continual basis. The simulator programs will be conducted in ground-base simulators at the Langley and Ames Research Centers and by use of the General Purpose Airborne Simulator at the Flight Research Center.

	1971	1972	1973
Configurations Research and Technology.....	$23,828,000	$18,930,000	$25,300,000

The configurations research and technology program is directed toward integrating aerodynamic and flight mechanics technologies with other disciplinary technologies for application to specific classes of aircraft to provide a sound technical base for future aircraft. The program elements described below are general aviation, STOL aircraft, VTOL aircraft, rotorcraft, transport aircraft, and military aircraft.

General Aviation

General aviation aircraft as a class have suffered from the lack of an integrated aerodynamics and flight dynamics design base. Therefore, the program elements for FY 1973 will include further investigations of configuration aerodynamics and emphasize improving stability, control, and handling qualities as an integral part of the aerodynamics of the configurations to be studied.

Program additions at the Langley Research Center in FY 1973 will include a comprehensive investigation of the stall spin characteristics of the current general aviation airplane. Emphasis will be on the development of design data and techniques that permit reliable prediction of the spin characteristics prior to flight test. Efforts by Wallops Station and Langley Research Center to document piloting and flight procedures in the operational environment will continue during FY 1973 with the concentration being placed on traffic

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patterns and landing approaches at uncontrolled airports. The examination of devices to simplify the piloting task will be continued covering a broad range of systems and components. The Flight Research Center's efforts during FY 1973 will define the minimum levels of system precision and complexity that will permit the marked improvements in handling characteristics already demonstrated. A design guide for the incorporation of aerodynamic spoilers into powered aircraft will be compiled in addition to a flight demonstration of the slot spoiler direct lift control concept by the Langley Research Center. Operational demonstrations of materials and techniques for improving crash survivability will continue with the application of new fire resistant materials to general aviation cockpits.

STOL Aircraft

Flap system configuration details will be investigated parametrically in FY 1973 on static rigs and in small-scale wind tunnels at the Ames Research Center to reduce lift augmentation noise with a minimum sacrifice of performance. The results will be employed in the design of advanced systems to test on large swept wing wind-tunnel models to determine whether the performance and noise optimization is valid in three-dimensional flow in a large-scale configuration representative of a modern STOL transport. Also some small scale tests will be conducted in the Langley Research Center V/STOL Transition Tunnel of novel STOL configuration concepts conceived at the outset with low noise as a goal. Tests will be completed in this facility of four different lift augmentation systems on a common STOL model for direct comparison of aerodynamic characteristics. Research will continue to evaluate the handling and ride qualities of specific STOL concepts configuration designs, as well as the flying characteristics which would be desirable and realistic for operational STOL vehicles utilizing ground-based simulators and appropriate available flight test aircraft. The latter includes an OV-10A aircraft with a high-lift rotating cylinder flap to provide STOL capability, as well as VTOL research aircraft and variable stability helicopters operating in simulated STOL flight conditions.

VTOL Aircraft

Research in this category of aircraft, which excludes rotorcraft, will give primary emphasis to the lift-fan concept. In FY 1973, the interactions of lift-fan inlet and exhaust flows with flight flow, with the ground, and with major aircraft components such as the wing, fuselage, and engine pods will be studied. This will be done parametrically in small scale wind tunnel testing at the Langley Research Center, and will also be included in lift-fan configuration investigations of aerodynamic performance, stability, control, and noise in large scale wind tunnel tests. A complete configuration of a large lift-fan VTOL model will be tested in the Ames 40- by 80-foot wind tunnel. Additional model configuration tests will be governed to some extent by the outcome of three lift-fan aircraft study contracts to be completed in late FY 1972 as described under Systems and Design Studies. These studies will also be the basis for extensive flight simulator investigations of lift-fan vehicle handling qualities characteristics and requirements.

Particular attention will be given to vehicle control systems using blended propulsive and aerodynamic control inputs. Handling qualities research will also continue in flight tests of the XV-5B, X-14B, and X-22 research VTOL aircraft.

Rotorcraft - Recent work on the dynamics of aerodynamic flows on helicopter rotor blades and in the rotor wake is showing real promise for payoff in terms of performance, vibration, and noise. The effort will be extended to investigate how well the knowledge can be applied in rotor blades and control systems. A new high performance rotor test rig will become available in FY 1973 to provide greatly improved rotor test capability in the Ames 40- by 80-foot wind tunnel. Simultaneous measurements will be made of blade local pressure loads and noise. The rotor tests will include one of the type designed for the tilt rotor aircraft concept. Research on rotorcraft handling qualities including improved flight control systems and pilot displays for all weather operation will continue using ground-based simulators and flight test helicopters.

Transport Aircraft - In FY 1973, aerodynamics and flight dynamics problems of existing type aircraft or improved modifications will be investigated in wind tunnels and simulators as required. Primary emphasis, however, will be on advanced aircraft concepts. For subsonic/transonic transports this will include research at the Ames Research Center to reduce wave drag on novel configurations, and interference drag from engine installations. Supersonic transport configuration research at the Ames and Langley Research Centers will investigate, both analytically and experimentally, advanced supersonic transport concepts to improve the aircraft's overall performance and to provide satisfactory low speed stability and control characteristics. Hypersonic transport research at Langley Research Center will examine configuration concepts to exploit favorable interactions between aerodynamics, propulsion and structures using advanced cooling concepts with emphasis on devising reliable performance prediction techniques, on understanding Reynolds number effects, and on integrating the engine and airframe optimally.

Military Aircraft - Beyond assistance on major DOD projects described under the DOD Assistance Program, NASA conducts configuration research of a more general nature in both wind tunnels and flight on a variety of military advanced aircraft (fighters, bombers, and interceptors) and missile concepts (surface-to-air and ground-to-air). Generalized analytical and wind tunnel investigations will continue in FY 1973 in search of improved prediction methods and vehicle configuration concepts for optimized aerodynamic performance of military type vehicles. Flight tests will be conducted of devices to improve transonic maneuvering on a military airplane. A joint United Kingdom/NASA flight, simulator, and wind tunnel program will be continued to evaluate the use of thrust vectoring in improving fighter maneuverability. Control characteristics of advanced fighter aircraft will be investigated in flight using a large scale remotely controlled model launched from a B-52 aircraft.

	1971	1972	1973
Life Sciences Research and Technology.....	$2,100,000	$3,100,000	$3,050,000

The Life Sciences project addresses the effects on man's performance which result from the stresses imposed on him by aeronautical systems.

Comparisons on physiological measurements and task analyses in actual flight and in the laboratory, and correlation of physiological measures with workload in order to establish techniques for measuring performance will be initiated in FY 1973 at the Flight Research Center. At Langley Research Center a project is underway to determine what constitutes hazardous noise. This is a laboratory study which uses various species of animals as subjects to study the effects on the hearing mechanism of noise of various frequencies, intensities and duration. At Ames Research Center, the relationship of desynchronosis to performance degradation will be studied in FY 1973.

Our objective in aircraft noise abatement is to provide information about human reaction to noise which will be helpful in alleviating or abating the aircraft noise problem. We are developing more accurate psychological and sociological techniques for predicting community response to aircraft noise, and developing standards which relate noise annoyance to noise exposure. The effectiveness of the Dynamic Preferential Runway System as a method of noise abatement is being evaluated, and will continue in FY 1973. At Ames, a study will be initiated to determine the factors which shape the reaction of the community to new technology such as STOL.

Concern has been expressed that STOL and VTOL aircraft may lack passenger acceptance because of unusual aircraft attitudes and motions. In FY 1972, a vibration simulator is being constructed at the Langley Research Center for laboratory research in this area. The Flight Research Center is readying a program on the General Purpose Airborne Simulator for inflight studies on STOL ride quality research. Both of these programs will start in FY 1973.

Pilots of future generations of aircraft, particularly STOL and VTOL aircraft, will be faced with a new operating environment. There will be increased automation in aircraft and air traffic control procedures. There will be a demand for more precise flight path control because of noise abatement requirements and increased traffic congestion; and a demand for flying in all types of weather conditions. To assure the proper pilot role in this future aircraft operating environment, new display and control concepts and criteria are being defined, and the pilot procedures using this equipment are being determined.

Analysis of aircraft crashes indicates that the probable causes of fatal crashes include human error in 54% of the cases in commerical accidents and 82% of the cases in general aviation. Studies will be initiated in FY 1973 to analyze accident data banks in order to determine if human errors occur in certain patterns and frequencies. This will tell us how to correct human errors and the required research to be pursued.

Casualties are high in landing and take-off accidents which are survivable, as shown by the fact that others survived the same accidents. Improved seats and emergency procedures and equipment could save many of these lives and we are developing these. Several aircraft have been destroyed or badly damaged on the ground during servicing of high pressure gaseous emergency oxygen systems. Other, safer techniques are available from past NASA work on space life support systems and the feasibility of adapting these to aircraft will be studied.

Flight simulators provide a powerful tool which may be used for pilot training and for research and development across a broad spectrum of aircraft design and life sciences problems. The cost of training and maintaining the proficiency of aviation personnel and of developing, testing and evaluating advanced airborne and ground systems could be greatly reduced by more extensive utilization of simulators, but this will only be possible if simulator realism is enhanced. To date, the test of simulator realism and fidelity has been chiefly subjective. A scientific and technological basis must be developed for objective evaluation of the realism and fidelity of simulation. It is necessary to understand how man perceives various cues, especially those of motion and vision, and how he integrates these cues. This information must be quantified in a form useful for designers of simulators and individuals responsible for checking the fidelity of simulators.

Analytical studies are underway to determine motion requirements for various maneuvers on simulators. At Ames, studies will be initiated in FY 1973 to define requirements for visual landing displays to be used in training simulators. Additional equipment is being developed to carry on these studies especially for visual cue research. Work will also be initiated to define the required simulator characteristics necessary for training STOL aircrews.

	1971	1972	1973
Operations Research and Technology.....	$5,277,000	$2,100,000	$3,700,000

The programs in this research area are divided into four groups: (1) knowledge of atmosphere and its effect on design and operation of aircraft; (2) runway safety and increased capacity; (3) operational safety; and (4) airport air pollution reduction.

Improved designs of aircraft for safer, more economical operations need an increased understanding of basic atmospheric properties and their effect on aircraft. The planned effort covers fundamental measurements of the life cycle and computer modeling of warm fogs; analysis of low level wind data which could affect STOL port operations; measurements of turbulence, both cloud and clear air, that can affect passenger comfort, structural integrity, and military refueling operations; and severe storm hazards such as gusts, hail damage, and lightning induced voltages on sensitive electronic systems.

In FY 1973 emphasis will be placed on problems in runway safety and use which are associated with (1) maintaining adequate control of the aircraft

on the runway after landing touchdown; (2) limitations of the number of take-offs and landings in any given time period. Laboratory and field tests will be used to develop improved braking and control of aircraft on the runway. Various runway surface materials and textures, grooved configurations, flooding conditions, and tire treads will be treated to determine relative merits of each parameter on aircraft braking effectiveness. Various techniques will be developed and evaluated for providing an accurate assessment of runway slipperiness in terms of additional distance required to stop as compared to normal conditions. Efforts to decrease runway occupancy time will be aimed at improving vehicle control during high speed turnoff, anti-skid braking, and improved landing gear systems.

Some of the operational hazards which cause aircraft accidents include clear air turbulence encounters, mechanical failures as typified by inflight jet engine rotor burst, poor visibility measurement, and wake turbulence. NASA is developing an airborne laser radar, which will be flight tested in FY 1973, for remote sensing of clear air turbulence. Laser technology will be explored to provide real-time measurements of visibility to the pilot at points along the landing approach path. In FY 1973, flight tests, model tests, and theoretical studies will be continued to better define trailing vortex formation, persistence, and break-up. This information will be useful in the development of techniques to monitor vortex location and to explore ways to eliminate the adverse effects of aircraft wake turbulence by aerodynamic design. To find ways to reduce hazards associated with jet engine rotor bursts, investigations will be carried out to study the mechanics, energies, and containment of high-speed masses. Use of new high impact resistant material will be tried to deflect rotor fragments from critical parts of the aircraft wing and fuselage.

Means will be sought to lessen the pollutant effects of aircraft jet engines by changes in aircraft ground and flight operating practices. Aircraft noise and sonic boom effects studies will be conducted under carefully controlled conditions to identify and quantify detrimental effects of the overpressure on ground structures and equipment. The information will be useful in future structural designs and in the development of operational procedures to minimize detrimental effects.

	1971	1972	1973
Technical Assistance to DOD Development Programs.....	$900,000	$900,000	$900,000

When requested by a military service, NASA carries out tests in wind tunnels or other ground-based facilities in support of military development projects. During Calendar Year 1970, the most recent year for which complete data are available, NASA received 26 requests for such tests. Over 16,000 hours of test facility time were involved representing some 25% of the total agency wind tunnel time spent on aeronautics.

During the first half of FY 1972, 22 requests for tests have been received, including support of the Air Force F-15, B-1 and AX airplane developments and

the Navy F-14 program. Support of these development efforts will be continued in FY 1973.

Research and Development funds requested in FY 1973 will be utilized to acquire specialized models, such as the radio controlled drop-test models to determine spin characteristics and for support of the specially equipped helicopter from which the models are dropped, for paying for computer time for the various simulators and for wind tunnel data processing; and specialized instrumentation and test gases, such as Freon, used in flutter testing.

Systems and Design Studies

	1971	1972	1973
System Studies.....	$993,000	$1,594,000	$2,200,000
Study and analysis.....	993,000	1,294,000	1,500,000
Air transportation system studies.....	---	300,000	700,000
Experimental Design Studies..	$4,150,000	$6,500,000	$4,800,000
Conventional take off and landing.....	---	---	500,000
Advanced technology experimental fighter study.....	---	---	2,000,000
Lift fan research vehicle..	500,000	1,000,000	500,000
Advanced transport technology systems studies...	3,650,000	2,700,000	1,300,000
Short take off landing system and design study..	---	2,800,000	500,000
Total.....	$5,143,000	$8,094,000	$7,000,000
Systems studies.....	$993,000	$1,594,000	$2,200,000

Study and Analysis

Major objectives in the study and analysis of potential, future aeronautical systems are: (1) Encourage, develop and study promising advanced concepts in aeronautics which meet important national needs or provide new or significant performance improvements. This activity entails the examination and analysis of new ideas for aeronautical missions and systems to yield potential benefits such as lower costs and improved performance for coming aeronautical systems. Representative efforts include the development of aeronautical long range plans in light of promising studies and analyses, the conduct of technology assessments and forecasts in Aeronautics, and the sponsorship of speculative technology symposia to encourage the exchange of creative ideas and concepts. (2) Develop an improved analytical capability to model and conduct parametric, computer-aided analyses of elements of a total transportation system in order to evaluate performance improvements, total system costs, examine safety considerations and potential environmental effects of new systems. This approach would provide guidance for future research and technology program and helps

in identifying key risks and uncertainties in prospective programs. Typical analytical efforts include air vehicle analysis, airport/airways analysis and total transportation system analysis. (3) Conduct studies of future civil air systems incorporating the results of separate aircraft, economic, safety and demand studies and integrating these results into total transportation system investigations including the evaluation of competing ground modes. Benefits of such studies would aid in identifying means of relieving traffic congestion, minimizing the environmental impact of future systems, improved operating economics, enhanced aircraft safety and research and technology program guidance for future civil aircraft systems. Study areas would include future short haul systems, promising long haul systems for the next decade, and general aviation systems. (4) In the area of NASA support of future military air systems, a synthesis capability for studying promising tactical, strategic and logistic military aircraft systems will be developed. Benefits would include the identification of promising future concepts, missions and relevant technology, methods of enhancing mission effectiveness, possible means of reducing military air system costs and provision of advanced study of prototype military aircraft. The focus of study and analysis effort would be on the next generation of advanced fighters, controlled configured aircraft and remote-piloted vehicles.

Air Transportation System Studies

Technology offers opportunities to make the air transportation system more responsive to the needs of the traveller and shipper of goods, while at the same time, less obtrusive upon the general public and more compatible with the aims of environmental improvements.

Programs in the Air Transportation Systems area are directed at seeking data that can facilitate decisions by which technology can be most effectively applied to the solutions of systems problems. These data encompass economic, operational, legal, and socio-political influences on air transportation systems, with a view towards how these factors may shape the NASA technology programs.

Since many of these factors are also of direct concern to the Department of Transportation, the Federal Aviation Administration, and the Civil Aeronautical Board, close coordination with appropriate offices of these agencies is a major activity in this area.

The FY 1973 program activity includes the examination of problems of Low-Density Short Haul Air Transportation Service. The objectives include: (1) Examination of the low density market. The market extends from the "thin" end of existing local service (or the so-called second level) carriers, through the air taxi/commuter market, down to very sparsely populated regions where air service is not now used. An accurate description of this market will help to identify technical objectives which NASA's R&T programs must meet. (2) Examination of the operating environment will identify and define factors which bear upon profitability of operation and which can benefit from new technology. (3) Examination of transportation models.

Using computer modeling, vehicle characteristics can be assumed and used to determine their effects upon the economic viability of a given vehicle transportation scenarios.

	1971	1972	1973
Experimental design studies..	$4,150,000	$6,500,000	$4,800,000

Conventional Take Off and Landing (CTOL)
Mk II Experimental Quiet Engine

The current CTOL Experimental Quiet Engine program has progressed on schedule. The design characteristics for this engine were selected in 1969 and data obtained to date indicates that the original program noise reduction goals will be exceeded. However, the CTOL Experimental Quiet Engine program used an available core gas generator from the TF39/CF-6 engine programs, and some aerothermodynamic design compromises were made to accommodate the existing engine hardware. As a result, the CTOL Experimental Quiet Engine is considerably heavier than an optimum flight weight engine.

Substantial progress has been made in noise reduction technology programs since the initial CTOL Experimental Quiet Engine Design decisions were made. Jet noise correlations have been improved and a firm data base for fan noise prediction has been developed. The feasibility of substantial reduction of the fan noise of the high bypass ratio engine, matched with similar reductions in jet noise, has been demonstrated. The result is that it now appears possible to design an advanced version named the CTOL MkII Experimental Quiet Engine, which will incorporate all the advances in technology and will have a more nearly optimum trade-off between noise reduction and installed weight.

Studies to seek an optimum configuration for this engine are planned for FY 1973 by the Lewis Research Center. These studies will be used as a basis for selection of CTOL MkII Experimental Quiet Engine design characteristics and to develop the necessary program planning information for an experimental engine program.

Advanced Technology Experimental Fighter Study

The Advanced Technology Experimental Fighter Study has resulted from a NASA inter-research center study group convened in mid-1971 to respond to a DOD request for NASA's participation in defining new technology flight programs. The objective of the experimental fighter program study is to investigate the potential of integrating all the new emerging technology into a fighter aircraft design to obtain a vehicle significantly superior to any achieved thus far. For example, supercritical technology shows great promise as does variable wing camber for highly maneuverable fighters but variable wing camber may not be compatible with the supercritical airfoil shape. The proposed program, therefore, builds on the current and planned work, integrating the results of the component flight work into a new advanced vehicle design.

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A team of NASA research personnel is being formed in FY 1972 which will define and conduct the research necessary to fill recognized gaps in the technology. In FY 1973 it is planned to utilize the design capability of industry. Industry involvement is highly important and an integral part of the program plan for two reasons; (1) to provide a focus for the new technology in the industry and (2) to obtain industry design capabilities to validate the potential of the new technology and define technological gaps that need further research. The preliminary design studies to be conducted in FY 1973 would involve several contractors.

Lift-Fan Research Aircraft Design Studies

Three major parallel contracted studies are to be completed in late FY 1972 for the purpose of examining advanced lift-fan VTOL transport vehicles for the 1985 time period, and defining a near-term research airplane program as a major step in developing lift-fan vehicle and propulsion technology. Each contractor is concentrating on a different size and configuration for the research aircraft, with different primary technology problems involved. Further engineering studies will be conducted in FY 1973 on specific vehicle and propulsion installation design problems requiring detailed investigation in regard to the proposed research airplane configurations. Particular emphasis will be on supplying engineering design data for use in NASA simulator investigations of flight characteristics and for establishing the most needed wind tunnel programs to evaluate the research airplane concepts under the Configurations Research and Technology Base program to the degree required for selecting one concept as being most suitable for a future flight research vehicle program.

Advanced Transport Technology Systems Studies

Advanced transport technology systems studies were conducted in FY 1971 and FY 1972 to: study the practical application, to postulated new subsonic/sonic transport designs, of projected advances in the key disciplines of aerodynamics, structures, propulsion, controls and avionics (including air traffic control interfaces); identify the technology advances offering the greatest potential benefits; and define the actions required to bring the advanced technologies to a state of readiness for industry utilization by the late 1970's.

The application of supercritical aerodynamics and related configuration treatment, engine noise and emission suppression techniques, composite structures and the use of active control systems have been shown to result in a quieter, safer, more economical transport having greater productivity than the current wide-body jet transports. The technology programs have been redirected to provide greater concentration, during the next several years, on assurance of technology readiness in these areas of high potential return.

The FY 1971/72 studies also pointed out areas which require additional in-depth study. These areas (e.g., control-configured aircraft, transport configurations designed specifically for minimum noise and traffic congestion relief, and terminal compatibility) will be studied further in FY 1973. These

studies will be conducted to ensure that the indiviuual discipline technology advances are directed toward development of optimum overall transport systems rather than optimization of the air vehicle alone.

Short Take Off and Landing System and Design Study

The objective of this study is to further the appreciation and understanding of short-haul STOL civil transport operations, economics, and implementation needs as they affect the technical aspects of the design, development and operation of STOL transports. In particular, these data will assist in the evaluation of current technical effort and help define future program needs for the development and application of an effective technology base for this class of aircraft. Although this study effort is directed at civil systems, it provides a basis for planning and direction of STOL technology programs which directly support the development of military as well as civil STOL transport systems.

In FY 1972, two interrelated major sets of studies were initiated. One set is directed at the definition and analysis of projected short haul transportation markets to help define the technical, operational, and economic requirements for turbofan propulsive-lift STOL transports. Preliminary design of representative aircraft is included to provide a realistic basis for economic analyses and to relate the developing technology to practical design applications. The other set of studies is directed at the definition of quiet, low polluting turbofan engines for power-augmented lift STOL aircraft. These latter studies serve both to support the aircraft/systems studies and as an aid in developing program plans for the definition and development of a STOL quiet, low polluting turbofan experimental engine program. This activity has been coordinated with the DOT and FAA. The DOT and FAA are supporting studies related generally to STOL markets and STOL systems implementation. Data from these general studies and the vehicle-related NASA studies are being exchanged among the contracting agencies and the contractors to maximize the mutual supportive value of the studies.

FY 1973 funding will support follow-on studies of selected areas of concern identified in the FY 1972 effort. Emphasis in the follow-on studies will be on defining redirection of technology development effort consistent with the results of the design and systems studies.

Systems and Experimental Programs

	1971	1972	1973
Experimental Engine Programs..	$8,054,000	$5,000,000	$12,000,000
CTOL experimental quiet engine.....	8,054,000	5,000,000	1,000,000
STOL experimental quiet engine.....	---	---	2,000,000
JT3D/JT8D engine quieting...	---	---	9,000,000
Flight Experiments Program....	$9,176,000	$9,200,000	$12,700,000
C-8 augmentor wing research aircraft.....	2,971,000	2,200,000	1,500,000
F-8 transport technology flight research.....	780,000	1,000,000	2,500,000
YF-12 research aircraft technology program.....	4,900,000	2,900,000	4,700,000
F-111 TACT (transonic aircraft technology).....	---	100,000	200,000
Fly-by-wire.....	525,000	1,000,000	1,700,000
Composite structures flight experiment.....	---	2,000,000	2,100,000
Research/Experiments Vehicle Program.....	$1,150,000	$13,340,000	$30,500,000
Rotor test vehicle research aircraft.....	---	740,000	1,500,000
Tilt rotor research aircraft	---	400,000	1,500,000
Quiet experimental STOL aircraft (QUESTOL).....	1,150,000	12,200,000	27,500,000
Operating Systems Experiments Program.....	$2,500,000	$4,290,000	$10,600,000
Noise reduction flight procedures experiment.....	---	300,000	3,400,000
Terminal configured vehicle operations experiments....	---	400,000	4,200,000
V/TOL operating systems experiments.....	---	300,000	500,000
STOL operating system experiments.....	2,500,000	3,290,000	2,500,000
Total.....	$20,880,000	$31,830,000	$65,800,000

Experimental Engine Programs

	1971	1972	1973
Conventional Take Off and Landing (CTOL) Experimental Quiet Engine.....	$8,054,000	$5,000,000	$1,000,000

The CTOL Experimental Quiet Engine project which was started in FY 1969 is progressing on schedule. Acoustic and aerodynamic testing of the three full scale fans in the program have been completed. The first engine, utilizing one of the low speed fans, was tested in a series of acoustic configurations. Acoustic data from both the fan component and full scale engine testing were as anticipated or better. The first Experimental Quiet Engine tests were conducted at the contractors facility during FY 1972. The measured engine noise levels show that the original program goals of noise levels 15 to 20 perceived noise decibels below B-707 and DC-8 aircraft levels will be more than achieved. The noise levels measured during the Experimental Quiet Engine tests are 10 to 15 EPNdB below certification levels for new aircraft.

The CTOL Experimental Quiet Engine test program will be completed in FY 1973 and will include several acoustic modifications of the engine, including the use of a high speed fan. The first Experimental Quiet Engine has been delivered to Lewis Research Center for additional testing. The engine will be mated with an acoustically treated nacelle specifically designed for the Experimental Quiet Engine. Tests on this complete system will begin during the fourth quarter of FY 1972.

	1971	1972	1973
Short Take Off and Landing Experimental Quiet Clean Engine.....	---	---	$2,000,000

The Short Takeoff and Landing (STOL) Experimental Quiet Clean Engine program which is a new program starting in FY 1973, will develop and demonstrate the technology for quiet, clean STOL propulsion. STOL operations near city centers require very low noise and exhaust emission pollution levels in order to be acceptable to the communities near STOL ports. In order to achieve short takeoff and landing performance it is necessary to use propulsion systems to augment the wing lift. These requirements result in engine characteristics different from those used on conventional aircraft.

The goal of the STOL Experimental Quiet Clean Engine program is to demonstrate noise levels of 95 EPNdB at 500 feet. This noise level is much quieter than the quietest engines currently in civil operations and quieter than the current CTOL Experimental Quiet Engine.

Engine design studies are currently underway with the object of defining optimum design characteristics for clean, quiet propulsion systems which meet stringent operational requirements with minimum adverse performance

impact. Following the completion of these design studies an experimental engine program will be initiated in late FY 1973. The experimental engine program will require about three years to complete and will culminate in a series of design evaluation and confirmation tests of experimental engine configurations. The Lewis Research Center will be responsible for the management of the STOL Experimental Quiet Clean Engine program. This program will be a FY 1973 new start.

	1971	1972	1973
JT3D & JT8D Engine Noise Reduction	---	---	$9,000,000

NASA and industry studies indicate that noise reductions of from 10 to 15 EPNdB in the current first generation jet transport aircraft fleet powered by JT3D and JT8D engines can be achieved through design modifications to the engines and the use of acoustically treated nacelles. Retrofitting these changes to existing aircraft would permit them to meet or better current federal noise standards for new aircraft. In a program coordinated with the DOT, NASA plans to initiate an experimental investigation of design changes to these engines and demonstrate certifiable, retrofittable modifications to aircraft currently in service. Concurrently, the DOT plans to initiate companion quiet nacelle development programs for these engines.

Engine modifications will be based on the use of higher bypass ratio, and quieter single stage fans. Development and demonstration of the modified quieted engines in new acoustically treated nacelles would be completed in FY 1975. Management of the NASA program will be the responsibility of the Lewis Research Center.

The JT3D and JT8D Engine Noise Reduction program will be a FY 1973 new start.

Flight Experiments Program

	1971	1972	1973
C-8 Augmentor Wing Research Aircraft.....	$2,971,000	$2,200,000	$1,500,000

The C-8 Jet Augmentor Wing Research Aircraft program is focused on providing proof-of-concept of the jet augmentor wing approach. The concept uses highly effective internally-blown jet augmentor wing flaps to provide the additional lift required for STOL transport aircraft. The joint program with the Canadian Department of Industry, Trade, and Commerce (DITC) was initiated in FY 1971 to modify a NASA C-8 propeller driven aircraft into an augmentor wing jet STOL vehicle. DeHavilland of Canada and Rolls-Royce of England, under contract to DITC, are providing the propulsion

package consisting of two modified split-flow turbofan engines. The Boeing Company, under contract to NASA, is modifying the wing and fuselage and incorporating the new propulsion package. The flight research program, scheduled to begin in late FY 1972 at the Ames Research Center following contractor checkout tests, consists of two major phases. The first, scheduled to be mostly completed in FY 1973, is a proof-of-concept investigation to evaluate the augmentor wing basic aerodynamics (providing a comparison with predictions based on previously obtained wind tunnel results); to document take-off and landing distances, climbout and descent capability, and noise characteristics; and to define the safe operational boundaries and procedures for the aircraft. Tasks will be defined that emphasize the unique operational characteristics of the airplane in each mode of the complete operational speed range. In addition to flight information obtained from an advanced onboard data acquisition system, pilot comments will be obtained on the aircraft flying characteristics including workload. For the second phase of the flight research program, the longitudinal control system of the aircraft will be modified to provide capability for conducting a variety of STOL research experiments. These detailed and intensive flight experiments are geared to establishing a data base for use in developing design and certification criteria, and operational procedures for turbofan STOL transports with emphasis on handling qualities and the critical terminal area phase of operation. Based on extensive ground-based simulation investigations of the aircraft carried out in FY 1971 and FY 1972, the research vehicle is expected to enable flight investigations at speeds as low as 60-65 knots and at descent angles as high as 12° providing a jet STOL capability for 1,500-foot field lengths.

	1971	1972	1973
Transport Technology (F-8) Flight Research.....	$780,000	$1,000,000	$2,500,000

Transport technology flight research evaluates the performance and operational characteristics of new technology in a true flight environment to provide the required confidence level necessary to permit early use of these concepts in practical air transport design.

A program is being conducted for flight verification of the supercritical wing. A high speed supercritical wing has been constructed on a TF-8A airplane. Over 25 flights have been conducted thus far in which performance, pressure distributions, stability and control, buffet and flutter have been investigated. Flight tests will continue in FY 1973 with the fuselage modified to contain side fairings designed to minimize drag. The results of these flights have been very encouraging and continue to indicate the importance of supercritical technology as one of the key technical advances for the next generation of air transports.

The need for a follow-on to this program is being studied. The design of any required follow-on experimental airplane or airplane modifications will be initiated in FY 1973.

Transport technology flight research also encompasses technology flight demonstrations directed at providing long life tests to insure reliability prior to operational commitment. The approach used consists of providing test exposure of functional operating components that are not critical to aircraft safety to gain service experience.

Demonstration tests initiated in FY 1972 will continue in FY 1973 and subsequent years. Examples of such tests include evaluation of FAA certified composite material spoilers for long-life utilization under actual operating conditions, and service life evaluation of acoustically-treated composite material engine nacelles.

	1971	1972	1973
YF-12 Research Aircraft Technology Program.....	$4,900,000	$2,900,000	$4,700,000

The joint USAF/NASA YF-12 Research and Development Program which began in 1969, consists of two phases. The USAF phase, already completed, was oriented toward defining tactical performance and support requirements of an advanced interceptor. The NASA phase uses YF-12 aircraft to investigate prediction techniques and problems of supersonic aircraft in regard to structures, propulsion systems, and aerodynamics in support of long range objectives for supersonic U.S. long-haul aircraft as well as for the development of advanced supersonic military vehicles. The flight portion of the structures program was completed in FY 1972.

Predictability of steady-state supersonic inlet performance, inlet flow dynamics, and interactions, of engine, inlet, and aircraft control systems is a major problem to be evaluated on YF-12 aircraft in FY 1973. The YF-12 inlet system, probably the most sophisticated on any aircraft, provides an opportunity to vary the important inlet parameters over a wide range of operation. The steady state performance characteristics of the air induction system will be determined in flight at Flight Research Center and compared to wing tunnel scale model results from Ames Research Center. Full-scale testing of a complete inlet system in the wind tunnel is also planned at Lewis Research Center. These wind tunnel data are very important not only for propulsion system performance but also for other aerodynamic research.

Mutual interactions of the YF-12 propulsion system and aircraft as the result of aircraft maneuvers, atmospheric turbulence, unsymmetrical inflow to the inlet, inlet geometry variations, externally rejected inlet airflows, and unstarts will be evaluated at the Flight Research Center. These data

will be compared to results obtained in the wind tunnel on a scale model at the Ames Research Center as well as applied to a synthesized dynamic digital inlet/engine simulation program at the Lewis Research Center.

The aerodynamics program at the Langley Research Center will provide precise laboratory measurement at supersonic speeds of a variety of parameters in boundary layer development, and these data will be analyzed and correlated with those of flight tests at the Flight Research Center on the identical test body with a view to providing a better analytical representation of the physics of the supersonic boundary layer process. In another program at the Flight Research Center, the drag of aft-facing steps will be measured to aid in the specification of fabrication tolerances for supersonic aircraft. The conditions for these tests will be that the aft-facing steps will be submerged in a thick boundary layer at M=3.

	1971	1972	1973
F-111 TACT (Transonic Aircraft Technology).....	---	$100,000	$200,000

There are various ways in which supercritical technology, developed through NASA research, can be utilized, i.e., (1) Thin Applications - to increase aerodynamic performance at higher subsonic speeds, useful for improved transport aircraft; (2) Thick Applications - to reduce wing weight and increase internal wing volume, useful for military and civil aircraft; and (3) Variable Sweep Fighter Aircraft - to improve maneuverability at transonic speeds. The "thin applications" is currently being flight tested in a NASA research program on a TF-8A airplane which was made available to NASA by the Navy. The "thick application" has been flight tested in a joint Navy/NASA program during CY 1971. In both the "thin" and "thick application" programs, the test results to date have shown the supercritical technology to provide the performance advancement as estimated from model test results and analyses. Application of supercritical technology to improve the maneuvering performance of fighter aircraft has been under study by NASA and the Air Force both analytically and experimentally in wind tunnels. The supercritical airfoil shows promise of increasing the lift that can be obtained at transonic speeds before buffet is encountered without any detrimental effects at supersonic speeds. Based on the work of the last few years, the USAF and NASA on June 16, 1971, consummated an agreement for a joint USAF/NASA program for the procurement and flight test of a supercritical wing on an F-111 aircraft. The results of the USAF/NASA program will have direct tactical application for the Air Force by providing the basis for determining the value of incorporating major new knowledge in supercritical airfoil technology on highly maneuverable advanced combat aircraft. The Air Force is managing the program, providing the funds and contracting for the design, fabrication and installation on an F-111 aircraft. NASA

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is responsible for conducting the necessary wind tunnel tests and technical consultation. In FY 1973 the modified aircraft will be ready for flight test and NASA will have technical and operational responsibility for the flight test phase through its Flight Research Center. NASA's R&D funding responsibility in this program is primarily for special research instrumentation.

	1971	1972	1973
Fly-By-Wire Experimental Program.....	$525,000	$1,000,000	$1,700,000

Incorporation of advanced flight control concepts in the initial aircraft design phases could yield gross weight savings of up to 20% for future aircraft through relaxation of inherent aerodynamic stability requirements and through reduction and control of aeroelastic loads. These weight savings would produce major performance improvements and significantly decrease operative costs. For example, studies of advanced transport configurations have indicated that direct operative costs could be decreased by 5-10% if sufficiently reliable and efficient flight control systems can be built and demonstrated.

NASA efforts in this field center on the development of digital fly-by-wire technology which can provide the flexibility and self-checking capability needed for practical implementation of such systems. Digital fly-by-wire systems would replace the conventional mechanical linkages between the pilot's control stick and the control surface actuators with electronic signals processed by an onboard digital computer. This technology, although used on Apollo and limited military helicopter missions, is as yet unproven in aircraft applications. An experimental program has therefore been undertaken to generate the design base for reliable and cost-effective digital flight control systems.

The initial phase of this program directed by Flight Research Center, will establish the feasibility of a single-channel digital fly-by-wire system using modified Apollo equipment installed in an F8C aircraft. Flight tests of this system will begin in late FY 1972 and will continue into FY 1973. Based on successful completion of these tests, Langley and Flight Research Centers follow-on efforts in FY 1973 will concentrate on the design, development, and flight evaluation of reliable, multipurpose flight computers suitable for aircraft use and on research analysis, and on simulation leading to the development and flight verification of a multichannel, redundant digital flight control system by FY 1976. Results of this work will yield the technology base essential to early commercial and military use of advanced flight controls.

	1971	1972	1973
Composite Structures Flight Experiment.....	---	$2,000,000	$2,100,000

The objective is to demonstrate the performance and reliability of primary aircraft structures utilizing advanced composite materials.

Composite primary structures have the potential of significant weight savings and increased fatigue resistance over conventional metal aircraft structures. Full-scale applications to operational aircraft need to be demonstrated to establish the confidence necessary for design commitments to these advanced structures. These applications will be made in typical aircraft by incorporation of composites in critical structural components. Data will be collected during limited flight tests followed by routine service operations. Initial effort is underway with the CH-54 helicopter and the C-130 airplane. Applications to other aircraft are under study, and additional specific aircraft programs will be defined for initiation in FY 1974 and subsequent years.

Since the aircraft involved are controlled and operated by DOD or other agencies, specific cooperative arrangements are necessary. In the case of the CH-54 and C-130, arrangements have been made for the DOD to provide the aircraft for modification and to assist in data collection and inspection following return of the aircraft to service operation. The composite structures incorporated in DOD aircraft will demonstrate their suitability for civil aircraft as well as for military aircraft.

The CH-54 tail cone and tail skid modifications have been completed and operational tests are underway and are scheduled for completion during FY 1973.

The C-130 center wing box modification design is scheduled for completion during FY 1973, with fabrication scheduled for completion in FY 1974. It is expected that the operational test phase will extend into FY 1976.

Research/Experimental Vehicle Program

	1971	1972	1973
Rotor Systems Test Vehicle Research Aircraft.....	---	$740,000	$1,500,000

The rotor as exemplified by the helicopter with its low downwash velocity, is the only efficient means of fulfilling civil requirements and accomplishing military missions where any significant hover capability is required. However, currently operating rotor systems are prone to excessive vibration

and thus short fatigue life, they are noisy, and are relatively low speed. Within the ongoing VTOL research and technology program several rotor-system advances are emerging which offer promise for substantial improvements in helicopter high-speed performance, vibration and dynamics, stability and control, handling and ride qualities, and noise. However, there are serious limitations with the techniques now available within Governmental agencies for testing and evaluating many of the advanced rotor-system concepts to the point where they can be confidently incorporated into the design of operational vehicles. Contract studies were initiated in FY 1972 to determine the feasibility of providing a rotor test vehicle which would enable the operation of various test rotor systems in flight under closely controlled operating conditions with adequate provision to measure the characteristics in both level flight and maneuvers. Detailed design and fabrication of the vehicle will be initiated early in FY 1973, leading to initial research flight tests by FY 1975. The Rotor Systems Research Aircraft will be a FY 1973 new start and is a joint NASA/Army program conducted through the Langley Research Center. The costs will be shared equally by NASA and the Army, as stated in a NASA-Army agreement signed on November 1, 1971.

	1971	1972	1973
Tilt Rotor Research Aircraft.....	---	$400,000	$1,500,000

Extensive NASA research conducted since the early 1960's show considerable promise for the tilt rotor concept for both military and commercial applications--offering the potential of low noise, higher cruise speeds and more efficient cruise flight compared to conventional helicopters; ease of converting between the cruise and landing or take-off configuration; and safety through its autorotation capability in case of power failure. Based upon these factors, two contracted studies were initiated early in FY 1972 to assist in defining the course of future tilt-rotor research centered around a research aircraft. The objective of the research aircraft is to prove in flight tests the overall technical and operational feasibility of tilt V/STOL aircraft designed for cruise speeds up to about 350 knots.

The research aircraft will be a new start in FY 1973 and is a joint NASA/Army program conducted through the Ames Research Center. Detailed design of some of the vehicle supporting systems will begin late in FY 1972, with fabrication and development of the vehicle beginning in FY 1973 to achieve initial flight tests by FY 1975. The costs of the program will be shared equally by the Army and NASA as stated in a NASA/Army agreement signed on November 1, 1971.

	1971	1972	1973
Quiet Experimental STOL Transport Research Airplane (QUESTOL).....	$1,150,000	$12,200,000	$27,500,000

The objective of this program is to provide the technology required for the development of transport aircraft, with quiet propulsion, capable of steep ascent and descent and short takeoff and landing operations by means of power-augmented lift. This technology is an essential key to community noise reduction, airport congestion relief, and the creation of an environmentally acceptable short-haul air transportation system to meet the pressing need for improved transportation service. For the military, it is an important basis for improvement of tactical airlift.

The urgency of the need, and the progress in technical development, have led to planned intensification of the effort through flight research to assure technology readiness for the successful development of improved civil and military STOL transports.

The Phase I competitive design contracts are under way in FY 1972; these design studies will produce Phase II proposals for fabrication of two quiet experimental STOL jet transport research airplanes for use by NASA in conducting flight research essential to development of propulsive-lift technology. Final design and the start of fabrication are planned for FY 1973. Flight testing is planned for the FY 1974-76 time period.

The experimental airplanes will function as a versatile research facility with which NASA can generate technical data obtainable only through flight research. Information relative to flying qualities and airworthiness criteria, noise and environmental effects, terminal operations, runway requirements, safety margins, and the relationship of the aircraft to other elements of the transportation system will be obtained. The flight testing will demonstrate and verify advanced STOL concepts for terminal navigation and flight path control procedures as well as the operational characteristics of the vehicle. This information will reduce the technical risk associated with industrial development of both civil and military STOL transports. Equally important, it will provide an essential technical foundation on which the Government regulatory agencies can establish realistic criteria for certification of commercial subsonic STOL transport aircraft and for enroute and terminal area operations.

The two aircraft will be built initially in the externally-blown-flap configuration, with design provisions for subsequent conversion to other promising powered-lift concepts such as the augmentor wing and the internally-blown jet flap. The experimental aircraft will utilize modified

existing engines, acoustically treated to provide an acceptably quiet base for STOL noise investigations. A parallel quiet STOL experimental engine program being planned by NASA will develop the data which will enable the engine manufacturers to incorporate equivalent quieting provisions in the efficient, low pollutant, economical engines required for operational transports.

The program is closely coordinated with FAA, DOT and DOD. The flight research program constitutes an extension of current NASA/FAA joint programs (handling qualities simulation research for establishment of certification criteria, and integrated STOL avionics research). The experimental flight program represents an advanced phase of powered-lift technology development preceded by considerable NASA and Air Force laboratory and study activity. Together with the nearer term technology being pursued in the projected Air Force prototype STOL transport program, the advanced technology program will provide a flexible range of options for military STOL transport development decisions.

Analytical and wind tunnel studies of turbofan powered-lift concepts will be continued in FY 1973, together with investigations on STOL-related problems of flight control, ride qualities, noise and propulsion. Emphasis will be on externally-blown flap, internally-blown flap, and augmentor wing concepts initiated in FY 1971 and FY 1972 in preparation for the experimental airplane program.

The FY 1973 funding request provides for initiation of Phase II for final design, development, and fabrication of the two experimental STOL transport research airplanes, and for continuation of supporting technology effort in ground-based facilities and related analytical work.

Operating Systems Experiments Programs

	1971	1972	1973
Noise Reduction Flight Procedures Experiments.....	---	$300,000	$3,400,000

Experiments will be conducted for reducing the noise impinging on the sensitive neighborhoods around the airport by not only finding solutions which permit quieter approach and take-off flight paths and techniques but also finding ways to implement them. The research activity in this area will provide some near-term relief of jet transport noise by providing the technology for flying noise abatement paths with a system which is practical for existing fleet-wide implementation and which is operationally feasible under typical scheduled airline conditions. A limited flight program has demonstrated that two-segment noise abatement landing approaches

are safe, easy to fly, do not add substantially to the pilot workload, and give substantial noise reduction provided the pilot is given the proper guidance information. The technology is available. Nevertheless, there remain two problems which require resolution before this technique is considered practical for implementation: (a) selling the line pilot on the suitability of three-dimensional, area navigation flight procedures as a means of flying two-segment noise abatement procedures and (b) demonstrating to major airlines that the avionics modifications are practical for fleet-wide implementation and are useful for other applications as well as noise abatement NASA and FAA are planning a cooperative program to accomplish these objectives. Since the use of modified flight operational procedures holds out the potential in the very near term of substantial relief for the airport neighbors from jet aircraft noise, greatly increased emphasis will be given in FY 1973 to equipping several types of existing air carrier fleet aircraft for the two-segment approaches and conducting indoctrination flights with the major airlines, groups of their pilots, and management under a variety of weather conditions. It involves the costly leasing of current operational aircraft from several airlines. Emphasis will be placed on the 737's, DC-9's, 727's, DC-8's and 707 aircraft. The Ames Research Center is in the process of formulating a flight program with the airlines and defining the implementation steps. A longer term program, providing further noise abatement but not considered practical for use in existing aircraft, would be applicable to the next generation aircraft. NASA will conduct technology demonstrations of the airborne capability to take advantage of the new instrument landing system which is being developed by the FAA which will provide guidance information needed for curved, steep and decelerating noise abatement approaches. This advanced avionics and display system for use in advanced aircraft will include automatic operation of lift/drag/thrust devices and trim compensation, electronic altitude director and horizontal situation indicators, and automatic path control for curved, steep approaches.

	1971	1972	1973
Terminal Configured Vehicles Operations Experiments.....	---	$400,000	$4,200,000

This activity encompasses the aeronautical aspects of advanced Air Traffic Control (ATC) and is a companion to the FAA ATC automation program. Between 1975 and 1980, the upgraded third-generation air traffic control system with its computer assisted metering and sequencing, microwave landing guidance system, and other improvements will have been deployed operationally. From that time it is felt that the ATC capability for directing high flow rates will exceed that of the aircraft to comply safely in IFR conditions unless steps are taken to make aircraft responsive to the advanced form and precision requirements of the ATC commands. In the future air traffic control system aircraft may be

required to fly steep or curved vertical profiles for noise abatement, curved ground tracks for noise abatement and for air space efficiency, and maintain arrival at the runway threshold in order to maximize runway capacity. Specifically, this program would provide control systems research and development; cockpit, avionics, and display R&D; and flight tests to optimize the aircraft configuration for its performance in the advanced air traffic control environment. A systems approach to this problem is necessary since all elements in the terminal area must be studied in relation to each other and to their environment. A closer integration of the airplane's structural, aerodynamic, and propulsion systems with the control and guidance system must be achieved to insure that the vehicle dynamics, maneuver rate, and airspeed regulation will place as few limitations as possible on trajectories which the air traffic control system may specify. This program was initiated in FY 1972 and has consisted only of development of computer simulation using mathematical models of system elements in order to provide tools to define relations between ATC system parameters and a number of aircraft dependent aspects of guidance and control which impose constraints on the flight paths and rates of change of flight speeds and directions which are practically achievable. In FY 1973, concept formulation and system definition of the aeronautical system will be initiated. Simulation will be used to determine the impact of advanced air traffic systems on aeronautical and avionic systems technology requirements. Flight tests for verification of simulation results will be started on elements of the system using advanced avionics adapted from other programs such as the fly-by-wire program, the integrated avionics system for STOL aircraft and the active control technology program. This work will establish aircraft characteristics and operational requirements to optimize airport traffic flow rates within the constraints of safety, passenger comfort, pilot workload, community noise and engine emission, and minimum fuel and time expenditure. The program will ultimately provide the proven technology, which will be demonstrated in a flight program to ensure that the next generation transport aircraft will be competitively superior in the world's aircraft market.

	1971	1972	1973
VTOL Operating Systems Experiments.....	---	$300,000	$500,000

This program provides technology and operating data peculiar to VTOL aircraft operating in an air traffic control environment. Emphasis will be placed on decreasing the weather dependence of the VTOL air transportation system by the development and technology demonstration of automatic take-off and landing systems for VTOL aircraft in adverse weather conditions. The development of an automatic approach and landing capability is needed especially for VTOL aircraft for managing

powered lift in order to minimize fuel consumption and pilot workload on IFR approaches. These aircraft will be required to fly extremely accurate flight paths in order to achieve the potential promised by a VTOL air transportation system.

	1971	1972	1973
STOL Operating Systems Experiment.....	$2,500,000	$3,290,000	$2,500,000

The objectives of this program are to decrease air traffic system congestion and increase the safety of terminal area operations by providing proven STOL technology options by 1976 in the area of navigation, guidance, flight control, and operational procedures on which logical decisions can be based for transportation systems in the 1980's. This effort will provide engineering and operational procedures data peculiar to STOL which are needed to prepare a short haul air transportation system plan. STOL aircraft have characteristics which will deliver the air passenger much closer to where he actually wants to go, require less real estate for runways, will permit reduction of noise nuisance because they will readily follow a much steeper glide path, will unload runways at major hub airports, and provide better and safer utilization of airspace. In the STOL operating experiments program, the DOT and NASA have joined together in a program to develop and conduct flight experiments with advanced navigation, guidance, and control concepts, and experimental hardware and software which can make all-weather STOL operations technically feasible and which will take full advantage of STOL vehicle performance. This technology and operating procedures will be available to make the short haul air transportation concept attractive to the user, the operator, and the investor.

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RESEARCH AND DEVELOPMENT

FISCAL YEAR 1973 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

SPACE RESEARCH AND TECHNOLOGY PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1971	1972	1973
Research and technology base.....	$96,015,000	$65,999,000	$53,485,000
Systems and design studies.....	2,027,000	706,000	1,000,000
Systems and experimental programs..	6,962,000	8,400,000	10,275,000
Total.....	$105,004,000	$75,105,000	$64,760,000

HIGHLIGHTS OF BUDGET PLAN

	1971	1972	1973
Research and Technology Base.....	$96,015,000	$65,999,000	$53,485,000
Materials - Basic and applied research studies aimed at increasing the long life performance and reliability of materials in the space environment.....	11,900,000	8,686,000	7,000,000
Structures - Development of advanced structural concepts and structural dynamics technology, including thermal protection system and deployable space structures.....	12,305,000	9,003,000	5,500,000
Propulsion - Liquid and solid chemical rocket and electric propulsion technology advancements....	18,817,000	14,000,000	9,225,000
Power - Advancements in solar array, battery, fuel cell and power processing technology.....	9,399,000	7,529,000	7,500,000

	1971	1972	1973
Entry - Aerothermodynamic and thermal protection system effort for solution to the problems of high-speed entry and flight of spacecraft in atmospheres of Earth and other planets.....	$8,409,000	$8,301,000	$7,700,000
Guidance, Control and Information Processing - Development and evaluation effort in the areas of precise guidance and control of space vehicles and experiments; storage and processing of data; high data rate information transfer; imaging and measuring; and reliable, long-life electronic components and systems.....	17,527,000	14,780,000	13,660,000
Safety - Safety research in aeronautics, space, and nuclear flight and oxidizer systems plus a safety data bank to serve many users.....	1,858,000	1,700,000	1,900,000
Civil Technology Assistance - Uses NASA capability to assist in the solution of public sector problems.	---	2,000,000	1,000,000
Life Sciences - FY 1972 and 1973 effort funded under Space Flight Operations.....	15,800,000	---	---
Systems and Design Studies - Analysis and study to identify technology requirements for focusing technology programs and identification of new areas of opportunity.	$2,027,000	$706,000	$1,000,000
Systems and Experimental Programs..	$6,962,000	$8,400,000	$10,275,000
Flight Experiment Programs.....	$1,200,000	$1,500,000	$3,700,000
Synchronous Laser Communications Experiment - Develop and flight test laser systems as optical communications link between earth and synchronous satellite.....	---	800,000	3,000,000

	1971	1972	1973
Lifting Body Flight Tests - Support of manned flight tests or research vehicles designed to investigate the performance, stability and control, and handling qualities through supersonic, transonic, and subsonic flight regimes for entry spacecraft.....	$1,200,000	$700,000	$700,000
Spacecraft/Payload Programs.....	$3,003,000	$3,200,000	$2,975,000
Electric Auxiliary Propulsion - Ion thrusters, pulsed plasma thrusters, and biowaste resistojets.....	1,703,000	1,400,000	475,000
Space Storable Propulsion Module - Demonstration of a FLOX/Monomethyl Hydrazine propulsion module with 10 year in-space life.....	1,300,000	1,800,000	2,500,000
Transportation Programs.....	$2,759,000	$3,700,000	$3,600,000
Reusable Oxygen/Hydrogen Space Propulsion System - Demonstration of a high performance Oxygen/Hydrogen propulsion system for the Tug-class..	800,000	1,300,000	1,500,000
Solid Rocket Motors - Restartable solid motor, low acceleration solid motor and low cost sounding rocket motor.....	1,101,000	1,300,000	800,000
Solar Electric Propulsion - Solar array-powered ion engine system for spacecraft primary propulsion.....	858,000	1,100,000	1,300,000

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1973 ESTIMATES

AERONAUTICS AND SPACE TECHNOLOGY

SPACE RESEARCH AND TECHNOLOGY PROGRAM

FLIGHT SCHEDULE

PROJECT	MISSION	YEAR
Materials Research and Technology	Meteoroid Technology Satellite	1972

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

SPACE RESEARCH AND TECHNOLOGY PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

Space Research and Technology program goals are designed to build a technology base which will adequately support space activities of the future. Such technology work must be accomplished years ahead of project development and operations, the time span depending on the complexity of the new technological approaches.

One major area of technology investigations involves a series of technology investigations which support advanced earth orbit systems. Advanced monitoring systems for observing the earth have great potential value for determining mineral resources, evaluating and managing crops and forests, detecting agricultural diseases, and studying routes for roads and locations for dams, in addition to the already established weather monitoring systems operating from space. Another field of great but only partially developed practical benefit is that of communications. Advanced earth orbit systems, operating above the light filtering and diffusion/diffraction effects of the earth's atmosphere, offer greatly enhanced astronomical observations, which portend a greater understanding of the fundamental science of the universe.

Essential to future operational space systems is the development of versatile and economical transportation to and in space, and of long-lived space observatories and laboratories. During the past three years, a highly focused effort has produced a base of technology adequate for development of the space shuttle. In FY 1973, as the shuttle enters its development phase, a vigorous program of technology support will continue. The FY 1973 program will extend technology efforts on long-lived equipment, particularly power sources, for space laboratories, both unmanned and manned. Such work will be augmented by space experiments to confirm the validity of our new technological approaches in the operational environment or to investigate space phenomena, such as zero-g effects, which must be adequately duplicated in earth facilities.

Exploration of distant planets requires significant improvements in several technical areas: high energy space transportation capabilities; planetary entry and landing system technology; and communications capabilities, particularly power and antenna pointing accuracy. Because light waves can carry several orders of magnitude more information at a given power level than can radio waves, laser communication methods are being investigated. Because roundtrip communications times to outer planets are several hours, effective exploration demands a higher degree of automation and decision making capability, often called artificial intelligence,

incorporated into the planetary sampling and rover systems. Such automation, coupled with robot-type operators, is being examined.

The FY 1973 program will continue efforts to define specific public sector problems to which space technology can be applied, to develop conceptual solutions, and to demonstrate the feasibility of selected concepts.

In addition to technology development for the missions mentioned above, NASA will continue conducting research and developing technology for new capabilities and missions which are not presently amenable to definition.

NASA will employ its FY 1973 funds on a balanced mix of research and technology base work, systems and design studies, and the continuation of a systems and experimental programs designed to verify the application of new technology. No new starts or program additions are included in the FY 1973 budget.

The FY 1973 program can be summarized in the following principal categories:

Research and Technology Base

The Research and Technology Base project comprises the disciplinary work in materials, structures, propulsion, power, entry, guidance, control, and information processing, safety, and assistance on selected civil problems.

The fundamental work of this program is aimed at providing an understanding of physical phenomena pertinent to space programs. It includes research concerned with material properties and behavior, artificial intelligence, lasers and other optical phenomena, materials and techniques for improved electronic devices; gas dynamics and aerothermodynamics phenomena associated with planetary atmospheric entry; combustion processes, fluid dynamics, plasma characteristics, ion optics, and discharge characteristics associated with chemical and electric propulsion; and basic understanding and improvements in the theory and technology of chemical power producing machines and solar power conversion materials.

The Research and Technology base also includes applied research programs which utilize the fundamental technology developed by the basic research in the development of improved materials and structures, guidance, control and information systems, propulsion and power for shuttle, space station, applications; science and planetary programs.

Systems and Design Studies

Systems and design studies analyze future missions in terms of new technology requirements. These studies provide direct guidance to the research and technology projects. Studies of commonality of hardware elements for space programs offer the opportunity to design systems to fulfill several mission needs.

The aim of these technology programs is to verify the application of new technology through tests and demonstration in realistic environments. These programs are grouped under three categories: Flight Experimental programs, Spacecraft/Payload programs, and Transportation programs.

Flight Experiment programs include a laser communication experiment and research flight test program utilizing the M_2-F_3 and the X-24B lifting bodies.

Spacecraft/Payload programs include development of an electron bombardment cesium ion engine; development of a pulsed plasma micro thruster; and demonstration of a space storable propulsion module.

The Transportation program is made up of three elements: a reuseable oxygen/hydrogen space propulsion system effort; an effort involving three small specialized solid rocket motors; and an experiment in solar-electric propulsion.

SUMMARY OF RESOURCES REQUIREMENTS:

	1971	1972	1973
Research and technology base...	$ 96,015,000	$65,999,000	$53,485,000
Systems and design studies.....	2,027,000	706,000	1,000,000
Systems and experimental programs.....	6,962,000	8,400,000	10,275,000
Total.....	$105,004,000	$75,105,000	$64,760,000

Distribution of Program Amount by Installation:

Manned Spacecraft Center.....	$ 7,028,000	$ 2,302,000	$ 900,000
Marshall Space Flight Center..	10,868,000	8,075,000	7,100,000
Goddard Space Flight Center...	6,333,000	4,607,000	4,485,000
Jet Propulsion Laboratory.....	14,615,000	14,183,000	15,555,000
Wallops Station.....	100,000	---	---
Ames Research Center.....	14,060,000	6,484,000	6,510,000
Flight Research Center.....	2,130,000	1,200,000	800,000
Langley Research Center.....	24,165,000	16,156,000	13,510,000
Lewis Research Center.....	18,090,000	16,302,000	14,210,000
Headquarters.....	7,615,000	5,796,000	1,690,000

BASIS OF FUND REQUIREMENTS:

Research and Technology Base

	1971	1972	1973
Materials research and technology	$11,900,000	$8,686,000	$7,000,000
Structures research and technology	12,305,000	9,003,000	5,500,000
Propulsion research and technology	18,817,000	14,000,000	9,225,000
Power research and technology	9,399,000	7,529,000	7,500,000
Entry research and technology	8,409,000	8,301,000	7,700,000
Guidance, control and information processing research and technology	17,527,000	14,780,000	13,660,000
Safety research and technology	1,858,000	1,700,000	1,900,000
Civil technology assistance	---	2,000,000	1,000,000
Life sciences	15,800,000	---	---
Total	$96,015,000	$65,999,000	$53,485,000

Materials Research and Technology	$11,900,000	$8,686,000	$7,000,000

Fundamental research on the nature and behavior of solids and surfaces is essential for the development of new materials as well as for the improvement of existing metals, ceramics, and polymers. The goal of this research is to understand the atomic and molecular structures of solids and their surfaces and then to relate them to their properties. Only through such understanding can the performance and efficiency of materials be improved. The nature of this research area is broad and long range but in FY 1973 emphasis will be put on superconductors, high temperature metals, surface physics, electronic materials, and the physics of materials processing in space.

In the area of electronic behavior, validation of a new theory for superconductivity will be pursued at the Jet Propulsion Laboratory. Increased understanding will also be sought to explain why high temperature metal alloys lose ductility.

Research on surface physics at Lewis will be directed at studies of oxidation and corrosion and the contribution of the surface to the mechanical properties of metals. An understanding of the basic nature of materials surfaces should be instrumental in obtaining increased operating lifetime in corrosive environments.

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In the physics of space processing, the research emphasis is on understanding the conditions of crystal growth encountered in a weightless environment. In FY 1973 this research will be directed toward analytical and experimental studies which may lead to new concepts for improved materials which can be processed in space. This work is carried out at Marshall.

Basic research on electronic materials will be directed by Langley at improved, high density, high efficiency computer memory materials as well as non-silicon solar cells. New concepts for achieving energy conversion from sun light will also be investigated.

Environmental effects pose problems for the designer of advanced spacecraft for long mission times. Of particular concern is the temperature control of space vehicles. Thermal control coatings have been developed which are suitable for up to two years in near-earth orbit. The emphasis in FY 1973 will be on developing white coatings stable in outer space for longer times. Research and development of alternatives, such as heat pipes, which progressed to the application stage in FY 1972 will be continued to broaden the technology base. Radiation shielding, particularly to high energy cosmic rays, is required for long time missions in outer space. Studies on dosimetry and shielding for detection and protection will be continued in FY 1973. The protection of spacecraft from meteoroids also becomes more important as mission times increase. Emphasis in FY 1973 will be shifted to flight testing of new structural concepts and verifying ground obtained data.

Research on advanced materials relates to a broad spectrum of applications. There will be increased emphasis in FY 1973 at Lewis on materials for nuclear space power systems, with the objective of explaining and minimizing such phenomena as the degradation of fuels, claddings, and insulators in a high radiation flux field. On the other hand, improvements in high-temperature refractory metals, graphite, oxides and charring ablators for planetary entry will continue on a reduced level. A moderate sized effort aimed at increasing the life and reliability of bearings and related mechanical components in the space environment by fundamental and applied studies of friction and wear will also continue.

As the status of materials engineering for space shuttle moves into development, the size of the advanced technology program will decrease. Work will continue in FY 1973 by Lewis on advanced composites whose strength, stiffness and lightness promise to reduce structural weight substantially. Continuing effort will also be aimed at developing advanced techniques for inspecting materials after each flight, extending the useful temperature range of lubricants and bearings and improving material-environment capability.

	1971	1972	1973
Structures Research and Technology	$12,305,000	$9,003,000	$5,500,000

The scope of this program encompasses the development of technologies for advanced structural design and dynamics coupled with new structural concepts for future space systems. Included are the technologies needed for the near-term reusable earth-to-orbit transport systems and those anticipated for other future capabilities. The effort related to the space shuttle will be somewhat reduced in FY 1973 with emphasis placed on the most urgent problems and on potential future improvements. Increasing attention will be given to development of advanced structures for greatly extended astronomical observation, long-lived space laboratories-stations, and other space systems. In addition, the potential of these advanced concepts for ground applications of space technology will be identified and explored. This work is primarily carried out at Langley and Lewis.

Significant aspects of the structural design technology area include development of design and test methods to provide capability for enhanced structural efficiency and reliability, exploration of advanced structural concepts, and demonstration of potential improvements with large scale laboratory tests of typical components and assemblies. For the shuttle, substantial progress is being made in analytical studies, experiments with small specimens, design and fabrication of large test components, and improving the needed test facilities. Emphasis in FY 1973 will be directed to essential improvements in fracture control methods, testing of advanced concepts utilizing composite materials, and testing of various structure-thermal protection systems which will also be applicable to other future systems.

One of the important considerations in the design of the shuttle is to be able to predict the dynamic loads that will act on the vehicle and the response of the vehicle to the loads. The dynamics program is aimed toward uncovering dynamic problem areas on the shuttle, and to provide the shuttle contractors with design data and recommended analysis and test techniques for handling these problem areas.

Much of the planned dynamics technology effort for the shuttle has been completed but much remains to be done. Some of the more important areas to be completed are the effects of combined vibration and temperature on Thermal Protection System panels; prediction of the vehicle POGO characteristics and active and passive systems for suppressing POGO; the effects of ground winds on new launch configurations; the effects of water impact on the reusability of the launch vehicle; and planning for large scale dynamic testing. Increased emphasis will be given to related dynamic problems for other advanced space systems.

Advanced concept studies for spacecraft configurations which employ unique geometries and new principles will continue as part of the Structures program. These will include new approaches to deployable structures, laminated panels,

and prestressed structural components. Part of this effort will continue to be directed toward a more applied effort on a large deployable antenna for deep space communications.

	1971	1972	1973
Propulsion Research and Technology	$18,817,000	$14,000,000	$9,225,000

Space Propulsion research and technology includes activities in liquid propellant rocketry, solid propellant rocketry, and electric propulsion. The effort incorporates basic research, discipline research and technology, and Space Shuttle propulsion technology. From this broad base will emerge the technology for propulsion systems for future launch vehicles, upper stages, interplanetary stages, planetary retro/landing/take-off, and spacecraft attitude/position control.

The basic research activity examines the physics and chemistry of propulsion to understand critical propulsion processes and to explore new concepts offering significant performance advantages. Chemical rocket combustion and fluid flow will receive particular attention with the goal of efficient, stable performance and refined methods to predict behavior. For example, the flow behavior at the edge of a rocket plume will be studied to predict the potential of spacecraft contamination from a thruster. Ion optics and plasma characteristics investigations will continue with a goal of both high specific impulse (3000 seconds) and high efficiency (greater than 80%). New horizons in propulsion will be evaluated, including atomic hydrogen, laser transmitted energy to heat working fluids and the use of planetary atmospheres as a propellant.

Long life is the primary goal in the liquid propellant rocket discipline research and technology area because of requirements for long residency in space (up to 10 years) and/or reusability (greater than 100 missions). An engineering test model of a zero gravity propellant transfer experiment will be designed pointing toward a full scale space experiment on a future shuttle flight. A "dual mode" (biopropellant for performance, monopropellant for minimum impulse bit) engine is to be tested. New and improved concepts in liquid rocket components, such as a non-spark resonance tube igniter, will be evaluated.

A relatively high energy hybrid rocket incorporating a liquid oxidizer and a solid fuel will be tested. Solid propellants that can withstand the 250°F thermal cycles for sterilization will be formulated and tested. New protechnic devices such as a laser initiated, debris-free actuator will be evaluated. The atmospheres of several planets are sufficiently dense that conventional rocket chamber pressures and nozzles will not perform efficiently; very high chamber pressure (10,000 psi) solid propellants will be examined.

Long operating life--greater than 10,000 hours--for ion thrusters is a major goal of the electric propulsion research and technology activity. Methods of increasing the impulse bit level of pulse plasma devices are to be developed, while resistojet technology will be focused on lower impulse bit, thus closing the gap between the two. Since electric thrusters may be able to provide continuous thrust for months and years, new options for trajectory are possible. Examination of such characteristics of low thrust systems in terms of software and propulsion/spacecraft interactions will provide a base for optimal mission use of ion thrusters for interplanetary transfer.

The propulsion technology specifically focused to the needs of the Space Shuttle will be reoriented to the current Shuttle designs. Most of the component level proof-of-technological-readiness testing will be completed in the next 18 months.

	1971	1972	1973
Power Research and Technology	$9,399,000	$7,529,000	$7,500,000

Studies show that major improvements (2 fold or better) in solar and chemical power systems performance, life, and cost are possible. The potential benefits to be derived from such improvements include major increases in space mission capability, estimated annual savings of $20-40 million/year and technology directly applicable to the generation and utilization of electric power on earth. It is the purpose of the solar and chemical power program to provide the technology necessary for such improvements in a cost effective manner utilizing an existing industrial, university, government laboratory team of demonstrated technical and managerial competence.

Basic research in the fields of photovoltaic energy conversion and electrochemical energy storage provides a major impetus to the program. A goal of doubling silicon solar cell efficiency has been established and several approaches aimed at obtaining an improved higher purity crystal structure having less internal strain in silicon single crystals have been defined in prior years' programs. In FY 1973, an experimental program recently initiated under the direction of the Lewis Research Center will be continued. In the field of electrochemical energy storage a goal of a 10 fold increase in energy density (watt-hours per pound) for secondary batteries has been established. Here the key to enable technology advancement will be an electrolyte material compatible with the high energy electrode materials available such as solium or potassium. Research on solid electrolytes (as contrasted with the current aqueous electrolytes) will be continued in FY 1973 aimed at discovering, modifying and evaluating naturally occurring materials having the desired electrical and physical properties and developing monocrystalline materials of improved characteristics. This work is also under the direction of the Lewis Research Center. In addition, small programs aimed at defining and evaluating new energy conversion and storage concepts will be initiated in FY 1973.

Discipline research and technology in the areas of solar arrays, batteries, fuel cells and the associated power processing, distribution, and control equipment contribute numerous, individual advancements which, when summed, will result in major system performance, life, and cost improvements. In the solar array area, efforts will be directed in FY 1973 toward obtaining a 40% weight reduction by means of such approaches as reducing solar cell and cover glass thickness, the substitution of welding for adhesives, fold-up for roll-up deployment concepts, and lighter weight structural concepts. Array life improvement (150%) and cost reduction (50%) approaches defined in FY 1971 and FY 1972 will be initiated in FY 1973. Secondary battery goals include increased life to meet future mission requirements (90,000 hours) and 12 and 20 watt-hours/lb for Ni-Cd and Ag-2n secondary batteries respectively. These programs will be continued in FY 1973 as will the long life prediction technology program initiated in FY 1970. Approaches to improving fuel cell life and weight by factors of 2-10 will be studied in FY 1973. Also to be studied are the various areas in terrestial electric power generation and utilization where solar and chemical space power system expertise can be applied to advantage. Specific concepts to be studied will include both stationary and vehicular power systems and the use of solar energy in space or on the ground as a primary power source.

In the area of power processing, distribution and control, there is a particular need for higher power capabilities and for longer operating life. The goal is to obtain 5 to 10 KW capacity in single power processor modules, with a capability for clustering to meet even larger future power requirements. 10 to 12 year operating life is an important additional technology objective, necessitated by long interplanetary travel time and to provide operating economy in earth-orbiting applications.

The limiting technology requirements in each of the above areas have been identified and development efforts initiated. Development of key devices such as power semi-conductors and energy storage capacitors will continue in FY 1973. Advanced circuits and circuit analysis techniques have been established and will be further investigated and evaluated in FY 1973.

The reusable shuttle concept utilizes a 400 horsepower gas turbine, fueled either by O_2/H_2 or monomethylhydrazine to provide the hydraulic and supplementary electric power required during reentry. A technology program was initiated in FY 1972 aimed at solving the problems posed by the reusability requirement and the special O_2/H_2 pressure and temperature control requirements involved in using O_2/H_2 from the main propulsion system tanks. This program will be completed in FY 1973.

	1971	1972	1973
Entry Research and Technology	$8,409,000	$8,301,000	$7,700,000

Entry research and technology is directed toward solutions to the aerothermodynamic problems of high speed entry and flight of spacecraft in

the atmospheres of Earth and other planets. Major efforts are focused on establishing an adequate base of knowledge to assure future capability for new missions and on achieving a low-cost transportation system to Earth orbit. The exploration of the solar system will include atmospheric entry probe missions to the planets Venus and Jupiter. Under the entry technology program conducted at the Ames and Langley Research Centers and the Jet Propulsion Laboratory, theoretical and experimental research in FY 1973 will continue to focus on entry problems associated with high speed gas dynamic phenomena such as high temperature gas transport and radiative heat transfer. Spacecraft boundary layer and flow field analysis and the effects of ablating heat shields will be studied using advanced computer techniques and laboratory facilities such as wind tunnels and high speed shock tubes.

Significant progress in heat shield research and design has been accomplished over the past year which contributes to NASA's goals of exploration of the outer planets. Research has shown that graphitic ablative heat shields can be designed to withstand the high radiative heating characteristics of Jupiter entry. During FY 1973, this type of activity will be continued and expanded to include comprehensive testing in the Ames Heat Transfer Tunnel of different grades of graphite as well as composite materials. Because of the relatively high weight of graphite, study of alternate means of heat shielding was started in FY 1972. One promising concept makes use of the high reflective properties of ablating dieletric materials to accommodate intense radiative heating. Research on reflective heat shield concepts will be increased in FY 1973 to further evaluate the performance of promising dielectric heat shield materials.

Better simulation of spacecraft entry phenomena in the laboratory is necessary to fully understand and solve the varied problems of high speed entry. During FY 1973, research will be continued to improve simulation capabilities and techniques in experimental and computer facilities. An improved test capability for entry heating simulation will be achieved in FY 1973 by coupling a high energy gas dynamic laser with a conventional arc-heated wing tunnel to provide combined high radiative-convective heating rates.

During the past year, over 10,000 wind tunnel hours in 18 different NASA wind tunnels have been employed in evaluation of Space Shuttle concepts. This large and active program has served as a screening process to help select aerodynamically promising Space Shuttle configurations for more comprehensive investigation. The operational flight problems of low cost reusable spacecraft have also been studied. In FY 1973, research and technology efforts will be focused on a selected space shuttle configuration to determine performance, stability and control, and handling qualities and to investigate associated aerothermal and operational problems such as orbiter-booster interface during staging and abort.

A major investigative effort will be undertaken in FY 1973 to define the heating environment of the space shuttle orbiter and booster during ascent and reentry into the atmosphere. This work will provide the required data

base for design of the thermal protection system. Replaceable ablative panels for the orbiter will be investigated with emphasis on design, manufacture, and installation. Research will be continued to develop an efficient reusable surface insulation system. Aerothermodynamic investigation and thermal protection system testing on the space shuttle will require a large number of NASA research center wind tunnels, arc-jets, and other facilities during the coming fiscal year. Important use will be made of the recently approved Interaction-Heating Shuttle Panel Test Facility at Ames and the Combustion Facility for Shuttle Thermal Protection Testing at Langley.

	1971	1972	1973
Guidance, Control and Information Processing Research and Technology	$17,527,000	$14,780,000	$13,660,000

Guidance, Control and Information Processing research and technology provides new concepts and improved functional systems performance for future space missions. During FY 1972, development of intelligent machines was initiated. FY 1973 efforts will emphasize machine perception and reaction and the development of a test vehicle to demonstrate advances in technology. University research on techniques for improving the efficiency, stability and tunability of lasers, will continue in FY 1973. Development of materials suitable for use as solid state displays and high density memory systems will continue in FY 1973 with the fabrication of laboratory devices.

During FY 1972, an approach guidance experiment on the Mariner 9 mission demonstrated improved precision of maneuvers at planetary distances. New techniques for processing navigation data and more accurate determination of planetary and satellite orbits for future planetary missions will be pursued in FY 1973. Research on spacecraft and experiment control systems and components will continue in FY 1973 to provide longer life, simpler, lower cost systems for precise control and stabilization of earth orbiting spacecraft. Guidance laws and procedures for the space shuttle, developed during FY 1972 and prior years, will be flight tested in the CV 990 aircraft at ARC in FY 1973 to demonstrate feasibility.

Data systems research focuses on techniques for increasing the speed and capacity of data handling systems. During FY 1972, techniques for organizing and programming multiple processors have been developed. In FY 1973, a laboratory model multiprocessor system will be assembled. Optical processors increase the through put of data systems by real time conversion of images from a noncoherent to coherent form suitable for parallel processing. In FY 1973, techniques for digital processing and compression of imagery data will continue. A breadboard 10^5 bit optical memory is being fabricated in FY 1972 to demonstrate high density data storage capabilities. This work will continue in FY 1973 with emphasis on storage capacities of 10^{10} bits or more. Self testing and repair techniques for onboard computer systems are being developed to provide operating lifes in excess of 10 years. In FY 1973,

a universal processor unit will be developed to perform functions of a number of subsystems and reduce the variety of spares required.

Low noise microwave receivers, power amplifiers and antenna systems are being developed for shuttle applications. In FY 1973 emphasis will be placed on antennas which can operate and survive during the shuttle reentry into the earth's atmosphere. To increase the data return capability of deep space networks, a dual frequency (S-X band) experiment will be flown on the Mariner Venus-Mercury 73 mission to evaluate the performance of X-band components in a space to earth data link. Development of extremely high frequency (Ku band), solid state transmitters will continue. Lasers, detectors and modulators are being developed to provide high data rate optical communication links for future missions. These efforts will continue in FY 1973.

The efficient use of large mirrors in space requires that techniques be developed for grinding and polishing these mirrors so they can retain their shape in the zero "G" space environment. In FY 1973, a large mirror blank will be acquired and, during this and subsequent years, ground and shaped for space applications. Methods for controlling telescope alignment, mirror figure, focus and pointing are also being developed and will continue in FY 1973.

Imaging sensors with dynamic ranges and resolution suited to the varying light requirements of outer planet missions are being developed. A prototype sensor will be procured and evaluated in FY 1973. Solid state sensors capable of color imaging are being developed for the 1975 Viking mission. Ion implantation, a new technique for processing solid state materials, is being applied to the development of infrared sensors. Laboratory devices will be fabricated and evaluated in FY 1973. Methods for automated testing of large scale integrated circuit arrays are being developed. In FY 1973, a device for automatically inspecting integrated circuit arrays will be tested. Gaging systems to measure fuel quantity and flow in a zero "G" environment are being developed for the Space Shuttle. In FY 1973, competing techniques will be tested and a baseline system design selected for shuttle vehicle use. Air data sensors operable over the full atmospheric flight regime of the shuttle will be developed and tested. Gas sensors to monitor composition of the cabin atmosphere during Shuttle operation are also being developed as part of the FY 1972-73 sensor program.

	1971	1972	1973
Safety and Operating Systems Research and Technology	$1,858,000	$1,700,000	$1,900,000

The Safety and Operating Systems Office is primarily a functional activity but it also supports several safety research and technology activities not otherwise covered by the program elements of NASA. Functionally, the office has responsibility for the operational safety of the OAST installations and serves as the focal point within OAST for implementation of the requirements

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set forth in the Occupational Safety and Health Act of 1970 and the National Environmental Policy Act of 1969. Safety is pursued in the discipline research and technology area through support of the Aerospace Safety Research and Data Institute (ASRDI). Funds requested in FY 1973 will be used as follows:

ASRDI - During FY 1973, effort will be concentrated on establishing and maintaining the NASA Aerospace Safety Information System (NASIS), maintaining an overview of NASA and industry safety research programs, seeking practical solutions to identified safety problems, and providing technical consultation to NASA, other Government agencies, and U.S. industry on safety problems. Fire hazards research in oxygen systems will be continued to cite one of several aerospace safety studies being conducted by ASRDI.

Nuclear Systems - During FY 1973, coordination of the aerospace nuclear systems safety activities carried out at the various NASA Centers and with other Government agencies will be maintained. Studies will be supported to insure the safe application of nuclear energy during all mission phases.

	1971	1972	1973
Civil Technology Assistance	---	$2,000,000	$1,000,000

The objective of this effort is to use the NASA capability to determine potential solutions for recognized public sector problems. Past experience has shown that considerable effort is necessary to fully define problems, to develop conceptual solutions, and to demonstrate the feasibility of selected concepts. NASA manpower and funding are needed to reach the demonstration point. Funding for actual development or implementation is expected to be provided by the agency needing the solution. The program content is variable with time in response to identified public sector problems and with the NASA ability to contribute to potential solutions. The FY 1973 effort will be directed toward the following areas:

Public Safety - Prior efforts to define problems and to laboratory test potential solutions for police air patrol functions and for crime laboratory instrumentation have been coordinated with the Law Enforcement Assistance Administration. Useful NASA capabilities have been tentatively established. A helicopter vision aid, a helicopter noise reducing muffler and a materials comparison instrument will be brought to the field demonstration stage in cooperation with user agencies. Additional uses of NASA expertise in communications and instrumentation will be explored.

Environmental Engineering - A heavy emphasis is being placed on this work, which is conducted in cooperation with the Environmental Protection Agency (EPA) and others. Instrumentation techniques for remote measurement of pollution sources will be tested, the capability of space life support systems to provide reductions in water consumption and sewage volume will be determined, and automobile power sources project management will be provided to EPA using the engine technology of the Lewis Research Center. Other

areas of waste management, energy conservation and alternative power sources will be investigated to determine feasibility.

Medical Engineering - This is a small but continuing effort to identify those techniques and facilities which might contribute to better materials, improved test procedures or special instrumentation for use in medical research or medical practice.

Public Service/Support - This area primarily includes specific responses concerning specialized instrumentation or modification to existing equipment to meet unique requirements. Principal support will be to the Forest Service to complete field testing of a laser surveying technique developed in prior years. A modified magnetometer, from the Pioneer program at Ames Research Center, will be delivered for long term test by NOAA as a potential new observatory standard.

Systems and Design Studies

	1971	1972	1973
Advanced concepts and mission studies.....	$2,027,000	$706,000	$1,000,000
Total.....	$2,027,000	$706,000	$1,000,000

The Advanced Concepts and Missions Studies project has three major objectives: to foster the generation of new technological ideas through systematic and synergistic activities; to analyse future missions in terms of scientific data requirements and need for technological advancements; and to analyse future space transportation requirements in relation to advanced technology in transportation related areas.

Advanced concepts are generated through the sponsorship of speculative technology activities which bring together interdisciplinary participants to hypothesize, discuss, and formulate ideas for future investigation. Seminars are sponsored at the Field Centers with NASA and invited participants, and larger meetings, on an annual basis, focus on more general topics such as: information and communication, transportation concepts, and extra-terrestrial development.

Analysis of mission requirements provides direct guidance to the research and technology projects of the OAST and other offices. The diverse desires of many constituant groups provide a comprehensive set of space mission goals. Specific missions are selected, as examples, for more detailed evaluation and these studies provide technological goals for the discipline technologists and indicate incremental improvements needed in the state of art. Some of the missions under study are Venus radar mapping, Asteroid flyby and sample return, Mars surface rover and sample return, and advanced earth observation missions.

Where mission analysis activity concentrates on operations of a space vehicle at its destination or during its data gathering operations, transportation analysis is necessary to plan efficient delivery of operational payloads. From mission goals a space operations network may be derived and optimization of transportation requirements may be conducted. Study of commonality of propulsion, guidance and structural elements across the spectrum of requirements with biases of development and operating costs and mission time or system velocity capability provides the input to prioritization of technology efforts in the field of chemical, nuclear, electric, and advanced propulsion systems. Specific systems with multiple applications such as: solar-electric mission modules, nuclear orbit-to-orbit shuttles, modular chemical systems, and nuclear-electric stages are under study.

Systems and Experimental Programs

	1971	1972	1973
Systems and Experimental Programs			
Flight Experiment Programs	$1,200,000	$1,500,000	$3,700,000
Synchronous laser communications experiment	---	800,000	3,000,000
Lifting body flight tests	1,200,000	700,000	700,000
Spacecraft/Payload Programs	$3,003,000	$3,200,000	$2,975,000
Electric auxiliary propulsion	1,703,000	1,400,000	475,000
Space storable propulsion module	1,300,000	1,800,000	2,500,000
Transportation Programs	$2,759,000	$3,700,000	$3,600,000
Reusable oxygen hydrogen space propulsion systems	800,000	1,300,000	1,500,000
Solid rocket motors	1,101,000	1,300,000	800,000
Solar electric propulsion	858,000	1,100,000	1,300,000
Total.....	$6,962,000	$8,400,000	$10,275,000

Flight Experiment Programs

	1971	1972	1973
Synchronous laser communications experiment.....	---	$800,000	$3,000,000

A space flight experiment which was started in FY 1972 to develop and evaluate a laser communication system will enter the equipment design stage in FY 1973. Plans include carrying this experiment in the ATS-G spacecraft scheduled for launch in 1975, and is to closely simulate the operating environment of one link of a tracking and data relay satellite system. Two way streams of simulated data at 30 megabits per second will be used to measure communication system characteristics such as error rates and

toleration of cloud cover and background noise. Measurements will also be made to determine turbulence of the atmosphere and means of minimizing its effect. One fixed station will be a modification of the 24" telescope now located on Madkin Mountain near Huntsville, Alabama. The mobile station will contain a six foot antenna and will be operated at various locations such as the Mojave Desert and Mount Hopkins, Arizona.

The experiment will be managed by the Marshall Space Flight Center, and the ATS-G spacecraft on which the experiment will ride is managed by the Goddard Space Flight Center. Liaison has been established with the U.S. Air Force through a special working group of the Aeronautics and **Astrionics Coordinating** Board to insure that a cooperative program is carried out.

This experiment will lay the groundwork for use of laser communications by future NASA missions as well as by commerical satellites.

	1971	1972	1973
Lifting body flight tests	$1,200,000	$700,000	$700,000

The Lifting-Body Flight Research project has provided a valuable base of technology adaptable to low cost, reusable, horizontal-landing spacecraft. The successful demonstration of supersonic and transonic flight and landing with the M2-F2, HL-10 and X-24A test vehicles provided a major impetus to proceed with NASA's current manned space shuttle program. A total of 94 flights have been completed to date in the lifting-body program. The M2-F3 is currently the only vehicle in flight status, having completed 13 test flights to January 1, 1972. During FY 1972 tests were conducted on a reaction control system for spacecraft at low altitudes and high dynamic pressures. During FY 1973, the M2-F3 will be used to test an improved Rate Command Augmentation System (RCAS) and, in the latter part of FY 1973, will be integrated with the reaction control system. The RCAS is an automatic stabilization system that can maintain an aircraft or spacecraft in smooth and stable flight in turbulent air and will allow superior handling qualities under design conditions that may otherwise be uncontrollable. The potentially lighter weight of a blended RCAS and reaction control system is attractive for use in the space shuttle. During FY 1973, initial test flights of the X-24B will be conducted. The X-24B is characteristic of a higher performance class of vehicle, compared to lifting bodies, and has strong potential as a high performance military hypersonic aircraft for the 1980's. The joint NASA/Air Force program will investigate flight performance, stability and control, and handling qualities from speeds of about M=2 to landing. The vehicle will be fabricated by modifying the existing X-24A to change the exterior while retaining the basic structure and most of the proven subsystems. In many respects, the M2-F3 and X-24B have flight characteristics similar to those of the space shuttle and will contribute significantly to the technology base required for space shuttle development.

	1971	1972	1973
Electric auxiliary thrusters	$1,703,000	$1,400,000	$475,000

This experimental project consists of three elements. Each one is an electric propulsion thruster approach to different thrust (impulse bit) regions for spacecraft and satellite auxiliary propulsion for attitude and position control. The three elements are: a cesium ion thruster, a pulsed plasma thruster, and a biowaste-fueled resistojet. In every case these advanced thrusters offer the satellite/spacecraft designer approaches that allow significant reductions in auxiliary propulsion weight when compared to cold gas or monopropellant hydrazine.

The first element involves the development of an electron bombardment cesium ion engine for an operational demonstration of north-south station keeping on the ATS-F Synchronous Satellite. The thruster system will be carefully matched to the spacecraft mission. Two systems, each carrying 3.4 kilograms of propellant and operating at a nominal specific impulse of 2500 seconds, will produce the capability of 20 months of station keeping. The flight hardware has been developed and is under test. The majority of the effort will be completed in FY 1972. The ATS-F launch is presently scheduled for 1973.

A pulsed plasma microthruster is being developed for precision control and east-west station keeping of the Synchronous Meteorological Satellite. This satellite will spin at about 100 revolutions per minute and needs a thruster which can pulse at the proper time in its rotation. The microthruster weighs about six pounds and will consume less than 20 watts electrical power. It has been designed for a rated impulse with a total impulse capability of 400 pound-seconds minimum. An engineering model thruster will enter testing in late FY 1972 with subsequent flight development to be funded by the project. Synchronous Meteorological Satellites are scheduled for launch in 1972 and 1973.

The biowaste resistojet activity will provide the technology for the impulse required for manned station's control moment gyro desaturation and orbit maintenance. The resistojet units will have high performance, long life, and minimum power consumption. The biowaste resistojet design has evolved from prior hydrogen and ammonia resistojet investigations. The present program is examining heater materials compatible with the biowaste gases (CO_2, CH_4, H_2O) at the high temperature required for good performance. The propellant collection and management system required to interface with the life support system will also continue to be examined. The program is aimed at completion in FY 1977 with a combined propulsion/life-support system demonstration test. FY 1973 activity will concentrate on continuing the evaluation of materials such as noble metal alloys and conducting ceramics for use as thruster heaters.

	1971	1972	1973
Space storable propulsion module	$1,300,000	$1,800,000	$2,500,000

The space storable propulsion module program is directed towards demonstrating the performance and operational capability of an advanced system designed to satisfy the demanding requirements of future planetary missions. High performance, maximum reliability and extended operational life (up to 10 years) are the principal propulsion system characteristics needed to perform the advanced planetary missions most effectively. The most performance sensitive propulsion system function during a typical mission is the insertion of the spacecraft into orbit around the planet. The high energy, space storable propellants with a specific impulse of 370 seconds offer significant performance advantages when utilized for the orbit insertion maneuver.

The additional available energy can be used either to establish more scientifically attractive orbits or to increase post orbit insertion maneuvering capability. Orbital altitude or plane change capability greatly extend mission flexibility. On the other hand, for a given energy level, the higher energy propellants require less launch payload delivery capability, which could be reflected in reduced launch costs, or inversely, for a given launch vehicle, increased scientific payload would be placed in planetary orbit or delivered to its surface.

The objective of this experimental program is to demonstrate the performance and operation of a complete propulsion module in a simulated space environment. The first phase of the program is directed towards modifying surplus Mariner '71 propulsion system hardware for FLOX (a mixture of liquid fluorine and liquid oxygen). The fuel, monomethyl hydrazine (MMH), remains the same. A previously tested FLOX/MMH engine will replace the Mariner N_2O_4/MMH engine. This modified Mariner '71 module will be tested beginning in June 1972 and will provide an early system feasibility demonstration and will provide handling experience on the system level with the highly energetic FLOX oxidizer.

The second phase of the program will involve the buildup of an engineering test module utilizing FLOX/MMH, specifically designed for this propellant combination including the required propellant quantities and associated tankage and properly sized lines and valves, component designs based on intersive fluorinated oxidizer technology, and a near flight-weight engine design, again based on component technology advancements. The resultant module will demonstrate the high specific impulse plus the capability of 10 year storage in space without venting any propellant. System testing is scheduled for completion in June 1975. This effort will demonstrate the feasibility of applying the space storable class of propellants to the future planetary missions of interest.

Transportation Programs

	1971	1972	1973
Reusable oxygen/hydrogen space propulsion systems.....	$800,000	$1,300,000	$1,500,000

This program is directed at using oxygen-hydrogen propulsion for such potential applications as the space tug. The major areas of technical concern are the rocket engines, thermal management and fluid management. Difficult technical problems include achieving maximum possible mass fraction and specific impulse. New and improved techniques must be evolved for achieving virtually zero propellant losses in long term exposure to both the sun and close-earth albedo, numerous restarts with zero or minimum propellant loss, provisions for docking and propellant transfer, adequate techniques to fully validate the vehicle before reuse, and man-rated reliability for many missions. Fortunately the need date for most of the applications is such that time is available to conduct a technology readiness program to attack these many problems systematically prior to actual development of such vehicles, where costs would increase dramatically due to the time urgency.

Early objectives are to provide a rational basis for propulsion, thermal, and fluid system activities. Tank-pressure idle, restart economy, chamber thermal fatigue, and flexibility of control will be studied. Engine system problems will be explored with emphasis on the start transient and off-design operating conditions. Auxiliary propulsion requirements for both docking and attitude control will be studied. In the area of thermal management, work will be done on the problems of long term storage of cryogenic propellants in near-earth orbit, storage during boost and orbit-hold in the cargo bay of the shuttle orbiter, the interaction of environmental protection measures with the thermal management techniques, and inspection techniques to assure adequacy for reuse. The fluid management area will be concerned with economical restart techniques, and also with problems of outage control from multiple tanks, venting, gauging under both positive and zero gravity, and provision for propellant transfer.

This experimental program is scheduled for completion in FY 1975. The end point of the program will be static testing in simulated space conditions (vacuum and thermal) of a combined demonstrator engine and propellant subsystem. These tests are designed to provide clear proof of the technological readiness for vehicle developments of the late 1970's and early 1980's.

The accomplishments anticipated in FY 72/73 include selection of all major design approaches (engine cycle, tank configurations, etc.), design/fabrication/test of critical components for the engine, determination of auxiliary propulsion best suited for this type of space vehicle, long term storage tests of insulated liquid hydrogen tanks, and tests of critical design parameters for the fluid management systems.

While the principal focus for this experimental program is the Space Tug Class of reusable vehicles operating as "third stage" from the Space Shuttle, there are other attractive options for use of this technology. The tug-sized vehicle might be used in the expendable mode to inject payloads to the planets, comets, and asteroids that are significantly larger than might be done with a Shuttle/Centaur combination. Through multiple Shuttle launches and in-space assembly, "tugs" could be clustered to provide a capability for transportation of very large payloads to and from synchronous orbit, the moon, and the planets.

	1971	1972	1973
Solid rocket motors.....	$1,101,000	$1,300,000	$800,000

This experimental program is made up of three unique solid rocket motor activities: the restartable solid motor, the low acceleration solid motor, and a low cost sounding rocket motor. In each of these activities motors are being designed, fabricated, and tested to demonstrate the technological readiness of the concept for operational use.

The restartable solid motor concept provides the capability to start, quench, restart, and quench again all on command. The approach used is that of insulated water bottles located inside the motor that are emptied on command to quench the propellant combustion. All other aspects of the motor design are "conventional". The feasibility of the water quench approach has been demonstrated in prior discipline research technology activity. The objective of the present program is to incorporate the concept into a full-scale, flight-weight, 3000 pound (weight) demonstration motor. Several sub-scale motors have already been built and tested. The full-scale motors will be made and tested in FY 1973 in a simulated space environment. The key advantage of this technology is that a single, relatively low cost propulsion system can perform a mission that normally requires two motors. For example, such a motor might replace the second and third stages of a launch vehicle.

The retro forces applied to a spacecraft being inserted into an orbit around a planet must be relatively gentle to protect science payloads, extended solar cell arrays, antenna, etc. Retro accelerations of no more than 0.5g are usually required. Conventional solid propellant rocket technology is inadequate to provide the low thrust and long burning times needed to insure low acceleration. This experimental program is designed to extend solid motor technology into this thrust/time region and to demonstrate technological readiness in a full-scale, flight-weight motor. The FY 1972 effort is developing the critical components such as a lightweight, all carbon nozzle that operates at incandescent temperature, a low shock igniter, and a propellant formulation that burns efficiently at low pressure and has extremely good mechanical properties. In FY 1973, two 800 lb (weight) motors incorporating these features will be tested.

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This test series will complete the experimental program, and, if successful, will provide designers of future spacecraft with an attractive, low cost option.

The third element of this experimental program is a low cost sounding rocket motor program conducted in cooperation with OSS. A motor containing a boost/sustain composite propellant grain and a one-piece molded plastic nozzle has been designed, fabricated and successfully static tested. In FY 1973, this same motor design will be flight tested in a joint CAST-OSS program. It is forecast that the improved sounding system will increase performance (payload) by 30% and cost 25% less.

	1971	1972	1973
Solar electric propulsion	$858,000	$1,100,000	$1,300,000

Electrically propelled spacecraft have characteristics which are significantly different than those of the familiar ballistic spacecraft. Rather than having all mission energy provided by a high thrust, short duration chemical rocket, the energy is added slowly over a significant fraction of the flight path by very high specific impulse (3000 seconds) ion engines. Solar array power in the range of from 5 to 20 kilowatt must be provided and power conditioning equipment capable of converting the array power into the form required by the ion engines is needed.

Thorough study programs by both OSS and OAST over the past several years have identified benefits associated with solar electric propulsion (SEP) which significantly outweigh the technological risk inherent in committing to any new technology. These benefits include the ability to perform missions not possible with existing automated spacecraft class launch vehicles or the Shuttle/Centaur without multiple launches. For example, direct flights of 550-650 kilogram spacecraft to the outer planets Uranus, Neptune and Pluto become feasible, obviating the need for accepting the hazards and launch data limitations associated with a Jupiter swingby. Jupiter and Saturn orbits and also the in close orbit of Mercury are also possible without propulsion development beyond the 5 segment Titan/Centaur. The increase in capability provided by SEP can also be used to reduce flight time thus reducing operations costs and enhancing probability of mission success. In the case of many difficult comet and asteroid targets the advantages can be quite dramatic, e.g., reducing flight time by 60% and eliminating retro-propulsion requirements.

The first breadboard of a fully automated electric propulsion system designed to demonstrate the functional capability of SEP to perform on such a planetary mission is currently in operation in ground test facilities. The elements of the system include a thruster array, which is movable to provide spacecraft attitude control, power conditioning, automatic controls, switchgear, and failure detection and correction computation. This test is providing considerable insight into the problems involved in incorporating SEP into a mission spacecraft. Thruster technology has also

advanced to the point where a life test model of the 30 centimeter mercury bombardment engine is being prepared for insertion into facilities where it will be tested for 6000 hours starting early in 1972. A vectorable version of this engine capable of operation over a 2:1 throttle range is also expected to be completed by mid-FY 1973.

The foregoing activities coupled with the SERT II orbital duration test of ion thrusters reported on last year, provide the confidence necessary to proceed to the next stage in the development of SEP technology. The objective of this experimental program is to demonstrate in ground facilities an engineering model of a modular mercury ion thrust subsystem for the 5-20 kw range. The subsystem will incorporate thrusters with greater than 5000 hour life capability and a throttling range of 2:1 or better. An additional objective is to achieve an overall subsystem specific mass of 15 kg/kw. With the plan to achieve system operation in FY 1975, a reasonable basis will have been established to commit this technology to mission operations in the late 1970's.

As work proceeds along these lines evaluations will be conducted with such competitive approaches as nuclear electric systems in order to arrive at timely technical decisions.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1973 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

NUCLEAR POWER AND PROPULSION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1971	1972	1973
Nuclear power.....	$13,900,000	$9,320,000	$9,200,000
Nuclear propulsion.....	38,000,000	15,000,000	8,500,000
Electrophysics.....	3,300,000	3,400,000	3,400,000
Total.....	$55,200,000	$27,720,000	$21,100,000

HIGHLIGHTS OF BUDGET PLAN

	1971	1972	1973
Research and Technology Base.....	$21,750,000	$17,220,000	$21,100,000
Nuclear Power - Energy conversion and generation focused primarily on conversion systems for advanced reactors; advanced reactor power focused principally on in-core thermionic and liquid-metal-cooled reactors; intermediate reactor power with emphasis on thermoelectric power conversion and zirconium hydride reactor; and isotope power emphasizing radioisotope thermoelectric generators.....	13,900,000	9,320,000	9,200,000
Nuclear Propulsion - Definition of a small nuclear propulsion system (15-20K lb. thrust), mission analyses and trade-off of alternate propulsion systems for unmanned exploration of the distant planets. Testing of critical components for a small nuclear propulsion system; and supporting research on advanced solid and gas core reactors.....	4,550,000	4,500,000	8,500,000

	1971	1972	1973
Electrophysics - Plasmadynamics research applicable to both propulsion and power production, high energy laser research aimed at generation, conversion, and transmission of energy at various wavelengths through space and planetary atmospheres; superconductors to achieve higher transition temperatures with resulting size, weight, and cost reductions in generation and transmission of power; and nuclear physics to bring theory closer to experiment ultimately leading to calculations of nuclear interactions.....	3,300,000	3,400,000	3,400,000
Systems and Design Studies - Nuclear Stage studies directed toward NERVA applications are being terminated in favor of the mission analysis and trade off studies.....	$450,000	$500,000	---
Systems and Experimental Programs - NERVA engine development is being terminated in favor of the program reorientation described in Nuclear Propulsion Research and Technology.....	$33,000,000	$10,000,000	---

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

NUCLEAR POWER AND PROPULSION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The major program efforts are directed toward development of the technology to establish engineering feasibility and performance potential of advanced propulsion and power systems which will contribute new capabilities for space operations and explorations.

Nuclear capabilities will enhance the potential of both power and propulsion systems and will enable the nation to conduct missions which otherwise could not be done or would be restricted in scope.

For example, in the exploration of the outer planets nuclear power is critical because there is no other practical way of providing the required electrical power. High energy space transportation systems is another focal point for nuclear research and technology. Nuclear powered propulsion systems (rocket and/or electric power) will broaden the scope of missions which can be achieved. Reduced trip times to the outer planets, close-in-orbits, and automated sample returns are all mission options for the 1980's and beyond which will be enhanced by nuclear propulsion systems.

There are a number of near earth missions where nuclear energy will make great contributions. Such missions include strategic defense and communication satellite missions which require information transfer or data processing capabilities more advanced than today's system.

Nuclear energy also holds the promise of even more advanced power and propulsion systems which can provide significant new capabilities for future missions. Directed research in new technologies will explore basic energy sources which could potentially have application either for power or propulsion.

As the nation's space program moves towards more advanced and difficult missions, nuclear energy will broaden the spectrum of missions which can be performed and thereby will be a significant factor in assisting the space program to meet its objective of assisting in the fulfillment of the nation's needs.

SUMMARY OF RESOURCES REQUIREMENTS:

	1971	1972	1973
Research and technology base....	$21,750,000	$17,220,000	$21,100,000
Systems and design studies.....	450,000	500,000	---
Systems and experimental programs	33,000,000	10,000,000	---
Total.....	$55,200,000	$27,720,000	$21,100,000

Distribution of Program Amount by Installation:

Marshall Space Flight Center..	$940,000	$475,000	$800,000
Goddard Space Flight Center...	213,000	60,000	60,000
Jet Propulsion Laboratory.....	3,594,000	3,053,000	3,450,000
Ames Research Center.....	340,000	478,000	515,000
Langley Research Center.....	565,000	416,000	410,000
Lewis Research Center.....	48,563,000	22,952,000	15,865,000
NASA Headquarters.....	985,000	286,000	---

BASIS OF FUND REQUIREMENTS:

Research and Technology Base

Power research and technology...	$13,900,000	$9,320,000	$9,200,000
Propulsion research and technology	4,550,000	4,500,000	8,500,000
Electrophysics research and technology.....	3,300,000	3,400,000	3,400,000
Total.....	$21,750,000	$17,220,000	$21,100,000

Power Research and Technology

Nuclear power is directly applicable to a wide spectrum of current and future missions. These missions have a broad range of power requirements and effort will concentrate on a minimum number of technologies which will meet the needed power ranges. Four categories of effort will be pursued. Research on energy conversion and generation systems will be conducted. Technology of advanced reactor power systems for high power levels will concentrate on establishing the engineering feasibility of thermionic reactor systems and advanced liquid-metal-cooled reactor systems. In addition to providing high power level capability these systems also provide potential capabilities for future nuclear electric propulsion. Intermediate reactor power technology will be directed at long life zirconium hydride reactor power systems. Isotope power sources technology will be directed primarily at spacecraft integration and systems technology.

Energy Conversion and Generation

The directed basic research in energy conversion, generation and transport is in areas such as thermionic electrode characterization, space reactor neutronics, high temperature heat pipes, and feasibility of liquid metal magnetohydrodynamic (MHD) conversion systems. These efforts primarily support the advanced reactor power program.

Advanced Reactor Power

This effort is oriented toward providing the base of technology suitable for such future missions as direct broadcast television satellites, for space or Lunar bases, and electric propulsion for future **missions requiring high energy transportation systems.**

Current emphasis is primarily on the in-core thermionic reactor with a secondary effort on an advanced liquid-metal cool reactor. The thermionic program is a joint effort with the AEC having prime responsibility for the fuel element and reactor development and NASA providing support in conducting application studies, materials research, diode testing and fundamental thermionic physics investigations. Feasibility demonstration could be accomplished in the late 1970's. The advanced liquid-metal-cooled reactor effort investigates basic materials and components to establish concepts and verify materials capability.

Intermediate Reactor Power

The current intermediate reactor power program is directed toward potential applications in the range of a few kilowatts up to around 20 kilowatts. The reactor in this program offers significant cost advantages for strategic defense missions. Potential mission applications also include communications satellites and medium powered space or lunar stations where operational or economic considerations may favor use of nuclear power. This program has two primary elements; i.e., the zirconium hydride reactor and thermoelectric power conversion.

The zirconium hydride development program is a joint effort with the AEC. The AEC will establish the basic nuclear design parameters and perform fuel element development and NASA will fund for the final design, fabrication and test of a power system to be operated in the NASA Space Power Facility at Lewis Research Center. This test is planned to start in FY 1977. The effort includes conceptual design of components, the design and analysis of the primary and secondary loop components and the initial efforts on the required modifications to the Space Power Facility, and effort on thermoelectric power conversion systems. The thermoelectric activity will parallel the effort necessary to prepare for a potential test of this system with the zirconium hydride reactor in the Space Power Facility.

Isotope Power

Current emphasis in the low power range is on radioisotope thermoelectric generators (RTG's). RTG's have been flown on several NASA missions in the past (Apollo, Nimbus III) and are currently scheduled for use on several DOD and NASA missions in the future (Pioneer, Viking, Lincoln Experimental Satellite). The basic development of the RTG systems for these missions and the technology for future missions is accomplished by AEC with NASA emphasis being on systems integration and spacecraft interaction effects. Where appropriate, the NASA program also includes long term testing of modules or generators to verify performance potential. In FY 1973, the primary NASA emphasis will be on RTG evaluations and generator tests related to the outer planet missions.

In addition to RTG's the NASA program includes a low level of effort on critical problems associated with dynamic conversion technology suitable for use with isotope heat sources which provide the only practical means for extending the electrical power capability of isotope systems above about 500 watts of electrical power to the range of a few kilowatts. Without the high efficiency of the dynamic conversion systems the use of isotope fuels would be precluded because of the high cost of the isotope fuels. Testing on conversion system components continues in FY's 1972 and 1973 leading toward a 20,000 hour (over 2 years) goal for component tests.

Propulsion Research and Technology

In the nuclear propulsion program NASA and AEC will define a small nuclear rocket system in the 15-20,000 lb. thrust class. This effort will be part of a broader program to define and make trade-off studies of alternative types of advanced propulsion systems, including chemical, solar-electric, and nuclear rocket systems for future missions to the distant planets Uranus, Neptune and Pluto.

Los Alamos Scientific Laboratory (LASL) will continue effort on solid core technology including fuel elements, related high temperature reactor components, and nuclear furnaces. Support effort will also be provided to the continuing program at the Nevada Nuclear Rocket Development Station in the testing of nuclear furnaces and non-nuclear components as appropriate, and preparations for a Pewee reactor test.

Supporting research and technology will be continued on advanced propulsion systems such as solid core reactors, gas core reactors, thermionic reactors (described in the section on power research and technology) and on critical component technology for these systems. The principle objectives of this work will be to determine the technical feasibility and performance potentials of these systems.

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Study and experimentation effort will be devoted to nuclear engine and stage technology, hydrogen storage techniques, and nuclear system related teleoperator technology.

Development of the NERVA 75,000 lb. thrust engine is being terminated in favor of the program described above.

Electrophysics Research and Technology

The electrophysics research and technology efforts include investigations in plasmadynamics, high energy lasers, superconductors, and nuclear physics.

Plasmadynamic research results may be applicable to both propulsion and power production. In FY 1973, continuing research will be aimed at raising the efficiency and power level of a magnetoplasmadynamic (MPD) channel which has provided recently some electric power output. The fundamental characteristics of the fissioning uranium plasma will be determined. The results are applicable to the gaseous core nuclear reactor concepts. Another research task will measure the interactions of enriched uranium 235 as part of uranium hexafluoride which will be compressed by a ballistic piston in a neutron environment.

High energy laser research is being conducted to learn how to most efficiently generate, convert and transmit coherent radiant energy at various wavelengths through space and planetary atmospheres. The radiation will be beamed to a spacecraft in which it will be converted to direct current or sixty cycle alternating power so that the vehicle equipment may be used normally. High energy laser research will emphasize new techniques, primarily atomic copper vapor and various molecules, for reaching higher efficiency lasing in the ultraviolet to optical wavelengths region. Also new ideas involving nuclear energy levels and nuclear moments will be explored to determine the feasibility of achieving lasing at shorter and longer wavelengths than obtained now from atomic and molecular energy levels. Propagation measurements will be focused on discovering wavelengths which have best transmission characteristics and which have not been mapped previously. The conversion of laser radiant energy will be examined thoroughly with the goal of reaching optimum conversion efficiency using solid state (silicon, germanium, gallium arsenide) and gaseous (cesium) devices.

Superconducting coils need no continuing power once they are energized. The coils can provide the magnetic fields needed in MPD and controlled thermo-nuclear fusion (CTF) devices. However, liquid helium ($4.2^{o}K$) equipment is needed for the operation of the coils. To reduce the size, weight and cost of the cryogenic equipment, research has been conducted to achieve a superconductor with a higher transition temperature (Tc). In FY 1973, emphasis will be given to reaching a higher Tc by exploring new atomic binary combinations in metallic thin films and also by depositions of various organic films between superconductors.

The experimental and theoretical nuclear physics research is undertaken with the objective of bringing theory closer to experiment so that correct and useful methods will be available to calculate nuclear interactions important in power, propulsion and the protection from space radiation of the occupants and equipment in a space vehicle. Therefore, in support of this objective, nuclear physics research will utilize the newly modified 55 MeV cyclotron to measure the neutron energy spectrum as a product of protons and alphas incident on targets on varying masses from carbon 12 to aluminum 27. There will be another investigation devoted to proton irradiation of fused silica and alumina to determine the effect of radiation on these substances. The fused silica is being considered for use in a gas core reactor a and its radiant transmission properties must not be degraded by radiation.

And finally, as part of a program to determine the most promising physics and chemistry experiment in space there will be continuation of the study for conducting research on the behavior of superfluid helium in an environment of wieghtlessness.

Systems and Design Studies

	1971	1972	1973
Nuclear vehicle definition....	$450,000	$500,000	---
Total.....	$450,000	$500,000	---

The nuclear stage definition studies were directed towards NERVA applications for manned missions and large scale logistic requirements with some consideration given to a variety of unmanned missions throughout the solar system. Results of these studies have provided performance data for mission and application analyses, in supplying relevant system data for design and procurement of the nuclear rocket engine, and in guiding technology programs. As a result of the termination of the NERVA program, these nuclear stage definition studies will also be discontinued in FY 1973.

Systems and Experimental Programs

	1971	1972	1973
NERVA engine.....	$33,000,000	$10,000,000	$ ---
Total.....	$33,000,000	$10,000,000	---

With the decision to terminate the NERVA project, the development program will be closed out. Termination efforts will be completed during FY 1972 to the extent possible.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1973 ESTIMATES

BUDGET SUMMARY

OFFICE OF TRACKING AND DATA ACQUISITION

TRACKING AND DATA ACQUISITION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1971	1972	1973
Operations	$211,680,000	$206,300,000	$203,600,000
Equipment	65,363,000	46,200,000	44,000,000
Supporting research and technology	12,900,000	11,500,000	11,500,000
Total	$289,943,000	$264,000,000	$259,100,000

HIGHLIGHTS OF BUDGET PLAN

Operations	$211,680,000	$206,300,000	$203,600,000
Spaceflight Tracking and Data Network - Apollo, Skylab, and unmanned mission support. FY 1973 support load will average 40 satellites. Satellite Network and Manned Space Flight Network to be consolidated over several years	115,086,000	108,500,000	105,800,000
Deep Space Network - Planetary and interplanetary mission support. Backup support for Apollo, FY 1973 workload includes Mariner 9, Mariner Venus/Mercury 1973, Pioneer F&G	37,949,000	37,900,000	38,000,000
Aeronautics and Sounding Rocket Support - Support for Wallops Station sounding rocket programs and Flight and Langley Research Centers flight research programs. Covers rockets, aircraft, and lifting bodies	5,598,000	4,900,000	4,500,000

	1971	1972	1973
Operations (Cont'd.)			
Communications - NASA's global communications network (NASCOM) supporting all NASA and NASA supported projects. Skylab is major addition to FY 1973 requirements.....	$ 37,111,000	$ 35,200,000	$ 34,100,000
Data Processing - Information processing for both real time control and analysis. Major new image data processing facility to support ERTS being installed in FY 1972.....	15,936,000	19,800,000	21,200,000
Equipment.....	$ 65,363,000	$ 46,200,000	$ 44,000,000
Spaceflight Tracking and Data Network - Procurement for consolidated Spaceflight Tracking and Data Network (STDN). Standardization and simplification of network systems.....	35,605,000	25,000,000	19,900,000
Deep Space Network - Long lead time procurements for Viking; completion of planetary tracking system for use at three 64-meter antenna sites; TV picture processing equipment for Mariner Venus/Mercury 1973.....	20,628,000	13,200,000	12,200,000
Aeronautics and Sounding Rocket Support - Procurement of non-recoverable flight hardware and specialized checkout and display equipment.....	3,769,000	3,900,000	3,100,000
Communications - Upgrading NASCOM voice circuit capability and expanding wideband data transmission capability.....	3,648,000	2,900,000	2,800,000
Data Processing - Initial procurement of Telemetry On-Line Processing System (TELOPS) to boost real time capability.....	1,713,000	1,200,000	6,000,000

	1971	1972	1973
Supporting Research and Technology.....	$ 12,900,000	$ 11,500,000	$ 11,500,000
Tracking, Orbit Determination, and Ground-Based Navigation - Improved techniques for ground-based navigation of planetary orbiters, landers, swing-by, and earth orbiter missions.....	3,131,000	3,063,000	2,770,000
Spacecraft-to-Ground Communications, Telemetry, and Command - Tracking and Data Relay Satellite System (TDRSS) studies emphasizing data management and data flow integration problems. Study extension of capabilities to handle multiple spacecraft support and increasing data rates.....	5,401,000	4,583,000	4,370,000
Network Operations and Control Technology - Study automation techniques for boosting rapid and real-time controls, and use of minicomputers for Deep Space Network.....	2,969,000	2,269,000	2,450,000
Data Handling and Processing - Definition of improved format standards. Development of processing systems for imaging data from earth resources technology satellites. Work on high data rate satellite problems.....	1,399,000	1,585,000	1,910,000

OFFICE OF TRACKING AND DATA ACQUISITION

TRACKING AND DATA ACQUISITION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The purpose of this program is to provide responsive and efficient tracking and data acquisition support to meet the requirements of all NASA flight projects. The Tracking and Data Acquisition program is a direct and vital counterpart to the total flight program of NASA through which the conduct of all space flight missions is carried out. In addition to NASA flight projects, support is provided, as mutually agreed, for projects of the Department of Defense, other government agencies, and other countries and international organizations engaged in space research endeavors.

Support is provided for manned and unmanned flights; for spacecraft, sounding rockets, and research aircraft; for earth orbital and suborbital missions; for lunar and planetary missions; and for space probes.

Types of support provided include: (a) tracking to determine the position and trajectory of vehicles in space, (b) acquisition of scientific data from onboard experiments, (c)acquisition of engineering data on the performance of spacecraft and launch vehicle systems, (d) transmission of commands from ground stations to spacecraft, (e) communication with astronauts and acquisition of biomedical data on their physical condition, (f) communication of information between the various ground facilities and central control centers, and (g) processing of data acquired from the space vehicles. Such support is essential for achieving the scientific objectives of all flight missions, for executing the critical decisions which must be made to assure the success of these flight missions, and, in the case of manned missions, to insure the safety of the astronauts.

Tracking and data acquisition support is provided by a worldwide network of NASA ground stations and an instrumentation ship, supplemented by appropriate instrumented aircraft. These facilities are interconnected by a network of ground communications lines, undersea cables, high frequency radio links, and communication satellite circuits which are leased from domestic and foreign carriers and which provide the capability for instantaneous transmission of data and critical commands between spacecraft and the control centers in the United States from which the flights are directed. Facilities also are provided to process into meaningful form the large amounts of scientific applications and engineering data which are collected from flight projects. In addition, instrumentation facilities are provided for support of sounding rocket

launchings and flight testing of aeronautical research aircraft.

The Research and Development appropriation provides funds for: (a) the operation and maintenance of the worldwide facilities; (b) the procurement of equipment to sustain and modify the systems to support continuing, new, and changing flight project requirements; and (c) the investigation and development of advanced tracking and data acquisition equipment and techniques.

SUMMARY OF RESOURCES REQUIREMENTS:

	1971	1972	1973
Operations	$211,680,000	$206,300,000	$203,600,000
Equipment	65,363,000	46,200,000	44,000,000
Supporting research and Technology	12,900,000	11,500,000	11,500,000
Total	$289,943,000	$264,000,000	$259,100,000

Distribution of Program Amount by Installation:

Marshall Space Flight Center	385,000	300,000	300,000
Goddard Space Flight Center	$207,361,000	$188,350,000	$186,250,000
Jet Propulsion Laboratory	63,149,000	54,770,000	53,150,000
Wallops Station	6,437,000	6,380,000	5,700,000
Flight Research Center	2,005,000	1,615,000	1,400,000
Langley Research Center	1,170,000	1,005,000	700,000
NASA Headquarters	9,436,000	11,580,000	11,600,000

BASIS OF FUND REQUIREMENTS:

The FY 1973 request reflects progress in reducing support costs through a continuing increase in total system efficiency. During FY 1973 the support workload will continue at a high level with Skylab support constituting a significant new support activity. The FY 1973 request also includes funds for the initiation of activity to consolidate the Satellite and Manned Space Flight Networks into a single Spaceflight Tracking and Data Network (STDN). This consolidation effort will take place over the next few years with the planned configuration objectives to be achieved during the period after the end of the Skylab project.

Operations

	1971	1972	1973
Spaceflight tracking and data network.....	$115,086,000	$108,500,000	$105,800,000
Deep space network.....	37,949,000	37,900,000	38,000,000
Aeronautics and sounding rocket support.....	5,598,000	4,900,000	4,500,000
Communications.....	37,111,000	35,200,000	34,100,000
Data processing.....	15,936,000	19,800,000	21,200,000
Total.....	$211,680,000	$206,300,000	$203,600,000

The total operational support workload in FY 1973 will remain relatively heavy and while there will be some cost increases for Skylab and ERTS support, the increases will be offset by support adjustments in other areas. The only significant increase within network operations is in the funding request for data processing operations, which includes a full year's cost for the operations and logistics of the ERTS data processing facility.

Spaceflight Tracking and Data Network (STDN) Operations

With the increasing trends toward high data rate satellites and real time or near real time control requirements in the unmanned area, plans are underway for the consolidation of the separate facilities of the Satellite Network and Manned Space Flight Network (MSFN) into a single Spaceflight Tracking and Data Network (STDN). This consolidation effort will take place over the next few years with the planned configuration objectives to be achieved during the period after the end of the Skylab project. While the STDN must retain many of the characteristics of the individual Manned Space Flight and Satellite Networks during the transition period, emphasis will be placed on achieving a single network configuration of fewer stations and with a flexible system capability to support the total workload of all earth orbital missions.

The network stations formerly associated with the MSFN will continue to provide support to the remaining Apollo and Skylab missions on a priority basis, along with an increasing support workload in the unmanned area. These stations include 11 prime land stations, 4 instrumented aircraft, and 1 instrumented ship. The eleven land stations are located at Cape Kennedy; Bermuda; Ascension Island; Grand Canary Island; Carnarvon, Australia, Guam; Kauai, Hawaii; Corpus Christi, Texas; Madrid, Spain; Canberra, Australia; and Goldstone, California. This network will be augmented in FY 1972 with a transportable S-band station located in Newfoundland, Canada, to provide Skylab launch support. This transportable station was formerly located on Grand Bahama Island and was deactivated after the successful Apollo 11 lunar landing.

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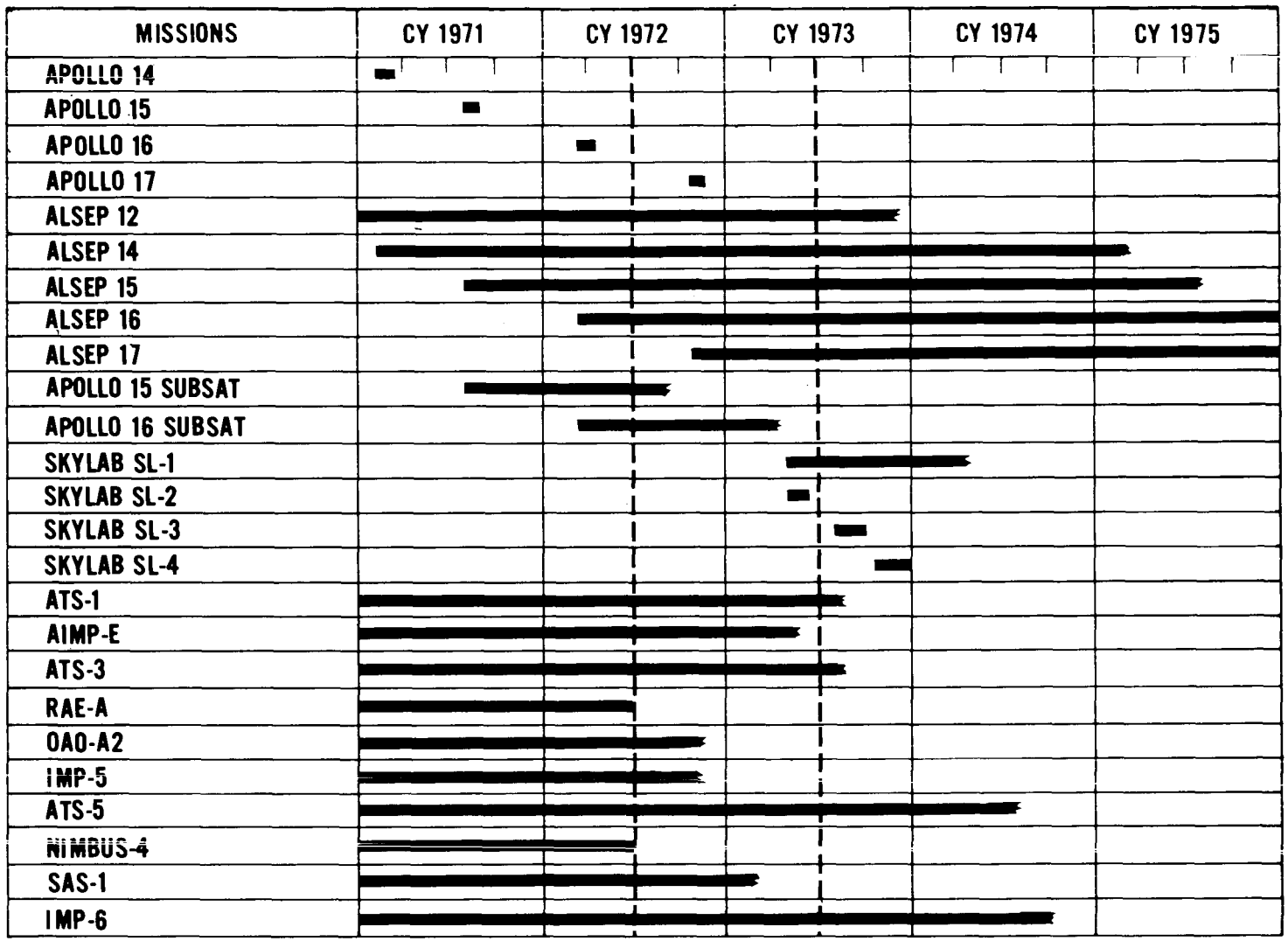
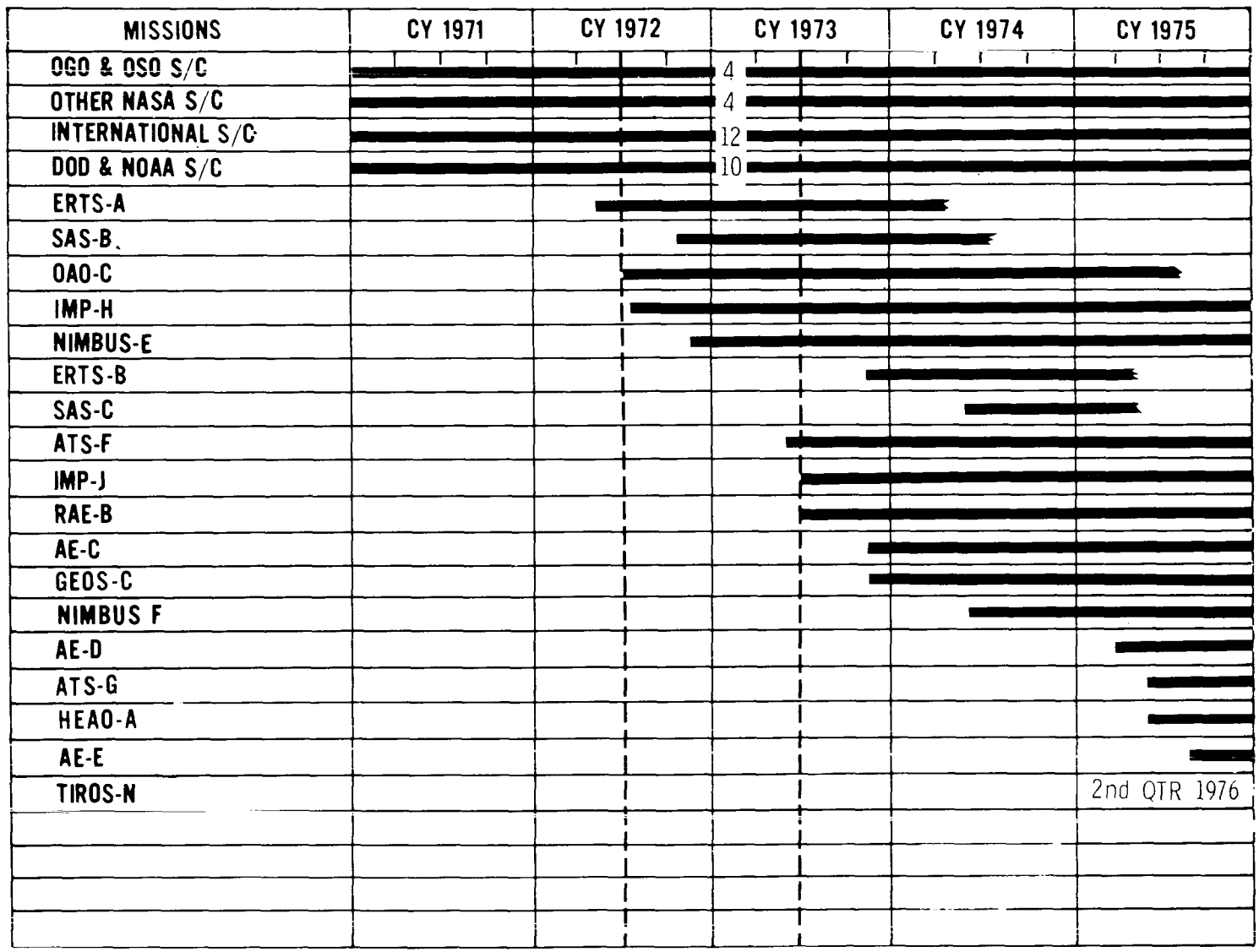
SPACEFLIGHT TRACKING AND DATA NETWORK WORKLOAD



NASA HQ TN72-15167 Rev. 1-4-72

SPACEFLIGHT TRACKING AND DATA NETWORK CONT. WORKLOAD



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The MSFN stations were designed to collect and communicate real time information needed to determine: (1) the precise location and operation of both the command and lunar modules as well as the Saturn launch vehicles; (2) the status of onboard equipment and experiments; and (3) the physical condition of the astronauts. The network is configured to provide this real time information to the Mission Control Center at Houston, Texas, so that immediate decisions affecting the conduct of the mission may be made and executed. In addition, information from scientific experiments both onboard the spacecraft and deployed for long term operation on the surface of the moon, is collected and processed for post flight analysis.

Along with the scheduled Apollo missions, the MSFN stations are currently supporting the Particles and Fields Satellite left in lunar orbit by Apollo 15 and the Apollo Lunar Surface Experiment Packages (ALSEPs) left on the moon's surface by the Apollo 12, 14, and 15 missions. Apollo 16 and 17 will also carry ALSEPs for deployment on the moon's surface. During FY 1973 the stations will be supporting Apollo 17, all the ALSEPs still producing usable scientific data, the satellites left in lunar orbit by Apollos 15 and 16 plus the Skylab orbital workshop mission.

These stations will also be required to support an increasing number of the more complex unmanned missions where the characteristics of the spacecraft closely match the existing capabilities of the stations. These characteristics include the tracking accuracies which the unified S-band equipment can provide, and higher data rate bandwidths which can only be accommodated in the S-band frequency range.

Those stations formerly associated with the Satellite Network will continue to support all unmanned scientific and applications satellite programs. These stations provide a ground system which: (1) tracks each satellite; (2) determines the status of onboard systems; (3) commands the satellite functions; and (4) acquires stored or realtime data from the satellite. The optical tracking stations operated by the Smithsonian Astrophysical Observatory will continue providing specialized services required for precision orbital tracking.

The ten ground stations presently associated with the Satellite Network are located at Fort Myers, Florida; Mojave, California; Rosman, North Carolina; Faribanks, Alaska; Quito, Ecuador; Santiago, Chile; Winkfield, England; Johannesburg, South Africa; Tananarive, Madagascar; and Canberra, Australia. In addition, a transportable facility is being modified at Mojave, California, prior to relocation for Applications Technology Satellites (ATS) F and G support.

The number of satellites requiring support in FY 1973 is expected to average approximately 40 satellites with a representative total of some 235 experiments. It will be necessary to make continuing adjustments in priorities of all satellites supported in order to assure adequate coverage

within the network capability. A significant additional workload will result from the launch of ERTS A in late FY 1972. Of the other new satellites to be launched, the Nimbus E, and OAO C missions will impose a substantial workload on the network due to their unique support requirements. The overall workload for the combined STDN is indicated in the accompanying chart.

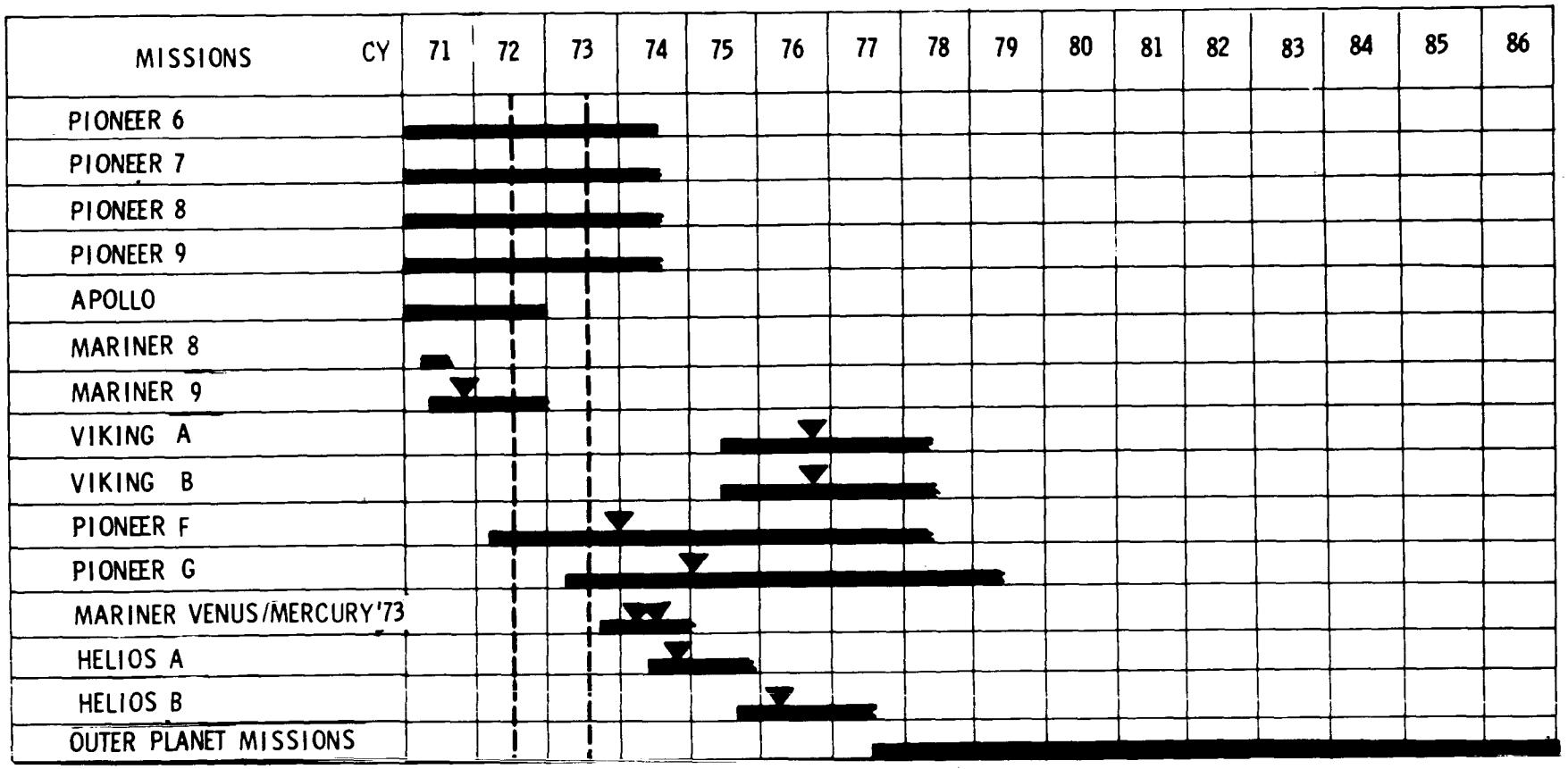
Deep Space Network Operations

The primary function of the Deep Space Network is to support planetary and interplanetary space flight missions. In the past these missions have involved spacecraft traveling to Venus and Mars, distances up to two hundred million miles from the earth. Future missions will travel to Jupiter and beyond involving distances of six hundred million miles and greater. As a result of these great distances, the facilities in this network which receive the data must be able to perform critical functions using extremely low signal levels. As flight distances continue to increase, equipment designs and computer program techniques are required in this network which truly push the state of the art in interplanetary communications. The Deep Space Network facilities also provide essential backup support to the Apollo program including the Goldstone 64 meter (210 foot) station, which plays a particularly important support role.

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

During FY 1972 the Deep Space Network workload consists of four ongoing Pioneer spacecraft, the Mariner 9 mission, the Apollo manned lunar missions, and the Pioneer F mission which is scheduled to be launched in the third quarter of FY 1972. The major portion of this workload, reflected in the accompanying workload chart, will continue on into FY 1973 along with support of the Apollo 17 and the Pioneer G mission, which is scheduled to be launched in the fourth quarter of FY 1973. The Pioneer 6, 7, 8, and 9 spacecraft are in an extended mission phase; support for these missions was reduced in FY 1972 and will continue at a reduced level in FY 1973. Because of the exceptional receiving system characteristics required to communicate with distant spacecraft, the Deep Space Network facilities also provide unique support to certain ground based radio science experiments. Support of these experiments will continue on a noninterference basis to the flight missions.

DEEP SPACE NETWORK
WORKLOAD



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The FY 1973 request includes funds for operation of the Deep Space Network facilities in support of the continuing workload. In addition to the routine mission support, indicated on the workload chart, network engineering, programming, and computational support are necessary to meet the requirements of Pioneer G. Mariner Venus/Mercury '73, Helios, and Viking '75 missions.

Aeronautics and Sounding Rocket Support Operations

Instrumentation systems are operated and maintained in support of sounding rocket programs conducted by Wallops Station, Virginia; and for flight research programs of the Flight Research Center, California; and the Langley Research Center, Virginia. General purpose tracking, telemetry, data handling, recording, timing, plotting, and communications systems are provided as well as special purpose fixed and mobile optical and sound ranging (acoustical) equipment. The budget request for FY 1973 reflects a slight reduction as compared to prior years.

Specialized mobile telemetry and optical equipments are maintained and operated at selected sites along the eastern seaboard and on the Bermuda Islands to support rocket flights from Wallops Station. Some of this down-range instrumentation is operated by the Langley Research Center, which also provides telemetry stations (two fixed and one mobile) in support of its aeronautical flight programs.

The 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, M2-F3, X-24B, C5-A, YF-12, and F-8.

Communications Operations

NASA's global communications network (NASCOM) interconnects the NASA tracking and data acquisition facilities in operational support of all NASA projects and projects of other agencies that are supported by NASA. It interconnects by means of leased circuits such facilities as telemetry and command control sites, launch areas, test sites, and mission control center. The Goddard Space Flight Center operates the network and serves as its major switching point. In the interest of economy, reliability, and full utilization of trunk circuitry, subswitching centers have been established at a number of domestic and overseas locations.

As the NASA flight missions have become more complex in terms of increased data rates and real time or near real time control, substantial advances and innovations have been required in communications technology.

Foremost among these advances have been the development of satellite communications and the use of computerized switching. A third innovation is expected to be used in support of the Skylab communications requirements, which represent a considerable increase over those of Apollo. For Skylab the NASCOM data circuit transmission rates will be upgraded from the 4.8 kilobits per second (Kbps) used for Apollo to 7.2 kilobits per second, a fifty percent increase in data transmission rates. This capability has been brought about through the use of newly developed terminal equipment which has the effect of increasing the amount of usable data that can be transmitted over a normal voice circuit. As a result, except for one additional telemetry/tracking circuit to all the manned space flight stations, the increased Skylab requirements will be met with the same number of circuits as were used for Apollo. These circuits also will be used for other high data rate satellites, such as ERTS, Nimbus, OAO, and HEAO.

The FY 1973 budget request provides for these Skylab requirements as well as the requirements of all other NASA flight projects. Improved efficiency in overall communications support allows a decrease in the budget request despite the increasing requirements.

Data Processing Operations

Information received in the form of tracking and telemetry data from spacecraft must be processed into a form that is useful both to those performing the real time control of the space vehicle and those responsible for analyzing the scientific and applications data acquired by the spacecraft. Support must be given to a wide variety of programs which vary from the small Explorer satellites to the large and complex Solar and Astronomical Observatories, and the Applications and Earth Resources Technology Satellites.

Tracking data are processed to provide orbital elements which are used to supply stations with predictions of future 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 1973 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, with the exception of the Earth Resources Technology Satellite (ERTS), without major increases in data processing capability.

In FY 1972, a major new image data processing facility to support ERTS is being placed in operation. This facility processes the large quantities of image data received from ERTS and provides photographic products to the principal investigators for analysis. This new facility will have its first full year of operation in FY 1973, which accounts for the increase in the data processing funds requested for FY 1973.

Equipment

	1971	1972	1973
Spaceflight tracking and data network.....	$35,605,000	$25,000,000	$19,900,000
Deep space network.....	20,628,000	13,200,000	12,200,000
Aeronautics and sounding rocket support.....	3,769,000	3,900,000	3,100,000
Communications.....	3,648,000	2,900,000	2,800,000
Data processing.....	1,713,000	1,200,000	6,000,000
Total.....	$65,363,000	$46,200,000	$44,000,000

The tracking and data acquisition support requirements placed on the networks establish needs for equipment which are essential to provide the continual on-going support to approved programs. Funds for equipment are required to replace obsolete and wornout items, to modify existing systems to maintain compatibility with changes in flight mission objectives and associated spacecraft instrumentation, to increase the support utilization and efficiency of existing systems, and to complete or provide new systems required to support specific flight missions of approved programs.

In FY 1973 the request includes funds for sustaining the existing capability of networks along with equipment additions to meet the requirements of upcoming planetary programs (Pioneer G, Mariner Venus/Mercury '73 Helios, and Viking). Also included in the request are funds for the initial

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effort to provide a standard network configuration for support of the advanced post-Skylab earth satellite missions, such as Nimbus F, Earth Resources Technology Satellite B, High Energy Astronomy Observatory (HEAO) A&B, and Atmosphere Explorer (AE) D&E. To accomodate the increasing data handling and realtime control requirements, funds are included in the FY 1973 request for a telemetry on-line processing system.

Spaceflight Tracking and Data Network Equipment

As in Operations, the Satellite and Manned Space Flight Networks have been combined into a single line item reflecting a planned effort to consolidate and treat these separate facilities as a single network. The Spaceflight Tracking and Data Network (STDN) equipment program encompasses procurement of equipment and services necessary: (a) to sustain the network's continuing capability for reliable support of on-going missions, (b) to meet new requirements for network support of manned space flight and unmanned scientific and applications satellite missions, and (c) to effectively combine the capabilities of the former Satellite and Manned Space Flight Networks to assure efficient tracking and data acquisition support for all earth orbital missions in the post-Skylab period.

During FY 1972, activity in the equipment program has been primarily devoted to sustaining the network's capabilities in a continuing state of readiness for support of on-going missions such as the manned Apollo 15 and 16 flights and the unmanned Orbiting Solar Observatory, Radio Astronomy Explorer, Particles and Fields Satellite, Applications Technology Satellites, and Apollo Lunar Surface Experiment Packages. The network's capabilities to support the Earth Resources Technology Satellite A, Nimbus E, Skylab, and other on-going scientific satellite projects have been completed during the year. In addition, modifications to provide a capability for processing data from Atmosphere Explorer C in the control center in near real time have been initiated in FY 1972 and will be completed in FY 1973.

During FY 1973, the network will support approximately 40 missions with requirements which range from the highly complex, mission operational, tracking and communications support of the Skylab manned orbital workshop and the very high data rates of the Earth Resources Technology Satellites to the localized tracking and telemetry support for launches of spacecraft. Continuation of the network's excellent performance for support of this demanding workload requires a continuing equipment modification effort in FY 1973 to maintain the quality and reliability of the network's systems and subsystems. Accordingly, funds are requested for replacement of failure prone systems with more reliable units, for equipment modifications to correct operational deficiencies, and for equipment to be used in operational control of the network. Funds are also requested for provision and modification of test equipment and for minor equipment modifications resulting from changes in support requirements from one mission to the next.

In addition, funds are requested in FY 1973 to initiate a phased plan for standardization and simplification of network systems to assure efficient tracking and data acquisition support for approved post-Skylab missions such as Nimbus F, Earth Resources Technology Satellite B, High Energy Astronomical Observatories A and B, Atmosphere Explorers D and E, and other space science and applications missions. Under this plan, standard systems based on the most technologically advanced equipment in the present Manned Space Flight and Satellite Networks will be implemented throughout the network for the major functions of tracking, telemetry, command and data handling.

The unified S-band system, which has demonstrated outstanding support capabilities for the Apollo lunar landing program, will be employed as the network's primary tracking and telecommunications system for major spacecraft. Modularly designed telemetry and command processing systems of the type initiated for the Satellite Network in FY 1971 will be implemented as standard systems for these functions in the consolidated network. As general purpose systems, they will be sufficiently flexible to encompass the majority of new project command and telemetry processing requirements with only minor modular additions and modifications.

This plan for consolidation of Manned Space Flight and Satellite Network systems is phased for completion in the post-Skylab period. On completion, the network's equipment configuration should provide the necessary flexibility for earth orbital flight project support and permit economies in network operations, logistics and software costs.

Deep Space Network Equipment

The equipment program in FY 1973 for the Deep Space Network includes the procurement of equipment and services needed to insure that the ground support systems can meet the more demanding support requirements of upcoming planetary and interplanetary flight spacecraft. At the same time it also provides for sustaining the network systems and facilities for supporting the on-going flight missions in a reliable manner.

In preparation for the upcoming Viking missions, a number of long leadtime procurements are planned for support of the complex dual orbiter/dual lander configuration. These include the acquisition of additional data handling and receiver capabilities to allow simultaneous reception and recovery of multiple downlink data channels from more than one vehicle required for the first time in the Deep Space Network. The data handling equipment will be similar to the general purpose types previously implemented for the Mariner '71 and Pioneer F missions. The receiver equipment will be similar to the dual S/X band equipment currently being implemented at the Goldstone 64 meter (210 foot) antenna site to support Mariner Venus/Mercury '73. The Mariner Venus/Mercury '73 will be the first planetary mission transmitting X-band and will demonstrate the technological advantages of

the higher frequency for improved communications and tracking required for future deep space missions. In addition to the receiver equipment, antenna microwave and maser augmentations associated with the S/X-band capability will be undertaken for the new overseas 64 meter sites to provide the support required for Viking and future missions beyond Mars.

In FY 1973, funds are included in the request to complete the new planetary tracking system initiated in FY 1972 for use at the three 64 meter antenna sites. This equipment, in addition to providing spacecraft ranging at planetary distances, will provide the capability required to track the two Viking spacecraft simultaneously in orbit around Mars. Funds are also requested in FY 1973 to initiate procurement of long lead-time components for the high power transmitter capability at the overseas 64 meter antenna stations for the Viking mission. Since Viking requires tracking and command for the two orbiter and two lander spacecraft, a higher powered transmitter system will be necessary to command simultaneously with dual transmission The transmitters will also be capable of communicating with and controlling more distant spacecraft such as the Pioneer F and G after they have passed beyond the planet Jupiter in their outward bound trajectories.

Funds are also requested for the control center at Pasadena to provide the necessary support for processing and displaying the TV pictures to be returned from the gravity swingby Mariner Venus/Mercury '73 mission. A phased implementation of additional data processing and display equipment was initiated in FY 1972.

As part of the on-going support to flight missions, FY 1973 funds are also requested to assure that network reliability and operational integrity are maintained. As in the past, this requires a continuing effort to replace obsolete or high failure prone items, and to modify the existing modules or subsystems where it is indicated that standardization is cost effective. Typical items requiring replacement in the network are test and calibration equipment, major cable assemblies, simulation modules, digital logic modules, R-F microwave components, recording equipment, and hydraulic components.

Aeronautics and Sounding Rocket Support Equipment

A wide variety of fixed and mobile equipment is used to provide instrumentation support of sounding rockets and re-entry vehicles launched from Wallops Station and other locations, and for aeronautical flight research projects conducted by the Flight Research Center and Langley Research Center.

At Wallops Station, funds in FY 1973 are required to sustain existing capability by the provision of maintenance and spare parts, and the procurement of nonrecoverable flight hardware such as onboard antennas, transponders, and support instrumentation.

Telemetry ground stations are operated by the Langley Research Center to support aeronautical research programs such as collision avoidance and noise abatement. The aircraft used in these programs are flown from the Wallops and Langley airfields. Funds are requested in FY 1973 to procure specialized checkout and display equipments which are necessary to adapt the ground stations to the requirements of specific flight missions.

The Flight Research Center's Aerodynamic Test Range consists of stations at Edwards, California, and Ely, Nevada, which support various aircraft and lifting body projects such as the F-111, F-104, M2-F3, X-24B, C5-A, YF-12, and F-8.

During FY 1973, funds will be required for the procurement of maintenance and repair parts and for equipment modifications. Radar and telemetry display equipments require continuing modification during the course of flight test programs due to changing requirements.

Communications Equipment

The FY 1973 budget request includes funds for the on-going sustaining effort to maintain the integrity and reliability of the NASA Communications Network (NASCOM). The request further includes funds for the procurement of equipment to improve the efficiency of the network.

In FY 1973 the major effort will continue to upgrade the voice circuit capability in the network and to expand the wideband data transmission capability. As flight projects with high data rates and real time control requirements have evolved over the past several years, communications technology has continued to push the state of the art to meet these requirements. As an example, data transmission speeds over a normal voice circuit have increased from 1,200 bits per second a few years ago to the 7,200 bits per second currently planned for support of Skylab. This increase in efficiency has been achieved through the use of recently developed terminal equipment. Similarly, in the expansion of the wideband data transmission capability, special data modems are being incorporated into the network.

To sustain the network in a highly reliable condition, a continuing program of equipment replacement, repair, and modification is necessary. Types of equipment required include modulating/demodulating units, multiplexers, encoders/decoders, line drive amplifiers, character generators, and control panels. In addition, the computer operated communications equipment must be maintained to a high degree of reliability and requires various modification kits, replacement units, and spare parts, as well as test and evaluation hardware.

Data Processing Equipment

FY 1973 funds are requested to initiate the procurement of a Telemetry On-Line Processing System (TELOPS). The increased data volume from future spacecraft coupled with increasing demands to provide data to experimenters in real time (or near real time) exceeds the capacity and capabilities of the present data processing systems. The design of TELOPS will meet these requirements which cannot be met by expansion of the present data processing facility.

The new system includes a large mass storage device, capable of containing, on-line, the large amount of data sent from scientific spacecraft supported by the Spaceflight Tracking and Data Network (STDN). This stored data can be extracted both for real time mission operations purposes as well as for nonreal time applications such as scientific analysis. Increased operational efficiency will be realized in this manner of operation by reducing the amount of data which is actually processed and in the reduction of magnetic tapes purchased along with their associated handling costs.

FY 1973 funds are also requested to maintain the existing data processing systems which are operated 18 hours per day. Obsolete and worn out equipment such as analog tape decks must be replaced, and normal sustaining items, such as logic modules and components, must be procured.

Supporting Research and Technology

	1971	1972	1973
Tracking, orbit determination, and ground based navigation..	$3,131,000	$3,063,000	$2,770,000
Spacecraft/ground communications, telemetry and command.	5,401,000	4,583,000	4,370,000
Network operation and control technology.....	2,969,000	2,269,000	2,450,000
Data handling and processing..	1,399,000	1,585,000	1,910,000
Total.....	$12,900,000	$11,500,000	$11,500,000

The purpose of the Supporting Research and Technology (SRT) program is to translate tracking and data acquisition requirements of future space missions into the ground support instrumentation capabilities and network operating techniques needed to successfully support these future flight projects. The SRT program provides the funds for the investigation, study, and development of hardware systems and operating techniques needed not only for support of specific projects but also for achieving a cost-effective and reliable overall tracking and data acquisition capability to support the total mix and variety of flight projects. Program effort in FY 1973 has been consolidated into four basic areas with the following major activities planned within each.

Tracking, Orbit Determination, and Ground Based Navigation

Developments in this area include effort on tracking system instrumentation, on improved measurement and computation techniques, and effort to improve the acquisition of weak signals thereby increasing the amount of data that can be obtained from the spacecraft in the more distant planetary missions. Also included are metric evaluation and analyses to meet the tracking and in-flight control needs of future space missions. Effort for FY 1973 is aimed at improved tracking systems techniques required to meet the ground based navigation needs of planetary orbiters, landers, and gravity assisted swing-by missions, and the guidance and control needs of earth orbiting missions. The effects of ground system tracking error sources on tracking and spacecraft navigation will be studied so that proper preproject planning and developments can occur. The development of mathematical models as a tool for analysis and as an aid for calibration has become a particularly important portion of this effort.

Spacecraft-to-Ground Communications, Telemetry, and Command

Under this area, work is conducted on new and improved spacecraft to ground communications, telemetry, and command systems, including antenna subsystems, receiving and transmitting subsystems, spacecraft transponders and station data handling and control subsystem.

The studies on the Tracking and Data Relay Satellite System (TDRSS) are funded in this area. In FY 1973, work on TDRSS will include studies of over-all system operation and control with particular emphasis on problems of data management and integration of the high volume data flow into network and control center data handling, communications, and control systems. Work will continue on ground station systems definition and design, on definition of design parameters for user spacecraft communications systems, and on development of critical ground station subsystems required to to implement TDRSS.

Studies and developments will be continued in FY 1973 to extend the capabilities of existing space telecommunications links to handle multiple spacecraft support and increasing spacecraft-to-ground telemetry data rates with high reliability. For the planetary missions, these capabilities are needed for acquiring greater volumes of data at greatly increased distances--- more than a half-billion miles to Jupiter, for example. Other efforts will include development of multiband, low noise, microwave subsystems and the investigation of techniques for greater efficiency in the operation of ground antenna systems and for rapid changeover from one equipment configuration to another to maximize station utilization. Studies will continue on signal coding and modulation techniques to improve telemetry data transmission efficiency, particularly for the outer planet missions where signals are very weak and must be received in the presence of high levels of electronic noise or static. Techniques will also be developed for improved transmission efficiency in sharing of the up-link by several spacecraft within a single antenna beam for simultaneous independent command

and control so as to improve the utilization of the high power ground transmitters.

Network Operations and Control Technology

The reliable and efficient functioning of future network systems and operating techniques for the least cost in the prime objective in this area. During FY 1973, work on techniques for achieving operating efficiency through automation of some of the station functions will be extended with particular emphasis on the increasing needs for rapid and real time control of network functions. A similar effort will continue for the Deep Space Network involving the use of minicomputers to reduce the mission to mission turnaround time at the stations while minimizing the number of operators needed.

Data Handling and Processing

Efforts in this area are directed toward the development of techniques and systems for central handling and processing of data to accommodate the needs of future spacecraft. In FY 1973 special attention will be given to the definition of improved data format standards and the switching, routing, on-line processing, and storage of data from very high data rate satellites. Also, emphasis will be placed on the development of techniques and systems for the processing and quality control of imaging data from earth resources technology satellites. Developments for planetary mission data processing will be aimed at a capability for simultaneous and rapid access to mission status and science data for multiple missions through development of standardized interface hardware and software.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1973 ESTIMATES

BUDGET SUMMARY

OFFICE OF INDUSTRY AFFAIRS AND TECHNOLOGY UTILIZATION

TECHNOLOGY UTILIZATION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1971	1972	1973
New technology dissemination.....	$863,000	$1,085,000	$850,000
New technology identification, evaluation and publication.....	1,151,000	1,055,000	1,100,000
Technology applications.....	1,586,000	2,335,000	1,600,000
Program evaluation and benefits.....	400,000	525,000	450,000
Total.....	$4,000,000	$5,000,000	$4,000,000

HIGHLIGHTS OF BUDGET PLAN

	1971	1972	1973
Identification and evaluation of new technology items; publication and distribution of Tech Briefs, technical support packages, and other special publications.....	$863,000	$1,085,000	$850,000
Dissemination and transfer of aerospace technology results to industrial and public sector uses; operation of regional user-oriented transfer services.....	1,151,000	1,055,000	1,100,000
Identification of public sector problems solvable by aerospace technology; operation of biomedical and technology applications teams; applications of aerospace technology to public sector needs.....	1,586,000	2,335,000	1,600,000
Program evaluation and benefits; analysis, improvement and implementation of transfer methods; assess economic benefits of aerospace technology.....	400,000	525,000	450,000

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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 law enforcement, environmental protection, and safety. Developing multiple uses of the nation's aeronautical and space developed technology provides an additional return to the public for its investment in NASA's research and development efforts.

The primary objectives of the NASA Technology Utilization program are: (1) to increase the return on the national investment in aerospace research and development by encouraging additional uses of the knowledge gained in those programs; (2) to shorten the time gap between the discovery of new knowledge and its effective widespread use; (3) to move new knowledge across industry, disciplinary, and geographical boundaries; and (4) to develop better means of transferring technology from its points of origin to its points of potential use.

In FY 1973 the emphasis of the Technology Utilization program will be to shorten the time between the development of new technology and its useful application into the market particularly in those areas of public concern for which technological contributions fulfill a currently unmet need. Efforts will be increased in applying technological solutions to significant public sector needs for demonstration of utility and eventual adaptation in the marketplace.

SUMMARY OF RESOURCES REQUIREMENTS:

	1971	1972	1973
New technology identification, evaluation and publication	$863,000	$1,085,000	$850,000
New technology dissemination	1,151,000	1,055,000	1,100,000
Technology applications	1,586,000	2,335,000	1,600,000
Program evaluation and benefits	400,000	525,000	450,000
Total	$4,000,000	$5,000,000	$4,000,000
Distribution of Program Amount by Installation:			
NASA Headquarters	$4,000,000	$5,000,000	$4,000,000

BASIS OF FUND REQUIREMENTS:

New Technology Identification, Evaluation and Publication

The work in this area is done by Technology Utilization officers at eleven NASA installations and by university and industry specialists who identify NASA-sponsored scientific and technical endeavors of potential utility to the nonaerospace sector of the economy. Examples include new technology in nondestructive testing, cryogenics, laser applications, and human factors engineering. Findings are published in TU Tech Briefs, Surveys, Handbooks, and Reports.

New Technology Dissemination

Six Regional Dissemination Centers, largely operated by universities, transfer aerospace technology to nonaerospace industry and business. They do this by computerized search-and-match efforts resulting in the identification and transfer of technology relevant to the client firm's needs.

During FY 1973, particular emphasis will be placed on location and development of manufacturing, production, and marketing for technical developments resulting from applications engineering and related public sector product development activities.

In addition, software for selected computer programs developed in the course of R&D performed for NASA and other government agencies will be made available to industry, government and other interested users through the Computer Software and Management Information Center (COSMIC).

Technology Applications

NASA-sponsored public sector Applications Teams assist groups concerned with medical technology, environmental pollution, urban affairs and public safety in the definition of problems to whose solution NASA aeronautical and space developed capabilities will contribute.

Selected projects will be sponsored to perform the necessary applications engineering. Such projects are required to demonstrate the effectiveness and applicability of the technology to specific public sector needs. Encouragement in the form of incentives will be given to private contractors to further develop technological solutions and public sector markets so that benefits will be widely available throughout the economy.

Program Evaluation and Benefits

The effect of such factors as time lag, technology characteristics and the structure of the industry on the effectiveness of technology transfer will be evaluated. Instances of effective transfer will be documented.

The impact of and benefits of NASA R&D programs on current industrial practice and on national capabilities will be studied. Findings will be brought to the User Community through conference exhibits.

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