National Aeronautics and Space Administration

BUDGET ESTIMATES

FISCAL YEAR 1972

Volume I

SUMMARY DATA

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1972 ESTIMATES

SUMMARY DATA

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FISCAL YEAR 1972 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. These activities contribute materially to: the expansion of human knowledge of the atmosphere and space; the improvement and usefulness of aeronautical and space vehicles; the development and operation of space vehicles; the preservation of United States leadership in aeronautics and space technology and utilization; the dissemination of pertinent information gained in the program to civil and military agencies; the cooperation with other nations in aeronautics and space activity pursuant to peaceful interests; and the effective utilization of scientific and engineering talents and facilities of the nation.

Appropriations totaling $3,271,350,000 are requested in FY 1972 to support current and proposed programs.

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 continue to be pursued within NASA installations, other Government agencies, universities, and research contractors. The major elements of the programs may be summarized in the following categories:

MANNED SPACE FLIGHT: A program for the continued development and demonstration of a capability for manned space operations and exploration; to maintain progress in manned space flight as the program evolves from an emphasis on lunar exploration to a focus on earth orbit missions that produce direct and practical benefits for man; to proceed toward the development of a space shuttle, a low-cost space transportation system that will allow man to journey into space routinely and economically; to study space station and experiment facilities for use in near earth orbit; and to provide information required for future decisions concerning follow-on space programs.

SPACE SCIENCE AND APPLICATIONS: A program of unmanned space flight involving: (1) scientific investigations of the earth, solar systems, stars, and space environment; planetary and interplanetary investigations; and experiments on the effects of the space environment on living organisms; and (2) the use of space and of space technology for the direct benefit of mankind in areas such as meteorology, communications, navigation, traffic control, geodesy, and earth resources.

ADVANCED RESEARCH AND TECHNOLOGY: A continuing program to provide the research and technology base for future space and aeronautics missions. Space Research and Technology activity provides the technology requirements for spacecraft and launch vehicle systems and includes efforts in such areas as materials, structures, guidance, control, and information systems.

Aeronautical Research and Technology provides the technology base for development and production of both civil and military aircraft. The program includes research on aerodynamics loads and structures, propulsion, flight dynamics, guidance, and control as related to aircraft requirements. Aeronautical research also emphasizes technology support for aircraft transportation systems and includes initiation of design and development of an experimental STOL transport research aircraft.

Nuclear Power and Propulsion activities provide the technology base for use of nuclear energy to meet space mission requirements for propulsion and electric power. Specific efforts include development of an advanced reactor and isotope energy conversion systems, improvement to efficiencies and life time of current power conversion systems, and development work on essential long-lead time components of a nuclear propulsion system.

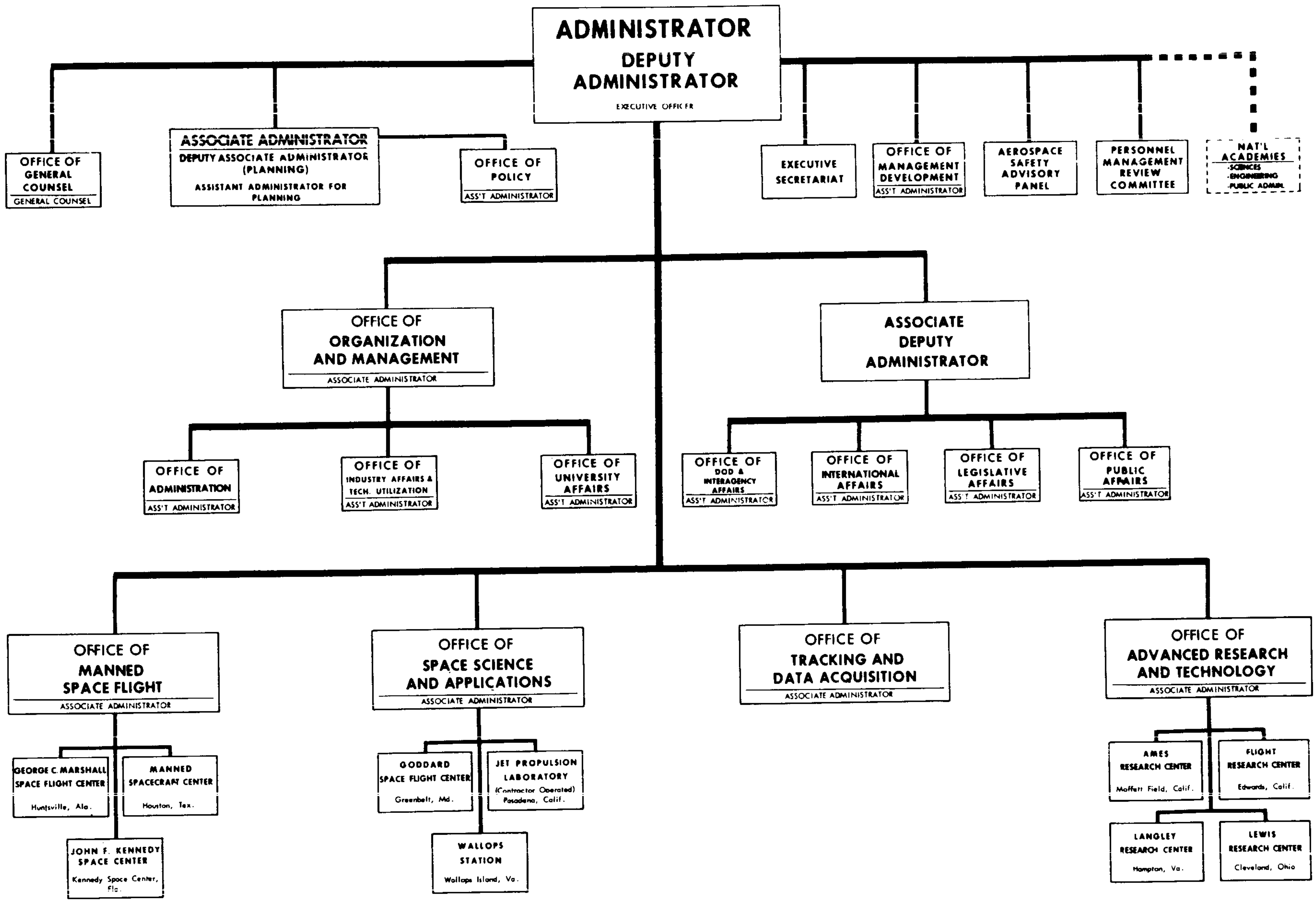
TRACKING AND DATA ACQUISITION: A program for providing the tracking and data acquisition support required by the NASA manned and unmanned space flight programs through maintenance and operation of the NASA worldwide networks.

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.

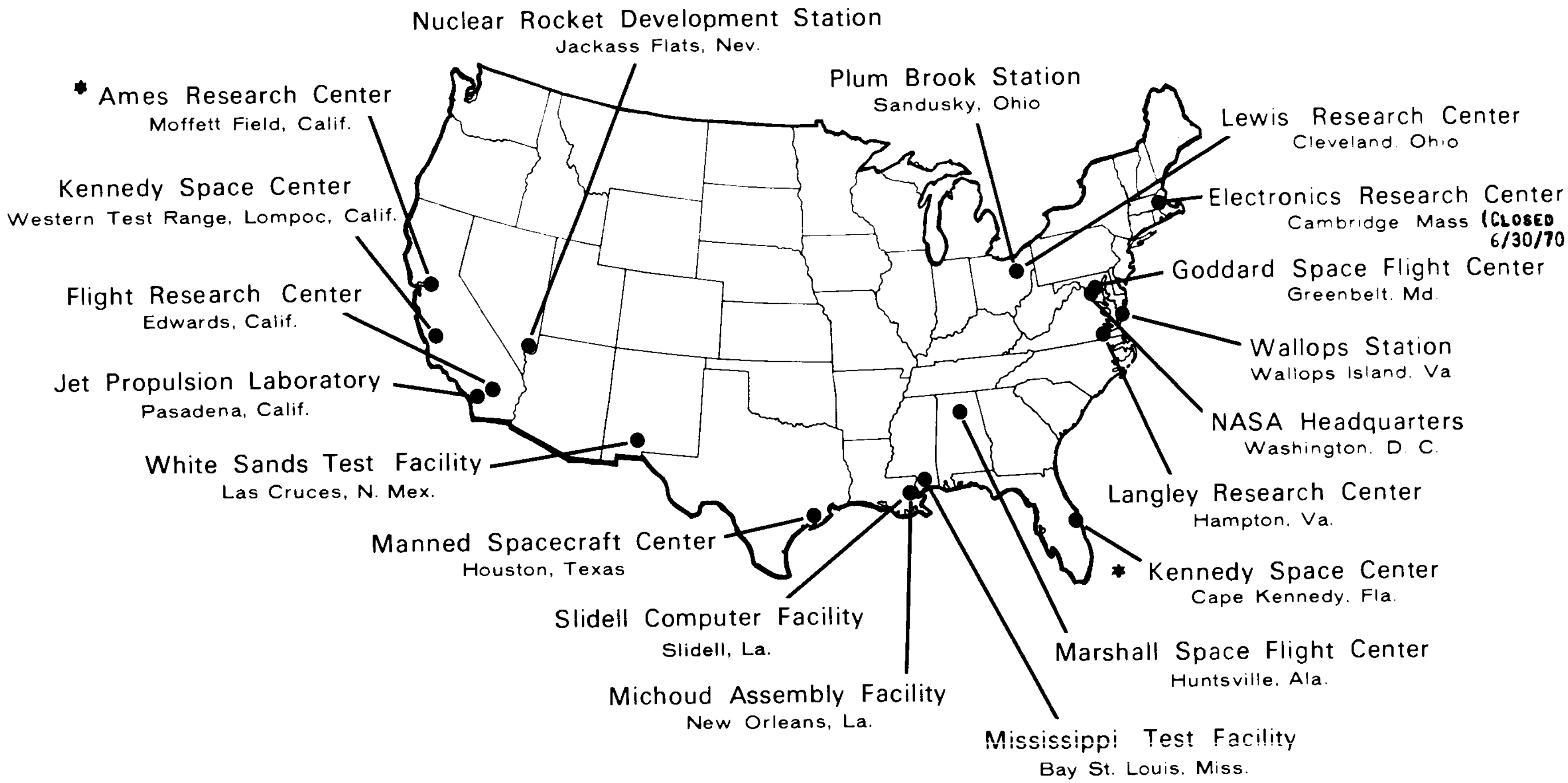
Detailed justifications of the FY 1972 budget estimate for the total programs of $3,271,350,000 are provided in the following three volumes:

II	Research and Development	$2,517,700,000
III	Construction of Facilities	56,300,000
IV	Research and Program Management	697,350,000
	TOTAL	$3,271,350,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION



NASA INSTALLATIONS



* Installations for which construction projects are requested in the FY 1972 budget estimates.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1972 ESTIMATES

SUMMARY OF APPROPRIATIONS

(In thousands of dollars)

	Total	Research and Development	Construction of Facilities	Research and Program Management
FISCAL YEAR 1970				
Independent Offices and Department of Housing and Urban Development Appropriation Act, 1970 (83 Stat. 229)......	$3,696,633	$3,006,000	$53,233	$637,400
Second Supplemental Appropriations Act, (84 Stat. 400)....................	38,000	---	---	38,000
Subtotal, Definite Appropriation.......	3,734,633	3,006,000	53,233	675,400
Second Supplemental Appropriations Act, (84 Stat. 403), Indefinite Appropriation.............................	14,583	---	---	14,583
NASA Appropriation Transfers (83 Stat. 230)........................	---	-13,046	---	+13,046
Transfer to "Operating Expenses, Public Buildings Service," General Services Administration (83 Stat. 229)..........	-474	---	---	-474
1969 Funds Applied to 1970 Program pursuant to P.L. 90-364................	+117,473	+117,473	---	---
Reprogrammed to prior year budget plan...	-3,121	---	-3,121	---
Appropriation available................	$3,863,094	$3,110,427	$50,112	$702,555

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1972 ESTIMATES

SUMMARY OF APPROPRIATIONS (CONTINUED)

(In thousands of dollars)

	Total	Research and Development	Construction of Facilities	Research and Program Management
FISCAL YEAR 1971				
Independent Offices and Department of Housing and Urban Development Appropriation Act, 1971 (84 Stat. 1449)................................	$3,268,675	$2,565,000	$24,950	$678,725
NASA Appropriation Transfers (84 Stat. 1450)................................	---	-10,000	---	+10,000
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
Proposed supplemental for civilian pay act increase.....................	+29,854	---	---	+29,854
Appropriation available and proposed..	$3,298,383	$2,555,000	$24,950	$718,433
FISCAL YEAR 1972				
Appropriation request..................	$3,271,350	$2,517,700	$56,300	$697,350

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1972 ESTIMATES

SUMMARY OF BUDGET PLAN BY APPROPRIATION BY BUDGET ACTIVITY

(In thousands of dollars)

Appropriation Title	Total	Manned Space Flight	Scientific Investigations in Space	Space Applications	Space Research and Technology	Aeronautical Research and Technology	Supporting Activities
Fiscal Year 1970............	$3,862,717	$2,379,788	$472,796	$164,514	$288,407	$198,844	$358,368
Research and development...	3,110,427	2,029,967	381,374	138,005	175,396	95,685	290,000
Construction of facilities.	50,112	14,250	1,170	---	---	4,767	29,925
Research and program management..............	702,178	335,571	90,252	26,509	113,011	98,392	38,443
Fiscal Year 1971............	$3,298,383	$1,770,160	$478,856	$214,376	$274,724	$195,626	$364,641
Research and development...	2,555,000	1,431,100	384,900	178,400	164,600	102,000	294,000
Construction of facilities.	24,950	570	700	1,880	1,250	---	20,550
Research and program management..............	718,433*	338,490	93,256	34,096	108,874	93,626	50,091
Fiscal Year 1972............	$3,271,350	$1,637,575	$649,300	$240,500	$208,025	$214,650	$321,300
Research and development...	2,517,700	1,286,475	544,800	204,400	104,025	110,000	268,000
Construction of facilities.	56,300	20,000	15,200	---	---	6,500	14,600
Research and program management..............	697,350	331,100	89,300	36,100	104,000	98,150	38,700

* Includes $29,854,000 for the proposed supplemental for civilian pay act increase approved in FY 1970. It is anticipated that a Government-wide supplemental will be requested separately for the amounts required in FY 1971 and FY 1972 to cover the pay increase approved by the President, January 8, 1971.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1972 ESTIMATES

SUMMARY OF BUDGET PLAN

OFFICE OF MANNED SPACE FLIGHT PROGRAMS

	(Thousands of dollars)		
	1970	1971	1972
Research and Development	$2,029,967	$1,431,100	$1,286,475
Apollo......................	1,684,367	914,400	612,200
Space flight operations......	343,100	515,200	672,775
Advanced missions...........	2,500	1,500	1,500
Construction of Facilities	14,250	570	20,000
Kennedy Space Center.........	12,500	570	---
Manned Spacecraft Center.....	1,750	---	---
Various locations............	---	---	20,000
Research and Program Management	329,836	348,807	332,005
Kennedy Space Center.........	97,582	97,246	95,559
Manned Spacecraft Center.....	106,561	109,113	106,255
Marshall Space Flight Center.	125,693	142,448	130,191
TOTAL, MANNED SPACE FLIGHT.	$2,374,053	$1,780,477	$1,638,480

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1972 ESTIMATES

SUMMARY OF BUDGET PLAN

OFFICE OF SPACE SCIENCE AND APPLICATIONS PROGRAMS
OFFICE OF UNIVERSITY AFFAIRS PROGRAM

	(Thousands of dollars)		
	1970	1971	1972
SPACE SCIENCE AND APPLICATIONS PROGRAMS AND PROJECTS			
Research and Development	$519,529	$565,700	$750,400
Physics and astronomy........	112,851	116,000	110,300
Lunar and planetary exploration................	150,900	144,900	311,500
Bioscience..................	19,655	12,900	---
Space applications...........	128,304	167,000	182,500
Launch vehicle procurement...	107,819	124,900	146,100
Construction of Facilities	1,170	2,580	15,200
Goddard Space Flight Center..	670	1,880	---
John F. Kennedy Space Center, NASA......................	---	---	15,200
Jet Propulsion Laboratory....	---	700	---
Wallops Station..............	500	---	---
Research and Program Management	96,140	101,268	100,326
Goddard Space Flight Center..	86,452	91,194	90,299
Wallops Station..............	9,688	10,074	10,027
TOTAL, SPACE SCIENCE AND APPLICATIONS.............	$616,839	$669,548	$865,926
UNIVERSITY AFFAIRS PROGRAM			
Research and Development			
Sustaining university program	$7,000	---	---

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1972 ESTIMATES

SUMMARY OF BUDGET PLAN

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY PROGRAMS
OFFICE OF TRACKING AND DATA ACQUISITION PROGRAMS
OFFICE OF INDUSTRY AFFAIRS AND TECHNOLOGY UTILIZATION PROGRAMS

	(Thousands of dollars)		
	1970	1971	1972
ADVANCED RESEARCH AND TECHNOLOGY PROGRAMS AND PROJECTS			
Research and Development	$270,931	$264,200	$212,825
Aeronautical research and technology.................	95,685	102,000	110,000
Space research and technology	119,977	107,000	75,105
Nuclear power and propulsion.	55,269	55,200	27,720
Construction of Facilities	4,767	1,250	6,500
Ames Research Center.........	---	---	6,500
Jet Propulsion Laboratory....	---	1,250	---
Langley Research Center......	4,767	---	---
Research and Program Management	213,044	203,795	205,338
Ames Research Center.........	37,602	39,899	39,719
Electronics Research Center..	19,106	---	---
Flight Research Center.......	10,308	10,895	10,974
Langley Research Center......	69,851	73,388	74,191
Lewis Research Center........	73,895	77,094	77,866
Space Nuclear Systems Office.	2,282	2,519	2,588
TOTAL, ADVANCED RESEARCH AND TECHNOLOGY...........	$488,742	$469,245	$424,663

	1970	1971	1972
	(Thousands of dollars)		
TRACKING AND DATA ACQUISITION PROGRAMS AND PROJECTS			
Research and Development			
Tracking and data acquisition.	$278,000	$290,000	$264,000
Construction of Facilities	17,000	1,250	1,100
Various Locations............	17,000	1,250	1,100
TOTAL, TRACKING AND DATA ACQUISITION...............	$295,000	$291,250	$265,100
TECHNOLOGY UTILIZATION - Research and Development	$5,000	$4,000	$4,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1972 ESTIMATES

NUMBER OF PERSONNEL POSITIONS

	Fiscal Year 1970	Fiscal Year 1971	Fiscal Year 1972
MANNED SPACE FLIGHT...............	13,030	12,605	11,986
John F. Kennedy Space Center, NASA..........................	2,779	2,681	2,544
Manned Spacecraft Center........	4,249	4,120	3,935
Marshall Space Flight Center....	6,002	5,804	5,507
SPACE SCIENCE AND APPLICATIONS....	4,900	4,900	4,649
Goddard Space Flight Center.....	4,412	4,412	4,187
Wallops Station.................	488	488	462
ADVANCED RESEARCH AND TECHNOLOGY..	11,294	10,448	9,915
Ames Research Center............	1,972	1,922	1,824
Electronics Research Center.....	600	---	---
Flight Research Center..........	535	535	508
Langley Research Center.........	3,872	3,790	3,596
Lewis Research Center...........	4,201	4,087	3,879
Space Nuclear Systems Office....	114	114	108
SUPPORTING OPERATIONS			
NASA Headquarters...............	2,126	1,897	1,800
TOTAL PERMANENT POSITIONS.....	31,350	29,850	28,350
POSITIONS OTHER THAN PERMANENT.................	1,226	1,058	959
TOTAL POSITIONS...............	32,576	30,908	29,309

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 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, [$2,565,000,000] *$2,517,700,000,* to remain available until expended. (*42 U.S.C. 2451, et seq., 50 U.S.C. 511–515; Independent Offices and Department of Housing and Urban Development Appropriation Act, 1971; 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		
	1970 actual	1971 estimate	1972 estimate	1970 actual	1971 estimate	1972 estimate
Program by activities:						
Direct program:						
1. Manned space flight:						
(a) Apollo	1,684,367	914,400	612,200	1,474,613	980,000	765,000
(b) Space flight operations	343,100	515,200	672,775	309,619	577,000	638,000
(c) Advanced manned mission studies	2,500	1,500	1,500	7,057	3,000	2,000
2. Scientific investigations in space:						
(a) Physics and astronomy	129,651	121,100	126,400	142,223	118,400	120,600
(b) Lunar and planetary exploration	162,400	172,200	340,300	172,255	175,800	290,800
(c) Bioscience	19,655	12,900	----------	20,022	14,000	7,500
(d) Launch vehicle development and support	69,668	78,700	78,100	70,491	72,100	77,600
3. Space applications	138,005	178,400	204,400	104,367	175,700	190,200
4. Space research and technology	175,396	164,600	104,025	199,058	176,400	131,000
5. Aeronautical research and technology	95,685	102,000	110,000	83,582	96,000	104,200
6. Supporting activities:						
(a) Tracking and data acquisition	278,000	290,000	264,000	276,653	290,800	269,600
(b) Sustaining university program	7,000	----------	----------	22,099	13,000	10,000
(c) Technology utilization	5,000	4,000	4,000	4,537	4,500	4,500
Total direct program costs, funded	3,110,427	2,555,000	2,517,700	2,886,576	2,696,700	2,611,000
Reimbursable program:						
1. Manned space flight:						
(a) Apollo	1,422	1,525	1,405	1,323	2,651	1,405
(b) Space flight operations	----------	650	300	----------	650	300
2. Scientific investigations in space:						
(a) Physics and astronomy	23	50	423	55	94	423
(c) Bioscience	80	----------	----------	----------	80	----------
3. Space applications	50,356	55,825	53,272	53,890	77,995	53,272
4. Space research and technology	30,236	24,582	8,300	27,126	37,694	8,300
5. Aeronautical research and technology	2,064	3,735	4,000	2,812	6,692	4,000
6. Supporting activities:						
(a) Tracking and data acquisition	680	633	300	1,309	669	300
(c) Technology utilization	146	----------	----------	----------	287	----------
Total reimbursable program costs	85,007	87,000	68,000	86,515	126,812	68,000
Total program costs, funded	3,195,434	2,642,000	2,585,700	2,973,091	2,823,512	2,679,000
Change in selected resources [1]	----------	----------	----------	240,080	−32,933	−93,300
Total	3,195,434	2,642,000	2,585,700	3,213,171	2,790,579	2,585,700

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) 1970 actual	1971 estimate	1972 estimate	Costs and obligations 1970 actual	1971 estimate	1972 estimate
Financing:						
Receipts and reimbursements from:						
11 Federal funds	−52,898	−50,058	−35,028	−52,898	−50,058	−35,028
14 Non-Federal sources [2]	−32,109	−36,942	−32,972	−32,109	−36,942	−32,972
21 Unobligated balance available, start of year:						
For completion of prior year budget plans:						
Direct				−121,625	−108,767	
Reimbursable				−44,691	−39,812	
Available to finance new budget plans: Direct	−117,473			−117,473		
24 Unobligated balance available, end of year: For completion of prior year budget plans:						
Direct				108,767		
Reimbursable				39,812		
Budget authority	2,992,954	2,555,000	2,517,700	2,992,954	2,555,000	2,517,700
Budget authority:						
40 Appropriation	3,006,000	2,565,000	2,517,700	3,006,000	2,565,000	2,517,700
41 Transferred to other accounts	−13,046	−10,000		−13,046	−10,000	
43 **Appropriation (adjusted)**	2,992,954	2,555,000	2,517,700	2,992,954	2,555,000	2,517,700
Relation of obligations to outlays:						
71 Obligations incurred, net				3,128,164	2,703,579	2,517,700
72 Obligated balance, start of year				1,256,241	1,392,771	1,486,350
74 Obligated balance, end of year				−1,392,771	−1,486,350	−1,593,050
90 Outlays				2,991,634	2,610,000	2,411,000

Note.—Reconciliation of budget plan to obligations:	*1970 actual*	*1971 estimate*	*1972 estimate*
Total budget plan	3,195,434	2,642,000	2,585,700
Deduct portion of budget plan to be obligated in subsequent years	84,652		
Add obligations of prior year budget plans	102,389	148,579	
Total obligations	3,213,171	2,790,579	2,585,700

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

	1969	*1970 adjustments*	*1970*	*1971*	*1972*
Stores	40,492	13,422	54,097	54,097	54,097
Unpaid undelivered orders	766,858		1,008,883	975,950	882,650
Advances	14,109		11,981	11,981	11,981
Total selected resources	821,459	13,422	1,074,961	1,042,028	948,728

[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 1972 ESTIMATES

SUMMARY OF RESEARCH AND DEVELOPMENT BUDGET PLAN BY PROGRAM BY COGNIZANT OFFICE
(In thousands of dollars)

BUDGET ACTIVITY	OFFICE/PROGRAM	Fiscal Year 1970	Fiscal Year 1971	Fiscal Year 1972
	MANNED SPACE FLIGHT..........	$2,029,967	$1,431,100	$1,286,475
1a	Apollo....................	1,684,367	914,400	612,200
1b	Space flight operations....	343,100*	515,200	672,775
1c	Advanced missions..........	2,500	1,500	1,500
	SPACE SCIENCE AND APPLICATIONS	519,529	565,700	750,400
2a	Physics and astronomy......	112,851	116,000	110,300
2b	Lunar and planetary exploration.............	150,900	144,900	311,500
2c	Bioscience................	19,655	12,900	---
3	Space applications.........	128,304	167,000	182,500
**	Launch vehicle procurement.	107,819	124,900	146,100
	UNIVERSITY AFFAIRS			
6b	Sustaining university program.................	7,000	---	---
	ADVANCED RESEARCH AND TECHNOLOGY	270,931	264,200	212,825
5	Aeronautical research and technology...............	95,685	102,000	110,000
4	Space research and technology...............	119,977	107,000	75,105
4	Nuclear power and propulsion..............	55,269	55,200	27,720
6a	TRACKING AND DATA ACQUISITION	278,000	290,000	264,000
6c	TECHNOLOGY UTILIZATION.......	5,000	4,000	4,000
	TOTAL BUDGET PLAN..........	$3,110,427	$2,555,000	$2,517,700

*Includes application of $117,473,000 reserved from apportionment in 1969 pursuant to the Revenue and Expenditure Control Act of 1968 (Pub. L. 90-364, 82 Stat. 251).

**In the Budget Appendix, page 835, the vehicle hardware portion of Launch Vehicle Procurement is statistically distributed to unmanned flight programs (e.g., Physics and Astronomy, Space Research and Technology) and the undistributed portion is identified as Activity 2d.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1972 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR

MANNED SPACE FLIGHT PROGRAMS

Program	1970	1971	1972
	(Thousands of dollars)		
Apollo..........................	$1,684,367	$914,400	$612,200
Space flight operations.........	343,100*	515,200	672,775
Advanced missions...............	2,500	1,500	1,500
Total.........................	$2,029,967	$1,431,100	$1,286,475

* Includes $117,473,000 of FY 1969 funds applied to FY 1970 budget plan.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1972 ESTIMATES

SUMMARY

OFFICE OF MANNED SPACE FLIGHT — APOLLO PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The launch of Apollo 14 to the surface of the moon coincided with the thirteenth anniversary of the launch of the first American satellite, and occured less than ten years after the Apollo 14 commander, Alan Shepard, made this country's first manned journey into space on a suborbital flight.

During the decade that followed, astronauts orbited the earth on sixteen missions as the country designed, developed, and acquired the capability and experience necessary to respond to the national commitment of landing a man on the moon and returning him safely to the earth.

Six Apollo crews have traveled to the moon, and the Lunar Module crews of Apollo 11, 12 and 14 have landed on its surface.

The lunar landing capability was demonstrated, and the Apollo program has been directed toward the application of that capability in the further exploration of that new world, and to further increase man's knowledge of the moon. The moon may represent, for man, the archives of the earth's history. Processes on the earth have completely obliterated events of the first billion years and have distorted and transformed much of the remaining record. The moon, it appears, has faithfully chronicled the history of the solar system since the days of its inception, and may provide the clues to the processes that formed the solar system. Evidence of cataclysmic events, changes in solar activity, and of physical and chemical phenomena unknown or extinct on earth is being found in the analyses of lunar material. The moon may be unique as a historical source, for man's initial comprehension of the nature of the other planets indicates that to varying degrees, their surfaces, and thus their history, have undergone obliterating transformations.

Beyond this opportunity to study the records of the past, the moon represents a newly discovered world, capable of producing unexpected findings such as having terrestrial plants thrive when grown in lunar soil, while some hardy terrestrial microorganisms have found it very toxic. Scientists studying the formative processes of lunar rocks have been able to more fully appreciate the significance of analagous counterparts on earth and this can lead to locating new mineral resources.

Continued exploration of the moon will produce a greater understanding of the processes that affect the earth. Laser reflectors will be used to measure continental drift, and the measurements may substantiate the Chandler's Wobble hypothesis that large earthquakes are often triggered by forces associated with periodic changes in the earth's axis.

Another lunar landing mission, Apollo 15, is scheduled in 1971 and the final two, Apollo 16 and 17, in 1972. The Apollo 17 mission has been delayed by five months to December 1972 to ensure that the scientific experiments that were originally to be flown on the now cancelled Apollo 18 and 19 missions will be fully available. The Apollo 14 mission with Alan Shepard as Commander, Stuart Roosa as Command Module Pilot, and Edgar Mitchell as Lunar Module Pilot was launched in January 1971. The landing site was Fra Mauro, which was the intended site for Apollo 13. This was the first Apollo landing at other than a lunar mare. The major objective of the mission was to investigate the Fra Mauro formation, an extensive geological unit, which lunar geologists believe is composed of material ballistically ejected and carried by the base-surge of gas and debris produced by the giant impact that created the Imbrium basin. Scientists hope to find rocks in the Fra Mauro formation which predate rocks from previous missions and which date from the time of formation of the moon and perhaps from the origin of the solar system.

The last three Apollo missions, Apollo 15 in July 1971, Apollo 16 in the spring of 1972 and Apollo 17 in December 1972, are the most sophisticated and comprehensive of the entire series. A whole new array of exploration procedures and instrumental concepts open new opportunities for research on the moon to scientists from all over the world. Eighteen new experiments have been selected to fly in the Apollo 15 through 17 missions. Changes in the Lunar Module (LM) and surface hardware will allow the astronauts to remain on the lunar surface for up to 66 hours; the landed scientific payload will be doubled to approximately 1,000 pounds; and the range and efficiency of surface operations will be increased through improved suit mobility, improved life support system, and a lunar roving vehicle.

In addition to increased surface science, changes are being made to add nearly 1,000 pounds of cameras, other remote sensing scientific equipment, and additional consumables to the Command and Service Modules (CSM) to increase the capability to study the moon from orbit. Findings from the widely separated landings can then be tied together and fitted into a total picture of the moon.

Apollo 15 and 17 missions will each deliver small, self-powered sub-satellites to lunar orbit to monitor the variation of magnetic fields and interplanetary charged particle streams in the vicinity of the moon to determine the electrical body properties of the moon and infer internal physical characteristics.

Of particular interest in these last missions is the increased surface mobility which will be provided to the astronauts by the lunar roving vehicle, This vehicle will significantly increase the mobility and range of the astronauts. It can carry both astronauts plus 100 pounds of instruments for exploration and the collected surface samples. A wide variety of samples will be collected during each of the three EVA's per mission to make a better assessment of the landing sites.

A lunar sounder and lunar seismic profiling experiments will be flown on Apollo 17. Data analysis from Apollo 12 implies that moonquakes, equivalent to earthquakes generated by slippage, always appear to slip in the same direction. This is very likely caused by a source of strain accumulating within the moon and being released by the additional tidal forces that occur at the time of close earth-moon proximity. At present we can only speculate as to the source of strain. Further data from the lunar seismic profiling experiment may provide a clearer insight into this phenomenon.

The lunar sounder, a radio sounding device, will be used to probe geological substrata from high altitude. It has a long development time and would not have been available for earlier flight schedules. The device is similar to radar in its transmission of a signal and sensing the return from the target area. However the use of multiple frequencies and their known penetration variations make it possible to extrapolate the density and makeup of the subsurface.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars) 1970	1971	1972
Spacecraft..................	$775,608	$411,086	$164,152
Saturn V....................	486,691	237,700	186,003
MSF operations..............	422,068	265,614	262,045
Total.......................	$1,684,367	$914,400	$612,200

BASIS OF FUND REQUIREMENTS:

Spacecraft

The Command and Service and Lunar Modules required to finish the Apollo flight program will be essentially complete by the end of FY 1971. Work on CSMs and LMs intended for missions now cancelled has been stopped, and no follow-on production capability is planned.

Fiscal Year 1972 activities relate to the preparation, flight and post flight analysis of Apollo missions; modifications, factory checkout and delivery of spacecraft; procurement of science payloads and equipment required to support the remaining Apollo flights.

An essential and critical requirement that must be met in FY 1972 is providing the contractor engineering 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 a 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 maintain required tooling and documentation.

Saturn V

All Saturn V launch vehicles' stages have completed manufacture and static test. The vehicle for Apollo 15 has been delivered to Kennedy Space Center (KSC), and those undelivered elements for the vehicles for both Apollo 16 and 17 will be delivered to KSC during FY 1972.

As with the spacecraft, an essential and critical Saturn V requirement for FY 1972 is the maintenance of the contractor in-plant engineering 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 a mission.

To complement the prime contractor efforts engineering and technical support will also be maintained at the Marshall Space Flight Center laboratories at the Slidell, La., computer facility and at the Mississippi Test Facility in sypport of the flight program.

In addition to the transportation of stages to KSC, and the mission peculiar systems engineering, integration and configuration activities efforts will be directed to the storage and maintenance of production tooling and facilities so that, if required, Saturn V production could be restarted at some future date. Videotapes and other graphic records of manufacturing techniques, test and checkout procedures, and associated production tasks will be made to facilitate any future restart, for future resumption.

MSF Operations

In addition to providing for the conduct of actual Apollo missions, MSF Operations funding provides for the basic capabilities in crew training, launch, flight, recovery and program-wide technical and Department of Defense support required for manned space flights regardless of program.

Requirements that are directly relatable to specific missions include mission planning, including trajectory analysis; failure analysis and evaluation of operational performance; and recovery operations.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1972 ESTIMATES

SUMMARY

OFFICE OF MANNED SPACE FLIGHT — SPACE FLIGHT OPERATIONS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

Space Flight Operations employs the scientific, technological, and operational capability developed in the Apollo program to exploit space for direct practical benefits, and to further expand exploration of that domain. The principal goal of the past decade was to demonstrate this nation's abilities in space by accomplishing a manned lunar landing and return before the end of that decade. This capability can now be directed toward the beneficial utilization of space initially through the eight month flight of Skylab, a precursor space station, and later through the operation of a reusable transportation system, and long duration space station. This reusable transportation system, or space shuttle, will be able to carry scientists, technologists and specialists of different skills and disciplines, as passengers into space without their having to qualify as astronauts. The flight characteristics of the shuttle as a passenger transport system would allow men and women from any interested country to travel into space. The station and shuttle would support a wide range of experiments and experiment disciplines.

Space Flight Operations activities will commence with the Skylab program, formerly known as Apollo Applications, in which a third stage (S-IVB) of the Saturn launch vehicle is being modified to serve as an orbital workshop. Skylab is a necessary first step toward developing a capability for long duration manned operations in earth orbit. Three successive teams of astronauts will occupy this experimental laboratory for periods of up to two months. They will use the installed equipment to perform scientific and application experiments, conduct solar observations, and determine the physiological and psychological effects of long duration flight on the health of the astronauts and on crew morale and effectiveness. Exercises, habitability factors, and other ameliorating conditions and adverse effects will be investigated.

In the latter part of the decade, the space shuttle, a fully reusable vehicle capable of carrying large payloads, composed of passengers, cargo or a combination of the two, to and from earth orbit, will provide an economical space transportation system designed to make near earth space more readily accessible for a great variety of manned and unmanned activities.

The primary objective of the space shuttle program is to develop and place into operation an earth-to-earth orbit and return space transportation system, with characteristics which not only reduce the direct cost of transportation to earth orbit but permit accompanying reductions in the costs of payloads. It is anticipated that the reduction in the costs of space operations made possible by use of the shuttle will permit far greater use of space than has been previously economically possible, and allow a substantial increase in the scope and range of benefits derived from space operations.

The Orbital Systems and Experiments category consists of activity in three areas: space station modules, experiments and space life sciences. Space station module and experiment study efforts will continue to define an advanced earth orbital facility, logistically supported by the shuttle, and characterized by routine, long term, flexible, productive operations, with minimum operating costs and increased crew efficiency and safety. The experiments to be conducted in association with station and shuttle operations encompass nearly all the scientific disciplines.

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 survive in space.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1970	1971	1972
Skylab..........................	$324,600	$405,200	$535,400
Space shuttle....................	12,500	80,000	100,000
Orbital systems and experiments	6,000	30,000	37,375
Total..........................	$343,100	$515,200	$672,775

Skylab

The Skylab project is now in an advanced state of development. The flight phase will commence early in 1973 with the unmanned launch of the workshop. Operations will begin one day later when the first of three crews will rendezvous and dock with this workshop in an Apollo Command and Service Module launched on a Saturn IB vehicle. The workshop consists of laboratories, work areas, control stations, living quarters, earth sensors and a solar observatory, and will be used to perform over fifty experiments for which over 2,200 astronaut hours have been allocated. This is more than three times the amount available in all prior U.S. manned earth orbital missions. Four areas of experiment activity are of particular importance: earth science, astronomy and space physics, space medicine, and engineering and manufacturing technology.

Earth sciences activity will include photography of the earth for use in studies of crop health and distribution, land use, forestry, meteorology, air and water pollution, mineral resources, geography, water management, oceanography, and population growth. One of the mission improvements made possible by the decision to shift from the Saturn IB to the Saturn V launch vehicle was to raise the orbital inclination to give earth survey coverage between 50° latitude North and South. This orbit covers some 75% of the globe, including 80% of food producing areas, and 90% of the population. Skylab earth sensing instruments will complement those that will be flying a polar orbit in the Earth Resources Technology Satellite (ERTS) at about the same time and will permit coordinated measurements of the same area by different systems. Aircraft and ground measurements of space test sites both in the U. S. and countries cooperating in this activity will also be made for purposes of calibrating and interpreting the data from the workshop and ERTS.

Astronomy and space physics activity will primarily center on experiments to be conducted using the Apollo Telescope Mount (ATM), which will be the first manned astronomical observatory in space. The ATM will overcome the limitations imposed on man's ability to study the sun because the atmosphere obstructs ultraviolet, extreme ultraviolet, X-ray and most infrared radiation from the sun and distorts optical images. Clouds and atmospheric pollution often interrupt or preclude viewing. Operating at an altitude of 235 miles, the manned observatory will be free from these distortions and interruptions and will have the capability for selective pointing. These observations will bring new insights into the dynamic processes that take place in and around the sun.

Space medicine experimentation will be of benefit primarily to future space activities, although it may also furnish new insight into basic physiological processes of men and animals, and certainly some of the instrumentation developed for measurements of body processes in space will find use in earth applications. This program will also provide the first opportunity for a scientist-astronaut physician to participate first hand in observations and experiments as a member of the flight crew.

The engineering and manufacturing technology experiments are concerned with space physics effects on materials and processes, human factors, and precision instrumentation. An important experiment will be the evaluation of the feasibility of manufacturing selected materials in space utilizing the space vacuum and zero gravity conditions.

The Skylab missions will begin in early 1973 with the unmanned launch of the Workshop into a 50° orbit of 235 miles altitude using a two-stage version of a Saturn V vehicle. On the day following launch of the workshop, a Saturn IB vehicle will launch a modified Apollo Command and Service Module whose three man crew will rendezvous and dock with the Workshop to allow completion of the orbital assembly and start of operations.

The initial manned mission will be primarily directed toward the accomplishment of medical experiments related to providing assurance for the well-being of astronauts during the three Skylab missions. Other areas of focus will be the solar astronomy, earth resources, and technical experiments which will be conducted concurrently with the medical activity. This mission is planned to last up to 28 days, beginning with the launch of the manned flight. The crew, before leaving, will prepare the Workshop for an unmanned period of two months, during which it will be maintained in a semi-active condition.

The second manned mission will be launched approximately three months after the first manned launch. This revisit mission is planned for a duration of up to 56 days. The mission will reoccupy the Skylab Workshop and gather much greater amounts of data from medical, technical, scientific, earth resources, and solar astronomy experiments, with the focus on these latter two areas. The third and final crew will be launched approximately three months after the second manned launch. This mission is also planned for a duration of up to 56 days from launch. Again, the crew's activities will emphasize the scientific and applications objectives of the experiments.

A change in program plan was made in May 1970 to provide for launching the Skylab Saturn IB vehicles from Launch Complex 39. The transfer of Saturn IB launch operations to Complex 39 was undertaken to reduce costs, to streamline Kennedy Space Center (KSC) operations by consolidating all manned space flight launches at one complex, and to improve launch reliability through use of the newer complex and its facilities for indoor assembly of the space vehicle. The four Saturn IB launch vehicles for the Skylab project will be scheduled for modification, refurbishment and checkout to support the 1973 launch dates. Modifications to the Saturn V vehicle for launch of the Skylab will be completed in FY 1972. The Apollo produced Command and Service Modules are being modified for Skylab use. Modifications are required because of the unique operational and support requirements of Skylab resulting in longer mission duration, new orbital rendezvous requirements, cluster support requirements, mission altitude constraints, increased return payload, and space retrieval capability. Changes resulting from the Apollo 13 mission are also being made. In FY 1972 the spacecraft for the first mission will complete checkout at the contractors' plant and be delivered to KSC. The three remaining spacecraft will be in the process of systems installation and checkout.

Contractor in-plant efforts on all prime modules of the Skylab, consisting of the orbital workshop, airlock module, multiple docking adapter and the Apollo Telescope Mount, will be essentially completed by the end of FY 1972.

During this period, the flight modules will variously progress through the processes of final assembly, installation and integration of systems and experiments, checkout, and related testing; the Multiple Docking Adapter and the Airlock Module will additionally undergo integrated testing, including an altitude chamber test; the ATM will undergo vibration and thermal-vacuum testing; following which the units will be delivered to KSC to commence prelaunch activities.

Space Shuttle

The key to economical space operations is the space shuttle, a reusable space transportation system that will revolutionize present day space operations by furnishing an airline-type accessibility to space at low operational cost.

Two major sources of cost reduction are associated with the use of the shuttle system. In addition to the substantial operational savings generated by reusable hardware, there are significant economies to be realized in the payload area due to relaxed weight and volume constraints, capability to return payloads and in-flight checkout of payloads.

The shuttle is planned as a two stage vehicle which will possess an all azimuth capability and have an operational availability such that it can be launched on short notice. It will take off vertically under rocket power with the booster accelerating the orbital stage to the outer fringe of the earth's atmosphere where separation will occur. The booster will then decelerate and cruise to a designated landing field and land horizontally. The orbiter will proceed to orbit, powered by its own rocket engines, to deliver its payload and perform its assigned mission. After spending up to seven days in orbit, the orbiter will re-enter and return to a conventional airport runway and also land horizontally. After a short turnaround period of approximately two weeks both shuttle stages will be ready for another mission.

The shuttle will be designed for 100 or more flights with a minimum of ground maintenance. Payload transportation will be similar to commercial airline practice. The orbiter will contain a large compartment of about 10,000 cubic feet to accommodate a varying payload mix of satellites, passengers, and cargo. In a passenger mode, ten people plus a crew of two can be accommodated. Moderate G loads and a shirt sleeve environment will allow average people in good health to fly into space without extensive flight training.

Once developed, the shuttle can replace essentially all the present day launch vehicles except for very small vehicles of the Scout class, and the very large Saturn V. Its low operational cost and its versatile capability can accomplish a variety of missions including transportation to and retrieval of satellites from low earth orbit, visiting orbiting satellites for periodic servicing, delivery of propulsive stages and payloads for high energy missions to low earth orbit, short duration science and applications missions, serving as a space research laboratory, and the transportation of personnel and cargo to space stations in low earth orbit.

Current plans for the shuttle focus on the beginning of horizontal flight testing in the mid-1970s, with a full operational capability by the end of the decade that will provide this country a space flight operations capability which by its unique and versatile nature will be unmatched for years to come.

The shuttle vehicle consists of a fully reusable booster and orbiter each using high pressure liquid oxygen/liquid hydrogen fueled rocket engines for propulsion. The shuttle's payload capability will range from 25,000 to 65,000 pounds depending on altitude, inclination, and orbiter configuration.

The FY 1972 program provides for detailed design and development on the engine--the longest lead time component of the shuttle. It also provides for proceeding on an orderly step-by-step basis with the shuttle airframe design. This effort may lead to detailed design or initiation of development depending on the progress of studies now underway.

Two concurrent definition studies are underway for the vehicle to provide data upon which to select configurations that can be carried forward with the design phase. Supplemental feasibility studies of alternate vehicle concepts are also being conducted.

In Fiscal Year 1972 vehicle definition will be advanced by wind tunnel testing to define the precise aerodynamic heating, launch aerodynamics, staging separation forces, re-entry stability and control characteristics, and atmospheric propulsion effects. Dynamics testing will proceed to determine wind loads, vehicle flutter effects, and the acoustic environment which will exist. Design of long lead time hardware and subsystems, test devices and tooling fixtures will be performed.

Test demonstrations to verify design concepts constitute an important part of the shuttle study program and will include tests of the static and dynamic performance of structures proposed for fuselage, wings, tanks, and attachment mechanisms. Mission simulations will be performed in combination with thermal protection systems. Analysis and test of many new alloys and promising materials are planned. A flight research program will investigate attitude maneuvers for the defined configurations, determine control system requirements, and provide the necessary flying test bed for flight system components.

A principal focus in the development of the engines for propulsion is the long lead time required for engine development. An early initiation of design effort is required to have the engines properly integrated into the vehicle system. This engine will have increased performance by virtue of developing higher specific impulse at much lower weight. A considerable base of technological experience with advanced hydrogen-oxygen engines has been developed over the last several years which provides a high level of confidence that the required shuttle rocket engine will be successfully developed.

Drawing upon data developed from feasibility studies that have been completed, the main engine characteristics being used as baseline in the definition studies now underway include a throttlable, high pressure, hydrogen-oxygen engine that will be clustered for use on both the orbiter and the booster. Three concurrent definition contracts are underway, and the main engine design and development is scheduled to begin in mid-1971. In Fiscal Year 1972 main engine efforts will include development testing of the thrust chamber and engine controls, and design of a prototype engine. Propulsion subsystem test facilities will be modified and development hardware tested. Fabrication of a prototype engine will be initiated during Fiscal Year 1972.

Orbital Systems and Experiments

Orbital Systems and Experiments encompasses work relating to manned earth orbital flight after the Skylab missions. The work focuses on studies of the major systems of a space station core and modules, on the experiments to be conducted in earth orbit in the space station or on shuttle missions, and on the life sciences aspects of space flight.

A long duration space station provides a facility for many diverse scientific and applications activities in low earth orbit. The station will be an evolutionary progression from Skylab, and its final design will incorporate flight data obtained from that program. Logistically supported by the space shuttle, the station will have extended in-orbit lifetime with maintenance and replacement of systems. The station will feature modularity so that elements can be replaced, updated, and added for greater capability. Program definition studies on a 33 foot diameter space station that could be placed in orbit by a two stage Saturn V vehicle are now being completed, however, there are other configurational approaches which can provide the same capability in a more evolutionary manner. Two modular station concepts are currently being considered. One uses only shuttle compatible modules that are no more than 60 feet long with diameters of no more than 15 feet; the other would evolve from the first Skylab using the same tooling for the core module and the same type of initial launch configuration on a two stage Saturn V. Studies are underway, both in-house and with the definition contractors, to develop and compare candidate concepts in detail relative to specific design characteristics, operational sequences, shuttle interfaces, experiment support capability, and resources requirements.

To augment the capability of both the space station and shuttle, NASA has undertaken the definition of research and applications experiments module. These modules can be operated in conjunction with a space station as attached modules or in a free-flying mode where experiments will require operations remote from the space station. The modules, while common in many respects for cost effectiveness, can be specifically configured for investigations in the various scientific disciplines.

Paralleling the space station studies are efforts required to develop a balanced program of payloads and experiments to utilize the initial shuttle capability and the space station when it becomes available. Definition activities are essential to the orderly evolution and development of payloads and experiments compatible with the future space flight transportation systems. The payload and experiment disciplinary program areas include earth surveys, physics and astronomy, materials science and manufacturing, space technology, and communications and navigation.

Experiment definition studies will also evaluate the use of the space shuttle to reduce the cost of payload and experiment design, and help establish requirements for the shuttle hardware development.

For the station itself, activities to be supported in FY 1972 include technical, programmatic, and cost trade off comparisons of space station concepts compatible with launch and return by the space shuttle, and in depth studies of specific technical problems; trade off analyses, to verify systems selection; initiation of preliminary engineering designs of selected long lead systems; technology verification and proof of concept through early initiation of breadboard testing of critical systems.

Definition efforts on the research and applications module undertaken in FY 1971 will be continued. Since the early and accurate definition of experiments and payloads is vital to eventual mission success and the achievement of program objectives and national goals, experiment definition efforts will relate to acquiring the technical and scientific effort expertise needed to identify and verify, through ground experimentation and analysis, those worthwhile experiments conducted by man in space, to assure effective use of future manned space flight systems. All major disciplinary areas will be represented with emphasis and priority being given to the start of work on long lead time items.

Space life sciences integrates space medical, biotechnology and biology activities of the National Aeronautics and Space Administration. Activities include bioresearch for study and investigation in medical, biological and behavioral areas to determine human effect, adaptation and tolerance to space operations; use of the space environment for the study of fundamental biologic processes; bioengineering for study and experimental test of bioinstrumentation and bioassay concepts on man and other living systems; the design of space vehicles for habitability; and bioenvironmental systems studies to test experimental life support and protective devices.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1972 ESTIMATES

SUMMARY

OFFICE OF MANNED SPACE FLIGHT — ADVANCED MISSIONS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objectives of the Advanced Missions activities include examining the enhancement of current and advanced manned space flight program concepts and developing the requirements for future systems. The studies conducted provide both guidance for the research and technology effort required to support these systems and technical information upon which to base future program decisions.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1970	1971	1972
Advanced mission studies.............	$2,500	$1,500	$1,500
Total............................	$2,500	$1,500	$1,500

BASIS OF FUND REQUIREMENTS:

Advanced Mission Studies

Advanced studies are conducted to provide the necessary knowledge to assess and to direct the future course of this country's manned space flight program. The studies utilize the capability of industry to perform conceptual designs and provide comparative technical data to supplement in-house activities. During FY 1972, the studies will investigate new requirements for near and long range flight missions, and conduct comparative studies of the possible long range utilization of systems presently being defined or under development, such as the space station, Skylab, and shuttle.

Lunar exploration studies for activities beyond the present Apollo program will be directed toward aggregating and assimilating the knowledge gained from previous missions, and applying this information toward the extent and nature of future exploration, both on the lunar surface and in lunar orbit.

An assessment of program directions will continually be compared with national objectives to assure that advanced planning is kept current and responsive.

Cost and performance improvements are to be studied in relationship to existing or prospective programs such as the shuttle and space station. The impact of new missions and systems on flight and ground operations and, conversely, the impact of advanced operations concepts on future missions and systems will be studied to assure that the entire program benefits from advances in each area.

As operational safety is of the utmost importance, studies will be directed towards promoting new safety criteria for advanced concepts during the early phases of mission development.

Areas of study that will receive attention during Fiscal Year 1972 are:

(a) Earth orbital mission analysis to determine the most advantageous combination of flight systems for projected mission objectives. In addition these studies can identify a requirement for alternative mission and flight hardware concepts when it is indicated that these alternatives show advantages over the concepts that had been planned for use.

(b) New missions requirements investigations to focus attention and NASA resources on potential applications of space that will improve the quality of life on earth.

(c) Lunar exploration, beyond the present Apollo program and in the next decade, for extended exploration of the moon and its near environment both from lunar orbit and on the lunar surface.

(d) Ground and flight operations analyses to determine how advanced concepts would affect projected operations using current systems, and how proposed new systems would affect future operations.

(e) An integrated space program safety study to produce guidance for future missions, by establishing a focal point within Manned Space Flight for new safety concepts as they relate to the development of advanced missions. This study will continue the safety study work conducted during FY 1971 to a greater level of detail and refinement.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1972 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR

SPACE SCIENCE AND APPLICATIONS PROGRAMS

Program	(Thousands of dollars) 1970	1971	1972
Physics and astronomy..............	$112,851	$116,000	$110,300
Lunar and planetary exploration......................	150,900	144,900	311,500
Bioscience.........................	19,655	12,900	---
Space applications.................	128,304	167,000	182,500
Launch vehicle procurement.........	107,819	124,900	146,100
Total............................	$519,529	$565,700	$750,400

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1972 ESTIMATES

SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS — PHYSICS AND ASTRONOMY PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Physics and Astronomy program, when viewed in the framework of broad scientific and technological efforts, has as its objective the understanding of the origin and continuing evolution of the earth, our solar system, the stars, galaxies, and the universe. We are exploring our space environment in order to understand its nature and the physical processes that shape it. In doing so, we are increasing our knowledge of the fundamental laws and principles of nature.

To attain this goal, a variety of techniques are used to gather information. These include theoretical and laboratory research; aircraft, balloon, and sounding rocket flights; as well as observations using small and large automated spacecraft and manned systems. Research groups participating in this effort are distributed throughout the United States and the free world. Groups are located at most of the NASA centers, at several other Government laboratories, and at many universities and industrial laboratories. Foreign participation is arranged through the science ministry of each of the participating countries.

The technology developed and data gathered in this program are made available to the scientific and technical community in order to contribute to future scientific research, education, and the advancement of technology.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1970	1971	1972
Large observatories	$47,798	$42,831	$43,400
Orbiting explorers	18,295	26,200	24,500
Sub-orbital programs	21,100	23,000	21,500
Supporting activities	25,658	23,969	20,900
Total	$112,851	$116,000	$110,300

BASIS OF FUND REQUIREMENTS:

Large Observatories

The large observatory program includes the Orbiting Solar Observatories (OSO), the Orbiting Astronomical Observatories (OAO) and the new spacecraft series known as High Energy Astronomical Observatories (HEAO).

The OSO provides a specialized space observing platform to contribute to our understanding of the sun. The spacecraft design provides a capability for experiments requiring solar and celestial pointing, solar scanning, or scanning of the celestial sphere. Four missions, including correlated ground-based observations of the sun, are scheduled through the mid-1970's. Previous OSO missions have made major contributions to our understanding of the sun and, in particular, the observational models of flares. Two observatories, OSO-5 and OSO-6 are continuing to provide valuable observations in support of our objectives. FY 1972 funds will provide for in orbit operation of OSO-H, continuing development of the instruments and spacecraft hardware for the remaining three missions, and reduction and analysis of data obtained from the active observatories.

The OAO was developed as an accurately stabilized automated space observatory system for telescopic observations of celestial objects in the electromagnetic spectral range from the X-ray region through the ultraviolet into the visible region. OAO-2, launched in December 1968, continues to make major contributions to our understanding of the universe by providing critical information in the ultraviolet region of the electromagnetic spectrum. Significant scientific accomplishments from OAO-2 include the discovery of ozone on the planet Mars and the discovery of extensive hydrogen clouds around two bright comets. OAO-B, launched on November 30, 1970 failed to achieve orbit when the launch vehicle shroud did not jettison properly. Fiscal Year 1972 funds support the launch of OAO-C, in-orbit operations of OAO spacecraft and the reduction and analysis of data obtained by the scientific instruments.

The primary 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. This program has been given the highest priority for new starts by the National Academy of Sciences (Woods Hole Summer Study) and the Astronomy Missions Board of NASA. A series of four missions are planned during the 1970's with the first mission scheduled for 1975. Titan class launch vehicles will be utilized for the first two missions. Studies will be conducted to determine the role of the space shuttle for the third and fourth missions, i.e., launch, repair, and updating. FY 1972 funding will allow experimenters on missions A and B to complete instrument design and procure long-lead items and also permit selection and contract award to the spacecraft contractor. Contractor effort will include detailed designs and procurement of long lead items prior to fabrication. In addition, feasibility studies will be conducted in regard to utilization of the space shuttle for the C and D missions.

Orbiting Explorers

In December 1970, the first mission in the Small Astronomy Satellite (SAS) series was successfully launched. SAS-A, or Explorer 42, also called Uhuru (Freedom) was launched by an Italian crew from the San Marco launch platform off the coast of Kenya. This is the first NASA satellite to be launched outside the United States, and the first to be launched by a foreign crew. A launch from the United States into the same orbit would have required a larger vehicle. The mission of Explorer 42 is to search systematically for X-ray sources in space and to map the brightness of the celestial sphere in the 2-20 keV energy range.

Fiscal Year 1972 funds will be used to support missions that will be launched over the next several years. These Explorer spacecraft will be used to obtain data for investigations in X-ray and radio astronomy, atmospheric and ionospheric physics, the radiation belts and magnetospheric boundary, and interplanetary space. Activities to be funded will include the development of the spacecraft and instruments, the pre-flight testing, launch, and the analysis of data from operating satellites.

Sub-Orbital Programs

The Sub-Orbital programs include Sounding Rockets, Airborne Research, and Balloon Support.

Sounding rockets are the only means of obtaining data below 150 kilometers, where satellites cannot survive, and of providing vertical profiles of geophysical parameters which are complementary to satellite observations. Sounding rockets are also a flexible, timely, and cost-effective means of providing space flight opportunities and, as such, constitute an invaluable component of a balanced program in space research. A flexible stable of relatively inexpensive vehicles is utilized to carry a wide variety of scientific instruments developed for studies in the disciplines of aeronomy, energetic particles and fields, ionospheres and radio physics, galactic and radio astronomy, and solar physics. Fiscal Year 1972 funding provides for a flight program at an approximate level of 80 flights per year. Some reduction in total flights may be anticipated as a result of increasing emphasis on the more complex stellar and solar investigations. Forty to fifty scientific teams will be engaged in carrying out this effort.

Airborne research with instrumented jet aircraft bridges the gap between ground-based experiments and those requiring balloons, rockets and space vehicle systems. The flexibility involving the direct participation of scientists and the large payload capacity with the ability for extended observations over any geophysical area has yielded excellent scientific results and correlations with NASA's satellite systems. The airborne research program is an operating approach which may be applicable to Space Shuttle and Space Station operations in the future. The physics and astronomy airborne research program emphasizes the support of infrared astronomy, and investigations of the physics of the aurora and airglow. Fiscal Year 1972 funding is almost entirely allocated for an Infrared Airborne Observatory and will be utilized for the completion of a 36-inch telescope and its integration into a C-141A aircraft.

Balloons play an important role in the Physics and Astronomy program by providing timely and relatively low cost flight opportunities for (1) testing proposed satellite instrumentation in the space environment, (2) obtaining observations at altitudes which are not accessible to satellites, (3) lifting instruments which are too heavy and voluminous for flight in present automated satellites, (4) utilizing instruments which can be safely recovered and reused, and (5) 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 60 balloon flights a year.

Supporting Activities

This area includes the Supporting Research and Technology (SRT), Advanced Studies and Data Analysis programs.

The SRT/Advanced Studies program enhances the overall scientific and technological return from NASA flight projects and helps assure continued excellence and viability of the future research program in space science. The objectives can be stated in the following categories: (1) Optimization of the return expected from future missions by problem definition, development of advanced experiments and concepts, and the careful preparation of new missions; (2) enhancement of the value of current space missions by a full complement of simultaneous ground-based, aircraft, and balloon missions; and (3) development of theories to explain observed phenomena and predict new ones. Fiscal Year 1972 funds will support research tasks at universities, non-profit and industrial research institutions, NASA centers and other Government agencies in two-thirds of the states and the District of Columbia. Of special significance is the initiation of Phase B studies for the Large Shuttle Launched Space Telescope (LST). SRT/Advanced Studies funds also provide partial support for the Goddard Institute for Space Studies, the Space Science Board, and the Research Associate program.

The objective of the Data Analysis program is to exploit the data obtained from space science experiments on NASA spacecraft. Reduced data records are forwarded by each principal investigator to the National Space Science Data Center (NSSDC) located at the Goddard Space Flight Center. The availability of the data is made known to the world scientific community through periodic announcements by the NSSDC. The funding in FY 1972 provides for a continuation of the data collection effort of the NSSDC and the support of correlative studies which utilize data from several separate investigations as well as new approaches to the analysis of available data. The Data Analysis program also supports research involving the use of data acquired from older satellites during periods of special activities for the purpose of attaining specific scientific objectives.

SCHEDULE OF LAUNCHES

Large Observatories:		
Solar Observatories	OSO-H	1971
	OSO-I	1973
	OSO-J	1974
	OSO-K	1976
Astronomical Observatories	OAO-C	1972
High Energy Astron. Obs.	HEAO-A	1975
	HEAO-B	1976
Explorers (Including International Cooperative Satellites)	4 - 6 launches per year	
Suborbital Programs:		
Sounding Rockets	About 80 launches per year	
Balloon Flights	About 60 flights per year	

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1972 ESTIMATES

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OFFICE OF SPACE SCIENCE AND APPLICATIONS

LUNAR AND PLANETARY EXPLORATION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Lunar and Planetary Exploration program is directed toward investigation of the moon, the planets and their satellites, asteroids, comets and the particles and fields of interplanetary space. Its goal is the acquisition of new and more detailed data and knowledge of the origin, history and dynamics of our solar system with particular emphasis on understanding the evolution of our earth and the processes that control its environment. The current program will gather information from the further exploration of the moon by manned systems as described under the Apollo program and from the exploration of the planets and the interplanetary medium using automated spacecraft. Intermediate and long range objectives encompass a broad exploration of the solar system and interplanetary space.

An understanding of the moon's origin, evolutionary history, relationship to the earth and the solar system, and processes of formation are the fundamental scientific objectives of the lunar exploration program.

Unmanned programs have already considerably advanced our knowledge of the moon through the Ranger, Lunar Orbiter, and the Surveyor programs. Currently, funds provided under this program finance the basic scientific research and planning essential to the design of experiments and the analysis of data from the Apollo Manned Space Flight program.

The Planetary program has experienced a high degree of success beginning with the Mariner 2 flyby of Venus in 1962. It has extended to the Mariner 4 Mars flyby in 1964 and 1965, the Venus flyby launched in June 1967 and the Pioneer 6 through 9 launched in the 1965-1968 period. The Pioneers 6 through 9 were designed to measure the interplanetary medium. The most recent successes, the Mariners 6 and 7, completed their flyby of Mars in July-August 1969 and returned the most comprehensive body of scientific data ever obtained from another planet.

The next phase of the Planetary program begins with the launch of two Mariner spacecraft in 1971 to orbit Mars for a minimum of 90 days each. Martian exploration will then be extended by the two Viking missions to be launched in 1975. Both missions contain separate spacecraft to simultaneously orbit and land on the Martian surface in 1976. In 1973 another Mariner is planned to fly by Venus and utilize the gravity assist available to make the first flyby of Mercury. Launches of Pioneer spacecraft are planned in 1972 and 1973, which will provide the first measurements of interplanetary medium in the region beyond Mars, in the asteroid belt, and in the vicinity of Jupiter. In each of 1974 and 1975, two cooperative U.S/German spacecraft (Helios) will be launched to investigate the particles and fields of the interplanetary medium in as close as approximately 0.3 AU (Astronomical Units) from the sun. One AU is the distance between the earth and the sun or 93,000,000 miles.

The FY 1972 budget provides for initial development of a long duration spacecraft suitable for a variety of missions to the outer planets, including flybys and orbiter missions. Initiation of this spacecraft development effort in FY 1972 is designed to take advantage of the unique alignment of the outer planets which will occur in the latter half of the 1970's and will make possible gravity assisted flybys of three planets with a single spacecraft. The mission set receiving primary attention includes 1976 and 1977 launches to Jupiter, Saturn, and Pluto and 1979 launches to Jupiter, Uranus, and Neptune. As an alternative to the first of these missions we will also study a mission to orbit Jupiter.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1970	1971	1972
Mariner	$63,871	$46,400	$52,800
Viking	40,000	35,000	180,400
Outer planets missions	---	---	30,000
Pioneer/Helios	22,570	37,400	20,100
Supporting research and technology/ advanced studies*	18,080	17,800	18,800
Planetary astronomy	3,800	4,800	4,800
Data analysis	2,579	3,500	2,400
Planetary quarantine*	---	---	2,200
Total	$150,900	$144,900	$311,500

BASIS OF FUND REQUIREMENTS:

Mariner

The objective of the Mariner program is to conduct the exploration of the planets with automated spacecraft in the medium weight class. Mariner 2

* The Exobiology part of SR&T and Planetary Quarantine were, in the prior years, part of the Bioscience program.

flew by Venus in December 1962 to provide the first direct temperature and magnetic field measurements from near the planet. This was followed by the Mariner 4 flight past Mars in 1965, which conducted initial close-up scientific observations of Mars showing a cratered surface similar to that of the moon. Valuable information on the planet's atmosphere and ionosphere was also acquired. In 1967, Mariner 5 flew past Venus some 2,600 miles from the planet's surface and made measurements to determine the properties of the Venusian atmosphere and the interaction between the planet and the interplanetary medium.

In 1969, Mariner 6 and 7 passed within 2,000 miles of the Martian surface, completing the most ambitious and successful planetary reconnaissance ever achieved by any nation. The scientific data returned greatly exceeded that originally anticipated for the missions, including more than 200 pictures of the planet taken by the spacecraft on their approach trajectories.

The scientific investigations of Mars using orbiting spacecraft will begin in 1971. The Mars 1971 spacecraft, which will use many of the proven subsystems of the Mariner 1969 flyby missions, will begin detailed studies of the atmosphere and environment of the planet, and provide a close-up look at large areas of the surface. This 1971 mission will provide broad topographic and thermal coverage, seasonal variations in the atmosphere and on the surface, and other long term dynamic observations. From orbit, the spacecraft will observe approximately 70 percent of the planet's surface including albedo changes, cloud movements and any other dynamic changes in the planet's atmosphere and on the planet's surface.

In 1973 using the same launch vehicle required to go to Venus, a single modified Mariner spacecraft will be accelerated by Venus' gravity and orbital velocity so that it can also swing by Mercury and begin the exploration of this, the closest planet to the sun. This spacecraft will return both ultraviolet and visual television pictures, atmosphere and ionosphere data, as well as thermal maps from both Venus and Mercury.

Fiscal year 1972 funds requested for Mariner Mars 1971 will be used to support post launch operations, orbital missions operations, and continued analysis of scientific and engineering data. Fiscal year 1972 funds for Mariner Mercury 1973 will be used for development and testing by the spacecraft system contractor, for launch vehicle procurement and for experiment development.

Viking

The exploration of Mars will be extended to surface exploration with the Viking landing missions launched in 1975. While the prior missions studied the planet from orbital or flyby distances, the 1975 missions will be the first opportunity to obtain data from direct measurements in the Mars atmosphere and on its surface. Particular emphasis will be placed on obtaining data on the biological, chemical and environmental factors relevant to the possible existence of life now, in the past, or in the future.

The lander to be used for this mission will be a soft lander similar to those used in the Surveyor project. This lander will be mated with a modified Mariner 1971 orbiter, which will have the capability to insert the lander into orbit prior to landing. This will permit orbital entry for the lander which has the advantage of smaller dispersions, lower entry velocities, and better control of entry angles.

Fiscal year 1972 funds will be used to complete the detailed design of most elements of the spacecraft and to complete breadboards of all critical subsystems. All major subsystem contracts will be let, consistent with the master schedule, and funds will continue to be provided for scientific investigator support.

Outer Planets Missions

The exploration of the inner planets is well underway. In the decade ahead we face the challenge of planetary exploration to the outer solar system, where lie most of the bodies in the solar system, including 5 planets, 29 satellites, and thousands of comets and asteroids.

Our experience during the 1960's has established a successful strategy of initially sending flyby missions to each planet to gain an initial knowledge of the planet and at the same time to lay a groundwork for the most productive planning of later orbiter, probe, and lander missions. We have initiated this logical sequence of exploration missions to Jupiter with the Pioneer F and G flyby missions to be launched in 1972 and 1973.

For the outer planets beyond Jupiter, it is again appropriate to initiate reconnaissance with flyby missions. Various alternate means have been examined to accomplish these initial flyby investigations. The most economical and productive approach has been determined to be two different three-planet flybys, the first to Jupiter, Saturn and Pluto with launch opportunities ranging from 1976 to 1978, and the second to Jupiter, Uranus and Neptune with launch opportunities centered at 1979. These missions are made possible by a unique alignment of the outer planets which occurs in the late 1970's but which will not reoccur for 179 years.

It would also be desirable to closely follow the Pioneer F and G flybys of Jupiter with a detailed second-generation investigation of that enormously interesting planet, featuring a planetology orbiter to be followed later with probe missions, at the same time we are conducting the multiple-planet flyby surveys of the remaining outer planets. It is recognized that available resources may not permit pursuit of both lines of effort during the same time period. NASA is continuing to study optimum strategies in partnership with both the Space Science Board (SSB) and NASA's in-house scientific advisory groups.

For all strategies under study, long-lead development of the Thermoelectric Outer Planets Spacecraft (TOPS), which has been under study for some time, must be started, basic experiments defined, and mission parameters determined to optimize the experiment returns. The experiment and mission planning effort will be greatly advanced during the coming year by a team of highly qualified scientists to be selected in March 1971 to assist NASA in planning outer planet missions.

During FY 1972 detailed design and development will begin on this TOPS multi-purpose outer planets spacecraft. The program is scheduled to have the TOPS spacecraft developed in time to take advantage of the Jupiter, Saturn, Pluto opportunity in 1976.

Our current program calls for the development of basic building blocks, including the TOPS spacecraft and its experiments, to permit flexible planning of an optimum program of investigation of the outer solar system.

A FY 1972 start on this effort is mandatory if we are to take full advantage of the rare and uniquely efficient multiple-planet flyby opportunities.

Pioneer/Helios

The objectives of the Pioneer project are to obtain scientific information at widely separated points in interplanetary space; to supply interplanetary environmental data on a continuing basis; and to conduct, during the 1972 and 1973 Jovian opportunities, exploratory investigations of the interplanetary medium beyond the orbit of Mars, the nature of the asteroid belt and the environmental and atmospheric characteristics of the planet Jupiter.

This project consists of three series of missions; Pioneers 6-9, Pioneers F and G, and Helios A and B. The first series of spacecraft weighed about 140 pounds each and were launched in 1965, 1966, 1967, and 1968. The four Pioneers now in solar orbit are all functioning, and Pioneer 6 has operated longer in interplanetary space than any other spacecraft. These interplanetary outposts are essential elements of our network of deep space "weather stations"

The development of Pioneers F and G was initiated in FY 1969. These spacecraft are to be launched into trajectories permitting the exploration of interplanetary space between one and five Astronomical Units (AU) from the sun including the asteroid belt and the vicinity of Jupiter. With this trajectory, we should be able to study the possibly hazardous region of the asteroid belt, to measure the gradient of the sun's influence on interplanetary space and the penetration of galactic cosmic radiation into the solar system. While the spacecraft are passing Jupiter, instruments will measure important properties of the planet and its environment. These missions will require new features on the Pioneer spacecraft to compensate for the lessening of solar radiation as a power source and the more demanding communications and thermal conditions. For example, Radioisotope Thermoelectric Generators (RTG's) rather than the more conventional solar cells will be utilized to provide electrical power to the spacecraft. New experiment instrumentation will also be required to make measurements in the asteroid belt and near Jupiter.

In FY 1969, NASA initiated its largest international cooperative project as part of the Pioneer program. The objective of this project, called Helios, is to investigate, in cooperation with the Federal Republic of Germany, the properties of, and processes in, interplanetary space in the direction of, and close to, the sun (about 0.3 AU). The spacecraft will be developed in West Germany with about one-third of the scientific experiments supplied by NASA.

Fiscal year 1972 funds will be used for the continued development of the Pioneer F and G spacecraft leading to launch in the third quarter of the year. Development of U.S. experiments for Helios will continue with delivery of engineering models.

Supporting Research and Technology/Advanced Studies

Supporting Research and Technology and Advanced Studies programs 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 and engineering capabilities essential to the performance of these missions. Included under Supporting Research and Technology are efforts in Advanced Technical Development, Lunar Science, Planetary Atmospheres, Planetology and Exobiology.

The activities of the Lunar Science program are devoted to increasing our scientific knowledge of the moon by continuing laboratory investigations and theoretical studies, drawing on basic data derived from ground-based research and automated and manned lunar missions.

The FY 1972 lunar science effort will include continued production of geologic maps of landing sites; plotting traverse routes; evaluation of future landing sites; and the appraisal of instrument concepts for remote physical and chemical analysis.

The Planetary Atmosphere program supports research in atmospheric phenomena of the planets including that of the earth, and the gaseous phenomena associated with comets. In FY 1972, research will emphasize the design, development, and modification of instruments for use in the exploration of the outer planets and the lower atmosphere of Venus.

The Planetology program supports research in the increasingly important field of planetary geology which includes geochemistry, geophysics and photogeology. In FY 1972 the emphasis will be on the development of instrumentation for geochemical and geophysical studies of Mars and the outer planets.

In the area of engineering technology, the Advanced Technical Development (ATD) program supports the development of new and improved spacecraft system, subsystem and component technologies for future missions. In FY 1972, research in the ATD program will continue work in these areas, with somewhat more emphasis on the critical technologies for Venus and Jupiter probes and comet rendezvous missions.

In the Planetary Advanced Studies program, surveys of potential future scientific missions are made, and their general system requirements and value in fulfilling established goals and objectives of NASA are defined. Alternate mission approaches and advanced technology requirements are examined. In FY 1972 it is planned to study orbiters and atmospheric probes of the outer planets, comet and asteroid rendezvous, and Mars rovers.

An integral and perhaps inevitable event in the origin and evolution of the universe was the origin of life. An understanding of the controlling factors in the origin of life and determination of the uniqueness of life on the earth are the primary objectives of the Exobiology program. The research areas considered basic to the program area are: chemical evolution; biological adaptation; life detection; flight experiments; return sample analysis.

Planetary Astronomy

The objective of this program is to increase our scientific knowledge of the planets and associated bodies by means of observations made from the vicinity of the earth. Observations will be made at wavelengths throughout the entire electromagnetic spectrum using instruments carried in aircraft, rockets, balloons, and earth orbiting satellites in addition to those at ground-based observatories. Supporting laboratory and theoretical studies are being carried out to assist in the reduction and analysis of the observations. In FY 1972, this program will be continued at the existing level of effort and will be implemented using existing instrumentation to the maximum possible extent.

Data Analysis

The primary purpose of spacecraft missions to the moon or to the planets is to conduct experimental investigations which will advance our knowledge and understanding. Data obtained by scientific instruments aboard the spacecraft are transmitted to earth for analysis by the scientists conducting the experiments. The initial data reduction and analysis is funded by the flight project as a part of its project responsibilities. Very often the time required to reduce and analyze the data, and to publish the results, is longer than the period of support provided by the project.

In 1972, lunar data analysis will emphasize data from the Apollo missions, and planetary data analysis will provide for data reduction from the Mariner Mars 1971 orbiter.

Planetary Quarantine

Accompanying NASA's high priority in space exploration to search for life or its origin is the absolute requirement that all feasible measures be taken to prevent the transfer of viable terrestrial microorganisms to the planets until the search for extraterrestrial life can be completed and a confident assessment of the consequences of contamination can be made. To accomplish this, outbound unmanned spacecraft missions destined for landing, flying by or orbiting a planet of biological interest, are required to meet rigid constraints so that the probability of biological contamination of the planet is less than one chance in a thousand.

Developing the new technology required to measure, control and destroy the microbial life in spacecraft hardware and finding appropriate compatible decontamination and sterilization procedures has been the major challenge in meeting the objectives of planetary quarantine.

A transition is underway from a research oriented program to one of operations for the Mariner '71, Viking, Pioneer and other planetary missions, although a lowered level of research is going ahead to provide alternate techniques of sterilization other than dry heat.

The planetary quarantine effort to date has been focused on Mars and Venus. However, within this decade we may be concerned with additional missions to the outer and inner planets. Efforts must be directed at defining the planetary quarantine constraints for these planets so that planning and analyses may be undertaken to see how the flight missions can comply with the requirements.

Spacecraft bioassay activities at the Cape Kennedy laboratory will continue to provide the inventory and surveillance data on Apollo missions and the upcoming Mariner Mars 1971 orbiting mission in accord with NASA directives.

Schedule of Launches

Project	Mission	Calendar Year
Pioneer	Pioneer F	1972
	Pioneer G	1973
	Helios A	1974
	Helios B	1975
Mariner	Mars 1971 (2)	1971
	Venus Mercury 1973 (1)	1973
Viking	Mars 1975 (2)	1975
Outer Planets Missions	Jupiter-Saturn-Pluto	1976
	Jupiter-Saturn-Pluto	1977
	Jupiter-Uranus-Neptune (2)	1979

OFFICE OF SPACE SCIENCE AND APPLICATIONS — BIOSCIENCE PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Bioscience program was established in 1961 to implement a Space Biology and a Planetary Biology program (Exobiology and Planetary Quarantine). A decision was recently made to bring together in the Office of Manned Space Flight the greater part of the NASA life sciences activities formerly distributed among the Space Medicine Division of the Office of Manned Space Flight, the Biotechnology and Human Research Division of the Office of Advanced Research and Technology, and the Bioscience Programs Division of the Office of Space Science and Applications.

The decision to consolidate Life Sciences activities was supported by a recent study of the National Academy of Sciences. The consolidation of Life Sciences excluded two general functional areas, Planetary Biology and Aeronautics. The Planetary Biology effort of Exobiology and Planetary Quarantine will be retained in the Planetary Programs Division of the Office of Space Science and Applications because of the central role that these activities play in planetary exploration. The Aeronautics portion of the former Human Factors program will be retained in the Office of Advanced Research and Technology because of its criticality to aeronautical flight and research operations.

The Life Sciences budget is included in the Office of Manned Space Flight budget in FY 1972.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1970	1971	1972
Planetary quarantine..................	$2,540	$2,000	---
Biosatellite..........................	5,970	332	---
Supporting research and technology/ advanced studies....................	11,145	10,568	---
Total.............................	$19,655	$12,900	---

RESEARCH AND DEVELOPMENT

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OFFICE OF SPACE SCIENCE AND APPLICATIONS — SPACE APPLICATIONS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objectives of the Space Applications program are to: (1) expand the knowledge of geophysical, oceanographic, atmospheric, and space phenomena; (2) conduct a broad program of research and technical development oriented toward the application of space techniques for the benefit of mankind; (3) develop and test procedures, instruments, subsystems, spacecraft, and interpretive techniques for the various applications; (4) fulfill NASA's responsibilities under the Communications Satellite Act of 1962; (5) develop and implement for the National Oceanic and Atmospheric Administration (NOAA), Department of Commerce; the operational meteorological satellite system; (6) cooperate with the user Government agencies, such as the Departments of Agriculture, Commerce, Interior, Navy and others to achieve practical benefits to mankind in earth resources; (7) cooperate with other Government agencies in space related activities in the communications, navigation, and geodesy/earth physics disciplines; and (8) cooperate to the extent possible with foreign countries in the general advancement of space applications.

The Space Applications program effort is directed toward research, development, and flight test of experiments, subsystems, and spacecraft in the areas of applications technology, communications, geodesy/earth physics, earth resources, meteorology, and navigation/traffic control, and includes development of operational systems for user agencies. Current flight programs include TIROS, Nimbus, Synchronous Meteorological, Applications Technology, and Earth Resources Satellites, plus a number of meteorological sounding rockets. Applications Technology Satellites offer great potential to mankind by developing and extending the technology common to many applications. Communications satellites provide an economical method for worldwide communication and can be used to relay to ground stations data obtained by applications and scientific spacecraft. Earth resources satellites can obtain valuable agriculture/forestry, geology/mineralogy, hydrology/oceanography, and geography/cartography data. Meteorological satellites provide the capability to improve weather prediction on a global basis and increase our knowledge of the atmosphere. Geodesy/earth physics satellites can help to determine the size and shape of the earth and the vector properties of its gravitational field and increase our knowledge of the dynamics of the earth's core, mantle, and crust; the motion of the poles of the earth; the rotation of the earth; and the general circulation of the oceans.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars) 1970	1971	1972
Earth resources survey:...........	$26,000	$59,950	$48,500
Earth resources technology satellite....................	(15,000)	(48,950)	(37,500)
Aircraft program................	(11,000)	(11,000)	(11,000)
Applications technology satellites	38,965	30,300	60,300
Nimbus..........................	27,239	25,300	23,100
Synchronous meteorological satellite......................	2,700	10,850	13,000
Cooperative applications satellite......................	83	100	2,600
Global atmospheric research program........................	---	1,000	2,500
Meteorological soundings..........	3,000	3,100	2,500
TIROS/TOS improvements............	3,700	3,200	1,600
Radio interference and propagation program....................	438	1,000	1,000
Geodetic satellites...............	1,700	1,700	1,300
Earth observatory satellite studies........................	---	---	1,000
Air traffic control satellite studies........................	---	3,000	---
Supporting research and technology/ advanced studies................	24,479	27,500	25,100
Total..........................	$128,304	$167,000	$182,500

BASIS OF FUND REQUIREMENTS:

Earth Resources Survey

The objectives of this project are to: (1) assess the practical value of remote sensing of earth's resources from space; (2) compare the capabilities in earth resources data acquisition of a space system with and without complementary aircraft coverage; (3) determine whether or not, and in what configuration, an operational space-assisted and user-oriented earth resources survey system could be developed to meet existing requirements; (4) determine which remote sensors are most effective for earth resources surveying; (5) develop and improve data handling procedures; and (6) ensure full understanding of future operational system requirements and costs.

The project includes three activities in the earth resources disciplines: (1) a program to design, develop, launch, and evaluate two spacecraft carrying earth resources experiments; (2) an aircraft flight program to develop and test remote sensing techniques, sensors, and data handling systems at altitudes of from 500 to 60,000 feet; and (3) coordinate applications requirements with OMSF which is developing the Earth Resources Experiment Package (EREP) to be flown on Skylab.

The objective of the Earth Resources Technology Satellite project is to design, develop, launch, and test a series of spacecraft to conduct experiments which will lead to a reliable assessment of the utility of spaceborne sensors for application to problems related to natural and cultural resources. This assessment will lead to the capability to design spacecraft and related data handling systems to support these national programs on an operational basis. It will also lead to an evaluation of the complementary roles of aircraft and spacecraft in acquiring data on the earth's resources. This effort is progressing in FY 1971 and will continue in FY 1972 through the detailed design and fabrication of spacecraft, payloads, and ground systems required to launch, support, and operate two Earth Resources Technology Satellites: ERTS-A in the spring of Calendar Year 1972 and ERTS-B about one year later. Both satellites are planned for sun-synchronous orbit and are expected to have useful mission durations of one year each. These satellites will carry instrumentation that will meet the immediate requirements of the user community in terms of spatial and spectral resolution as well as repetitive coverage. Both framing and line scanning sensors will be flown in order to assess the advantages of each. The satellite system will also concurrently relay data from remote ground sensors such as rain gauges, stream gauges, and seismometers to assess the value of such a network for complementing the spaceborne sensors.

The Earth Resources Survey aircraft supporting project objective is to conduct tests and experiments with instruments analogous to those being considered for the spacecraft systems to evaluate both the instruments themselves and the potential of using such instruments to perform useful tasks from space. The flights also contribute to an understanding of and solution to the data management problems that will be a part of the total system operation, including the interfaces with the extensive and diverse user community.

Fiscal Year 1972 funds are being requested to continue aircraft operations, sensor procurement, and data processing to conduct about 150 flights over 15 test sites which represents a change in flight emphasis needed in the preparation of ERTS-A and Skylab.

Applications Technology Satellites

The objectives of the project are to design, develop, flight test, and evaluate a variety of scientific and technological experiments within the applications disciplines by use of a series of seven spacecraft. Five spacecraft have been launched to date. ATS-1 and ATS-3 have performed successfully for several years and continue to operate. Due to launch vehicles anomolies the planned orbits for ATS-2 and ATS-4 were not achieved. ATS-5 experienced post-launch problems with the active stabilization system; however, many objectives from seven of the twelve experiments flight tested are being achieved. ATS-F and G are scheduled for launch in Calendar Year 1973 and 1975, respectively. These spacecraft will be launched into synchronous orbit and will flight test a space-erectable, parabolic antenna approximately 30 feet in diameter, demonstrate high pointing accuracy, and will flight test a number of scientific and technology experiments. Development of the ATS-F and G spacecraft, ATS-F experiments and project-associated ground equipment is underway. Effort will be continued on development of promising advanced applications flight experiments which have been defined but have not been assigned to a specific mission.

Fiscal Year 1972 funds are required to continue development of the spacecraft, ATS-F experiments and ground equipment, to initiate procurement of ATS-G experiments, to continue development of selected advanced applications flight experiments, and for extended experiments, operations and data acquisition, reduction and analysis from the ATS-1, -3, and -5 missions.

Nimbus

The Nimbus project objectives are to develop a significantly improved meteorological satellite to provide atmospheric data for scientific use; to prove instrument applicability by means of flight tests; to fulfill special data requirements of the atmospheric sciences research community; and to provide further significantly advanced technology for meteorological satellites.

The launch of Nimbus 3 was successfully accomplished April 14, 1969. Its measurement of temperatures in the atmosphere has been termed "as significant to the advancement of meteorology as the launching of the first satellite." On September 25, 1970, the aft scanner motor failed, seriously degrading stability. Limited operations continue.

Nimbus 4 was successfully launched on April 8, 1970. The advanced stabilization system has met or exceeded the performance specifications. New and improved experiments are carried on this spacecraft for determining the vertical temperature structure. Additional experiments include a temperature/humidity infrared radiometer, a monitor of the water content of the atmosphere, and a refined worldwide data collection system which is providing the first meaningful spacecraft-obtained wind measurements.

Nimbus E and F are planned for launch in Calendar Years 1972 and 1974 respectively. These missions will test new infrared radiometric and spectrometric and microwave instrumentation designed to extend determination of the vertical structure of the atmosphere into cloudy areas. These and other new instruments will extend sounding of the atmosphere to new areas of the electromagnetic spectrum and to higher altitudes in the atmosphere.

Fiscal Year 1972 funds are required for integration of the Nimbus E spacecraft systems and experiments, and final testing prior to the launch, in August 1972. They will also support continued development, assembly, and test of the Nimbus F spacecraft and experiments, and such continued acquisition and analysis of data from Nimbus 3 and 4 as appropriate to their operational status.

Synchronous Meteorological Satellite

The objectives of the Synchronous Meteorological Satellite (SMS) are to: (1) demonstrate a prototype operational SMS; (2) permit continuous observation of major weather systems routinely, thus enhancing the ability to predict and locate severe short-lived storms; (3) derive important wind field data over considerably large areas and in much less time than heretofore possible; and (4) 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 system for both IR and high resolution visible photography, a communications system for data collection and distribution, and a space environment monitoring (SEM) system. The spacecraft will be sized to permit launch into synchronous orbit by the Delta launch vehicle.

Fiscal Year 1972 funds are required to continue the procurement of these spacecraft, their subsystems, and sensors.

Cooperative Applications Satellite (CAS)

Two unrelated cooperative missions are included in this program: CAS-A, a cooperative project with France; and CAS-C, a planned cooperative project with Canada.

CAS-A: The CAS-A mission involves the use of instrumented balloons with an earth-orbiting satellite for obtaining characteristics of air masses. The data thus obtained will be used by U.S. and French scientists to assist in the understanding of the structure of the atmosphere and extending weather forecasting capabilities. One spacecraft and one backup with instruments and instrumented balloons will be provided by France. The spacecraft will be launched by NASA from Wallops Island in late 1971 using a Scout launch vehicle to gather data from approximately 500 balloons. The U. S. will provide the Scout vehicle, and backup if required, launch services, initial satellite tracking, and, along with France, analysis of the reduced data.

Fiscal Year 1972 funds are required for continued technical support and to provide launch and post-launch support.

CAS-C: For the second cooperative applications project the Canadian Department of Communications and the NASA plan to launch a Canadian Technology Satellite (CAS-C) in late 1974 which is a substitute for the fourth planned cooperative ISIS mission. The overall objective of this project is to advance the state-of-the-art in spacecraft and related ground based technologies relevant to future educational broadcasting and remote area communications and other satellite applications systems and to develop technologies above 10 Gigahertz (GHz). Major technologies flight tested by this mission will be super efficiency power tubes, unfurlable solar power arrays, and satellite communications experiments with 12 GHz terminals.

It is planned that the spacecraft will be developed and fabricated in Canada and launched from the Eastern Test Range (ETR) by NASA using a Delta class launch vehicle. The U. S. and Canada will subsequently conduct experiments on a time-shared basis.

Fiscal Year 1972 funds are required for CAS-C to begin high power tube development and initiate ground system planning and procurement. Canada will provide continuing funding support for the spacecraft and their experiments.

Global Atmospheric Research Program

The Global Atmosheric 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 fall of 1974 and a first GARP global experiment during the period of 1975 or 1976. Tentative requirements for atmospheric data, and tentative observing systems for acquisition of this data, have been defined by WMO-ICSU planning groups. Operational and experimental satellites of the United States, U.S.S.R., France, and other countries have been identified as essential to the GARP experiments.

During FY 1972, NASA will continue modeling and simulation studies to improve mathematical models of atmospheric behavior, incorporating quantitative atmospheric data obtained from meteorological satellites, and to further define observing system data requirements. Efforts will be continued to establish preliminary systems designs for satellite global observing systems employing operational and experimental satellites available through participation by interested nations. Detailed studies and comparative analyses will be conducted to identify facilities, logistics operations, and advanced technology, and advanced development tasks required to provide data acquisition, data transmission, and data processing support for the tropical experiment and the first GARP global experiment. Detailed planning will be initiated for the conduct of the first GARP global experiment and technological studies will be conducted toward the solution of unresolved problems in acquiring, on a global basis, essential atmospheric data.

Meteorological Soundings

The objectives of this project are to use research and development meteorological sounding rockets to measure the structure and characteristics of the atmosphere in the 30 to 100 km region and to develop an economical meteorological sounding rocket system to meet research, range support, and routine operational requirements. Three areas of effort are involved: (a) Research meteorological rockets of the Nike-Apache class are used to explore the characteristics of the atmosphere between 30 and about 100 kilometers. This region, which is important to meteorological science, cannot be reached except by sounding rocket. The relations and the mechanisms operating between and within the various regions of the atmosphere, and the effects of solar energy and its variations on the structure and circulation of the atmosphere are explored. (b) A small meteorological sounding rocket system for making economical atmospheric measurements in the region 30 to 60 kilometers is being developed. This system will be capable of launching reliable inexpensive operational meteorological sounding rockets amenable to the requirements for range support, atmospheric research, and network operations. (c) The field experiment support program which 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 data.

Fiscal Year 1972 funds are required to procure additional large research and small developmental rockets, flight test various payload experiments, improve rocket, sensor, and parachute performances, and to continue field experiment projects with other cooperating countries to obtain additional atmospheric research data.

TIROS/TOS Improvements

The objectives of this project are to provide research and development toward advanced operational meteorological satellite systems, specifically in support of the TOS program and the development of operational systems for the National Operational Meteorological Satellite System (NOMSS); to provide maximum interim operational data for use in weather analyses and forecasting; to provide improved operational subsystems for the acquisition of data necessary to the improvement of weather analyses and forecasts, specifically in the areas of infrared and visual observations of earth cloud cover, radiometric observations of reflective and absorbed energy for determination of vertical temperature and water vapor profiles and the earth atmosphere heat budget, and in the area of improved data processing and handling for timely operational use.

Nine TIROS research and development spacecraft funded by NASA and nine operational spacecraft funded by National Oceanic and Atmospheric Administration (NOAA), formerly ESSA, have been successfully launched. TIROS-M, developed by NASA as the operational prototype of the second-generation operational satellite series, the Improved TIROS Operational Satellite (ITOS), was launched January 23, 1970. The first operational spacecraft (NOAA funded) of the ITOS series, ITOS-A (NOAA -1), was successfully launched December 11, 1970. Under TOS Improvements, effort will be continued in the development of advanced sensors and subsystems, such as high-resolution radiometers and altitude-determination systems which will be incorporated into future operational spacecraft.

Fiscal Year 1972 funds are required to initiate design and development the advanced sensors for the next generation of operational meteorological satellites.

Radio Interference and Propagation Program

The Radio Interference and Propagation program (RIPP) commenced in Fiscal Year 1970 under Communications SR&T. Due to the growth in the program and the required interfaces with other agencies, it is desirable to identify this program as a separate line item in the Communications program. The objectives of RIPP are to: (1) determine whether communications satellite systems and terrestrial systems can continue to share the same frequency bands as the numbers of both systems increase; (2) determine the basis for sharing the same frequency band; (3) determine the influence of weather phenomena on satellite and ground communications systems; and (4) determine the utility of frequencies above 10 GHz for communications satellite services. This planned effort will consist of two phases: Phase 1 - to develop sharing criteria for 4 to 10 GHz, and Phase 2 - to develop sharing criteria above 10 GHz.

Equipment has been designed and assembled in an installation for measurement of ground-to-ground interference below 10 GHz. This installation, the only one of its kind in the nation, is jointly supported by the Office of Telecommunication Policy, the Department of Commerce, and the Department of Defense. Initial experimental data were obtained in September 1970. Interference and propagation measurement data at frequencies below 10 GHz will be used in support of U. S. proposed position at the 1971 World Administrative Radio Conference (WARC). Additional experiments and studies on uplink and downlink propagation and interference ground-to-satellite and satellite-to-ground, are a vital part of the program, especially with respect to use of the higher frequencies above 10 GHz for satellite communication services.

Fiscal Year 1972 funds are required to continue the present ground-to-ground interference experiments below 10 GHz and to initiate efforts to explore frequency bands above 10 GHz for satellite services by conducting satellite-to-ground and ground-to-satellite propagation and interference studies and experiments.

Geodetic Satellites

The purpose of the Geodetic Satellite project is to support the National Geodetic Satellite Program (joint NASA/DoD/DoC program) and to develop the technology of geodetic satellites for solid earth geophysics and oceanography. Geodetic Satellites launched to date are: Pageos-1, GEOS-1, and GEOS-2. Data are still being obtained from GEOS-2.

Fiscal Year 1972 funds are required to continue analyses of data obtained from the GEOS flights.

Earth Observatory Satellite (EOS) Studies

Studies will be conducted on the Earth Observatory Satellites (EOS) which will serve as the initial members of a family of advanced earth observations platforms for the efficient conduct of experimental research and development in earth resources surveying and meteorology. This will combine, in one multipurpose spacecraft, the functions previously provided by the ERTS and the Nimbus series of meteorological technology satellites. Primary emphasis for EOS is to be placed on observations of oceanographic phenomena and interactions of the ocean surface with the atmosphere in order to meet urgent needs for research data and the development of advanced operational sensors for oceanographic and meteorological disciplines. Consideration will also be given to other needs in atmospheric sciences and in earth resources surveying. In this capacity, the EOS will provide a space platform for the orbital test of experimental sensors and spacecraft subsystems, for the acquisition of environmental data for research and for the development of applications of these data and techniques to problem areas in resources/environmental management and meteorology.

Remote sensing development, data acquisition, and techniques development will address advanced research requirements for data in disciplines of oceanography, meteorology, and terrain observations.

Fiscal Year 1972 funds are required to initiate preliminary system design studies.

Air Traffic Control Satellite Studies

Studies will be conducted in response to DOT requirements to establish the basis for assessing the technical approaches and cost efficiencies of commercial proposals for air traffic control and communication satellite services. Studies will also be conducted in coordination with DOT and ESRO to determine the needs for advanced satellite systems and technology and the approach to the most effective operational system for the late 1970's and early 1980's.

NASA efforts will include in-house and contractor-support studies, NASA/ESRO studies as appropriate, and NASA/DoT studies. These efforts will utilize FY 1971 funds. No FY 1972 funds are being requested by NASA for this project.

Supporting Research and Technology

The objectives of the supporting research and technology effort are to conduct programmatic studies, basic and supporting research, advanced technological developments and the testing of new concepts, techniques, materials, components, sensors, instrumentation, data systems, and subsystems which have application to future aircraft and satellite projects. The disciplinary areas of effort in the space applications program include applications technology, communications, geodesy/earth physics, earth resources, meteorology, navigation/traffic control, and interdisciplinary applications.

Fiscal Year 1972 funds are required to maintain the current level of supporting research and technology efforts in the separate applications disciplinary areas and to place increased emphasis on earth resources disciplines in the earth observations area and on the advanced systems studies/user requirements in Communications.

SCHEDULE OF LAUNCHES

Schedule of Significant Research and Development Events

Project	Mission	Calendar Year
ITOS*	Launch of ITOS A-G	1970-1974 (subject to call-up by NOAA)

Nimbus	Launch of Nimbus-E	1972
	Launch of Nimbus-F	1974
Synchronous Meteorological Satellites	Launch of SMS-A	1972
	Launch of SMS-B	1973
Cooperative Applications Satellite	Launch of CAS-A	1971
	Launch of Back-up (if required)	1972
	Launch of CAS-C	1974
Applications Technology Satellites	Launch of ATS-F	1973
	Launch of ATS-G	1975
Earth Resources Technology Satellites	Launch of ERTS-A	1972
	Launch of ERTS-B	1973
Meteorological Soundings	Launch about 250 annually	---
INTELSAT**	Launch of INTELSAT IV Series	1971-1972 (subject to call-up by COMSAT)

* NOAA funded
** COMSAT funded

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1972 ESTIMATES

SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS — LAUNCH VEHICLE PROCUREMENT PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objective of the Launch Vehicle Procurement program is to provide a national capability to launch automated spacecraft. This is accomplished through the procurement of vehicle hardware and supporting services and equipment. These procurements currently provide a flexible, versatile family of vehicles consisting of Scout, Delta, Centaur, and Titan III C. In addition, the program provides support for vehicle systems maintenance and updating, in order to obtain greater performance and reliability at minimum cost, and for a supporting research and technology/advance studies effort to investigate promising areas of research and technology related to launch vehicles.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars) 1970	1971	1972
Scout	$13,700	$14,200	$16,500
Delta	32,400	34,000	37,200
Centaur	46,019	68,000	75,900
Titan III C	6,700	4,700	12,500
Agena	5,000	---	---
Supporting research and technology/ advanced studies	4,000	4,000	4,000
Total	$107,819	$124,900	$146,100

BASIS OF FUND REQUIREMENTS:

Scout

Scout is a four stage all solid propellant vehicle which is utilized to launch small satellite, probe, and re-entry missions. In FY 1972, funds will be used for procurement of hardware, vehicle system improvements, and maintenance of the required launch and engineering services and ancillary equipment.

Delta

Delta is a three stage vehicle, two liquid propellant stages with a solid propellant third stage, capable of launching payloads of moderate weight into earth orbit and smaller payloads into solar orbit. With its flexibility, the Delta vehicle is compatible with the wide variety of mission requirements generated by applications and scientific users. The requested funds for FY 1972 will be employed to initiate new procurement and to sustain current purchasing of vehicle hardware and supporting services. Necessary improvements to the Delta telemetry system and fairing will be continued.

Centaur

The hydrogen-oxygen propelled Centaur with the Atlas booster is the highest energy launch vehicle currently used by NASA for the launch of automated missions. Development now under way will team the Centaur with the Titan III booster to provide even greater capability for upcoming interplanetary and heavy payload, earth orbit missions. In addition to sustaining hardware and support services procurements, the FY 1972 request will continue the effort to improve the guidance system and to develop a large diameter shroud.

Titan III C

The Air Force-developed Titan III C is a four stage vehicle which will be utilized by NASA for the launch of heavy payload missions. This vehicle will be used to launch the Applications Technology Satellites (ATS) F&G missions in 1973 and 1975 respectively. The continuation of required hardware and service procurements will be accomplished with the FY 1972 funds requested herein.

Supporting Research and Technology/Advanced Studies

Through this project future mission requirements are defined, alternatives are arrayed from which optimum modes to fulfill these requirements are selected, and the required technology is developed in an orderly, timely manner. Supporting research and technology is currently carried on in five disciplines of launch vehicle technology: propulsion and energy conversion; guidance and control; instrumentation and electronics; structures and materials; and vehicle engineering. Advanced studies will be continued or initiated on solar electric propulsion, versatile upper stage, small versatile launch vehicles, and minimum cost vehicle systems with special attention to potential utilization on shuttle missions.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1972 ESTIMATES

SUMMARY

OFFICE OF UNIVERSITY AFFAIRS — SUSTAINING UNIVERSITY PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Sustaining University program was established in 1962 when NASA's expanding responsibilities required increased participation of the educational community in the space program. The objectives were to provide adequate laboratory facilities, to increase the number of highly trained people, and to conduct broad multidisciplinary research. Many of these goals have been met, NASA programs have benefited and the universities have been strengthened through their participation.

NASA will continue to support research at universities as needed for NASA's mission with funding requirements to be met from program office R&D resources. The Sustaining University program has been phased to an orderly conclusion.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1970	1971	1972
Sustaining university program.........	$7,000	---	---
Total............................	$7,000	---	---

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1972 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR

ADVANCED RESEARCH AND TECHNOLOGY PROGRAMS

	(Thousands of dollars)		
Program	1970	1971	1972
Aeronautical research and technology	$95,685	$102,000	$110,000
Space research and technology	119,977	107,000	75,105
Nuclear power and propulsion	55,269	55,200	27,720
Total	$270,931	$264,200	$212,825

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1972 ESTIMATES

SUMMARY

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY

AERONAUTICAL RESEARCH AND TECHNOLOGY PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The NASA Aeronautics program for FY 1972 is aimed at providing significant advances in the technology base to insure that this country remains the world leader in the development of military and civil aircraft. A research and technology program, coordinated with the FAA/DOT and DOD, is being continued which will increase aeronautical systems reliability and safety, will reduce obtrusiveness to the environment, and is relevant in the overall sense to this decade's military aircraft and civil transportation demands. Research will concentrate on aerodynamics, flight dynamics, propulsion, operating systems, vehicle systems, life sciences, electronics, materials and structures, and noise reduction for application to future generations of all subsonic, supersonic and hypersonic aeronautical vehicles. Emphasis in FY 1972 will be on propulsion research including engine noise reduction, aerodynamics and vehicle systems. A major new initiative in FY 1972 is the design and development of an experimental short take-off and landing (STOL) turbofan transport research airplane.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1970	1971	1972
Experimental STOL transport research airplane..........	---	$1,900	$15,000
Aerodynamics and vehicle systems....................	$37,439	45,000	42,000
Life sciences................	3,000	2,100	3,100
Propulsion...................	29,419	23,900	22,300
Operating systems............	6,996	8,000	6,500
Materials and structures.....	7,646	7,400	11,000
Guidance, control and Information systems........	10,190	4,200	3,000
Power........................	200	400	400
Supercritical technology.....	795	9,100	6,700
Total.....................	$95,685	$102,000	$110,000

BASIS OF FUND REQUIREMENTS:

Experimental STOL Transport Research Airplane

This effort encompasses a major new initiative beginning with design and development and leading to flight testing in the 1974 through 1976 period of two experimental short take-off and landing (STOL) turbofan transport research airplanes. The essential objectives of this experimental research airplane project are to validate the predicted performance and to permit the establishment of realistic criteria for certification of civil subsonic STOL jet transports and criteria for enroute and terminal area operations. Noise reduction through incorporation of technology developed in the quiet engine program will receive major emphasis.

Navigation and flight path control procedures will be tested and verified. This flight test program is a necessary step to confirm the results of studies, simulation and wind tunnel testing to complete the technology base necessary for development by industry of a jet STOL transport system. Such a system is essential to meeting future requirements for short haul air transport, a vital segment of the national transportation system.

NASA is currently working with DOT and industry representatives to establish a joint approach to a short haul transportation system, including the experimental STOL transport research airplane development and flight test program. The specific airplane configuration, scheduling, and participation by government and industry will be defined over the next several months.

The FY 1972 funding request provides for initiation of design, development, and fabrication on the two experimental STOL transport research airplanes, and for continuation of supporting model testing in wind tunnels, propulsion studies, and tests aimed at noise reduction.

Aerodynamics and Vehicle Systems

The Aerodynamics and Vehicle Systems program is directed to fundamental research in the disciplinary technologies of aircraft aerodynamics, aircraft loads, and aircraft flight dynamics for the following classes of vehicles: general aviation aircraft, V/STOL aircraft, subsonic aircraft, supersonic aircraft and hypersonic aircraft - both civil and military. Emphasis is placed, as required, on flight test programs and experimental hardware evaluations. This combined disciplinary and experimental hardware approach provides the data and information which can be applied by the aircraft industry and government agencies to the development of safer and superior civil and military aircraft, advanced aircraft concepts, regulatory criteria, new operational concepts and the integration of the pilot/aircraft system.

The FY 1972 program will include the continuation of studies to improve the safety of general aviation aircraft, studies of advanced rotors for helicopters and rotor-driven V/STOL aircraft; studies of airbreathing propulsion system-airframe integration and dynamic problems for application to supersonic and hypersonic aircraft, and flight dynamics studies for each class of vehicle to insure increased compatibility of the pilot-vehicle system, including terminal area and all-weather operations. Experimental research and development aircraft and engineering test pilot proficiency aircraft necessary to carry out and support the total aeronautical effort are part of this program.

Life Sciences

The aeronautical Life Sciences program is directed toward determining the limitations and adaptations of man relative to aeronautical environments; it develops methods and equipment to enhance human performance and safety in aviation systems; and advances the state-of-the-art of aeronautical simulation technology for its application of air and ground personnel training and proficiency maintenance, and for conducting aeromedical research relative to aeronautical problems. The aeronautical Life Sciences program is developing techniques for predicting the effects of new generation aircraft noise on man. To this end, research will be conducted to obtain quantitative information on and develop means to minimize human annoyance and physiological damage due to aircraft noise and vibration; and to measure the physiological and psychological effects of other stresses due to aviation systems such as fatigue, desynchronosis, disorientation and visual aberrations.

Aviation safety equipment and procedures have not kept pace with advancements in other aspects of aeronautical technology. This program will conduct research and technology to enhance man's performance as an operator and insure his safety and comfort as a passenger in aeronautical systems.

Propulsion

The primary goals of the aeronautical Propulsion Research and Technology program are to provide advanced technology through analytical and experimental investigations of engine components and engine systems. These programs are aimed at improving engine performance, operational capability, safety and reliability, and reducing weight and size. During FY 1972 a great deal of attention will be given to the environmental problems of aircraft noise and pollution. Aircraft noise research will include studies and experiments, both small scale and full scale. Particular attention will be given to the problems of aircraft noise for Short Take-Off and Landing vehicles. In addition to the noise research associated with the development of the NASA experimental quiet engine program, an extensive research effort will be undertaken to develop jet noise suppressors for supersonic aircraft propulsion systems. Research on pollution is aimed at reducing the amount of smoke and oxides of nitrogen from the exhaust gases emitted from turbo-jet engines.

Research effort will continue on engine components and propulsion concepts. Low-cost small gas turbine engines will receive particular emphasis for application to missiles, target drones, and general aviation aircraft. In the V/STOL technology area, research efforts will be focused on studying various high thrust to weight ratio propulsion systems that have the potential of meeting the stringent noise requirements for this class of vehicle. In supersonic propulsion, research will be aimed at the required high thrust to weight ratio engines capable of providing good performance at all design conditions which includes those flight conditions (flight maneuvers, gusts, turbulence, etc.) resulting in highly distorted flow entering the inlet and stalling the engine. In the Hypersonic aircraft technology area, research will be conducted on two and three-dimensional fixed geometry propulsion system concepts, and combustion experiments in supersonic penetration and mixing.

Operating Systems

The research effort under the aeronautical Operating Systems program broadens the traditional aeronautical engineering emphasis upon flight vehicles to include other technology areas such as navigation, guidance, air traffic control, runway and environmental impact interfaces. An air transportation system is very complex and impacts and is impacted by its environment. The problems of the system must be approached in their entirety rather than from the unconnected viewpoint of any single element. The role of this program is to focus specialized knowledge upon problems of the aircraft and its environment. In the area of air traffic systems, research will emphasize the application of advanced technology and new concepts in control, guidance, computers, and ground electronic aid systems. Joint programs in this area are being developed with the FAA and DOT.

Under operating factors, research will be aimed at solving problems related to runway surface and atmospheric environment, operational hazards, flight instrumentation, and sonic boom effects on buildings and equipment. These will involve analyses and laboratory and flight test experiments.

Materials and Structures

The Materials and Structures program has as its objectives an understanding of materials and the development of new materials and structures able to carry the loads, stresses, and temperatures encountered by advanced aircraft. A broad materials and structures program is necessary to increase the potential of all classes of aircraft. For example, general aviation requires low-cost, light weight, easily fabricable materials, while high speed aircraft demand stronger and lighter materials capable of operating at high temperatures and in corrosive environments.

Specifically, emphasis in FY 1972 will be on the development of improved titanium alloys, on stronger nickel base alloys for use in aircraft structures and turbine blades, and in new coatings to protect these alloys from oxidation at high temperatures. Work on composite materials incorporating recently developed high modulus and high strength graphite, boron, and glass fibers will continue, and their application to aeronautical structures will be studied in a broad program with emphasis on laboratory and service flight demonstrations on the use of these materials for selective reinforcement of metal structures. High performance plastic composites for both airframe structures and engine components will also be studied.

The synthesis of non-flammable polymers will continue in FY 1972 as a result of the encouraging results obtained from last year's effort. Several intumescent and foam compositions were developed which markedly reduced fire hazards in experimental aircraft fires.

As a result of research on carbons and graphites, improved seals for high temperature aircraft engines were recently developed. Additional studies on several new carbons will be made in FY 1972 with the goal of increasing life times. Basic studies on friction and wear phenomena will continue in order to identify the important parameters for low friction and wear bearings, seals, and lubricants.

Studies of fatigue, fracture mechanics, corrosion, frictions and wear will be continued to provide the materials needed for the advanced aircraft of the future.

Guidance, Control and Information Systems

The objective of the Guidance, Control and Information Systems program is the development of electronics technology which is basic to the needs of modern aviation. Accent in FY 1972 will be placed on aircraft control (either automatically or by the pilot) through improvements in electronic components, in improved displays and indicators, and on the development of new sensors for better navigation and hazard avoidance. Particular attention will be focused on the "fly-by-wire" control concept, which offers the advantages of improved ride characteristics, greater safety and reduced weight; on a new independent landing monitor which gives the pilot a picture of the runway and airfield even under instrument landing conditions; lasers and microwave detectors which warn of clear air turbulence; and optical detectors to warn of possible collisions with other aircraft. Research grants in the area of air traffic control technology will be initiated and work will continue on the development of the technology which supports FAA aviation system development.

Power

A thorough study of present and future aircraft electrical power requirements is continuing together with a low level R&D effort intended to reduce the weight, complexity and maintenance requirements of aircraft electrical systems.

Supercritical Technology

NASA is working on a broad-based and long-term program oriented toward achieving significant improvements in the quality of long haul aircraft operating at speeds near Mach 1.0.

The supercritical aerodynamic technology under study for the past 6 years appears to offer the potential of important cruise speed and economic advantages for transport aircraft. In combination with compatible advances in technical disciplines such as structures, materials, propulsion, and flight control systems, the supercritical technology will provide a basis for achievement of significant improvements in air transport quality. The program consists of three major elements: (1) fundamental technology, (2) exploratory flight research, and (3) systems studies to define the features to be incorporated in subsequent transport generations, and the research required to assure their development.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1972 ESTIMATES

SUMMARY

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY

SPACE RESEARCH AND TECHNOLOGY PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

Space Research and Technology (R&T) for NASA operations in the coming decades require a continuing strong research activity now. Near term projects must use the technology being developed for prior year's research. The FY 1972 Space R&T budget is a balance between the research and technology efforts that will be used in the future, and the more immediate support of the Agency's manned and unmanned program objectives of the present decade.

Research will be continued in the areas of materials and structures, power and propulsion, guidance, control and information systems. There will be a continued emphasis on advancing the technology to produce large amounts of electrical power in space, to develop high specific impulse propulsion systems, including electric propulsion. OART will support the Agency's near term objectives with activity in the critical areas of thermal protection systems, aerothermodynamics, configuration development and entry technology for the space shuttle program. Investigations will be conducted relative to advanced concepts.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1970	1971	1972
Space propulsion and power generation....................	$36,954	$36,500	$28,600
Materials and structures.........	29,419	25,800	18,600
Guidance, control and information systems............	23,473	17,500	17,055
Safety and operating systems.....	1,448	1,900	1,700
Entry technology.................	9,893	9,500	9,150
Life sciences....................	18,790	15,800	*
Total..........................	$119,977	$107,000	$75,105

*Transferred to Office of Manned Space Flight under the Space Flight Operations program.

BASIS OF FUND REQUIREMENTS:

Space Propulsion and Power Generation

Activities directed towards providing critical propulsion technology for the space shuttle should be completed with FY 1972 funding. This oriented technology includes component level examinations for the shuttle main engine, propellant feed system, and auxiliary propulsion system. Two approaches to high performance space storable propulsion modules are currently being pursued: pump-fed FLOX/Methane and pressure fed OF_2/Diborane. In FY 1972, emphasis will be placed on one of the two approaches. A major problem to be solved for space-based tugs and translunar shuttles is cryogenic propellant transfer at zero gravity. Ground testing (drop tower) and preliminary definition of a space flight transfer experiment will be performed in FY 1972.

Solid rocket motors demonstrating stop/restart capability and long burning, low thrust (for low impacted accelerations) will be fired. Investigations will continue in the areas of solid propellant combustion, mechanical behavior, and motor hardware. Liquid rocket technology work will include turbomachinery investigations, combustion research and long-life multiple-use component development. Electric propulsion research and technology will continue to capitalize upon the value of its extremely high specific impulse. A one millipound thrust cesium bombardment ion engine will be readied for the Application Technology Satellite (ATS-F). Pulse plasma and resistojet thrusters will be tested. A major portion of the electric propulsion activity will involve the relatively high thrust mercury electron bombardment thruster for solar-electric multi-mission space vehicle (SEMMS) flight testing.

Technology for large, high voltage solar arrays will be generated along with improved solar cell efficiency. Solar cell cost efficiency is a major goal of this activity. The cycle life and energy density of nickle-cadmium batteries will be improved. Component activity will focus on high energy capacitors.

Materials and Structures

The Materials and Structures program is composed of three parts; fundamental materials research, engineering materials research, and structures research and technology.

Fundamental materials research is aimed at understanding the basic properties of the solid state for structural, electronic and radiation shielding applications in space. In FY 1972, the research will emphasize atomic scale defect studies which will provide knowledge for high strength, high temperature structural materials and advanced electronic materials.

Materials engineering studies are concerned with how materials behave in the environments of space and in power and propulsion systems. The FY 1972 program will emphasize high temperature ductility and oxidation resistance, fundamental behavior of fiber-matrix systems for advanced composites, fracture and failure mechanisms, new high temperature adhesives, and materials for the protection of advanced spacecraft from the space environment.

Research and technology activities for space structures cover a broad spectrum of investigations to explore the potential of applying advanced concepts and materials, develop improved techniques for structural analysis and design, and provide advances in methods for determining the dynamic loading and response of complex structures. In FY 1972 emphasis will be given to the most critical structures problems associated with the space shuttle, planetary vehicles, and other types of future space systems which will require substantial advancement in technology to achieve the necessary levels of efficiency and integrity.

Guidance, Control and Information Systems

Maximum return of information from space exploration requires a continuing effort to improve the efficiency of space vehicle-to-ground communication links. Optical communication systems offer substantial improvement over current microwave links both in terms of tracking accuracy and data rates. In FY 1972, development of satellite to ground experiments will be initiated to demonstrate the feasibility of optical communications as high capacity data transfer systems. The large investment in current microwave networks requires that maximum returns be sought through improvements and innovations in the techniques by which data is handled. Research and development of the more efficient spacecraft antennas, higher power signal generators and advanced coding techniques is in process and will continue.

Concomitant with the demand for higher data rates is the need for more efficient and effective processing of accumulated data both on the ground and in space vehicles. Long duration missions such as outer planet exploration and space station require data processing systems with long, reliable operating lives. Techniques for self test and repair of computers have been developed and hardware will be evaluated in FY 1972. Techniques for interconnecting data subsystems by transmitting multiple signals over a minimum number of circuits are being developed for the space shuttle and station. Past efforts on data compression techniques have been very productive and will be continued in FY 1972.

Precise guidance and control is a fundamental requirement of spacecraft and transportation systems for many missions. Techniques for space shuttle guidance and control will be evaluated in flight tests in FY 1972. Sensors and techniques for mechanizing on-board guidance to provide sufficient accuracy in the vicinity of distant planets will be emphasized. The development of components with no moving parts to improve the reliability of guidance and control systems will be continued.

Technology efforts to make the use of large telescopes in space feasible will be continued. Comparative evaluations of several promising approaches for producing large precise mirrors for space telescopes will be initiated in FY 1972.

Research on advanced components and circuit technology will emphasize solid state display devices and high density memories. The development of large scale integrated circuit processing techniques will stress higher operating speeds and reliable techniques for interconnection.

Safety and Operating Systems

The Safety program is carried out by the assimilation and exploration of new technology for developing fundamentally safer ways to attain technical objectives. The main elements of the program are a Safety Management Information System for assimilation and Safety Research and Analysis for exploitation of this new technology.

The Safety Management Information System program is the Lewis Research Center aerospace safety data bank which is composed of the Lewis information storage and retrieval system and the data bank. Even in its initial implementation this system represents a most flexible and powerful data management capability. Several large files are presently being loaded into the system.

Safety Research and Analysis is composed of the following areas: spacecraft fire protection, space nuclear system safety, and oxygen handling in aerospace programs, safety of liquid methane as aircraft fuel, safety of hydrogen-fueled airbreathing engine for shuttle, and aircraft static pressure measurements.

Entry Technology

The entry technology program is composed of: (1) Lifting-Body Flight Research program and (2) Space Vehicle Aerothermodynamics program. The program is an applied research and technology program focused on space vehicle flight through the atmosphere of earth and other planets.

The major emphasis in FY 1972 will be focused on continued flight research using the M2-F3 and X-24A lifting-body vehicles to investigate promising spacecraft control systems and to extend vehicle flight performance evaluation to Mach numbers near 2 and on efforts associated with the manned space shuttle. These latter efforts will concentrate on detailed investigation of the aerodynamic performance, stability and control, and heating environment of selected orbiter and booster configurations and on performance tests of lightweight, reusable heat shield concepts. Research will also be continued in FY 1972 on aerothermodynamic problems of unmanned planetary probes with primary efforts directed toward development of a technology base for a Jupiter probe.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1972 ESTIMATES

SUMMARY

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY — NUCLEAR POWER AND PROPULSION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The overall aim of this program is to provide the technology and flight qualified space nuclear power and propulsion systems to meet the current and future needs of the nation's space program. Significant advances in space power and propulsion will become increasingly important as the space program undertakes more ambitious missions. Future flight programs include missions that will require increasing amounts of energy for both power and propulsion; nuclear energy is expected to play an increasing part in fulfilling these needs. This program is conducted in cooperation with the Atomic Energy Commission.

Nuclear Power and Propulsion is composed of three parts, nuclear power, nuclear propulsion, and electrophysics. The objective of the nuclear power effort is to obtain the experimental and analytical data needed for the evaluation and development of the energy conversion equipment to be used in advanced nuclear electric power generating systems as well as to obtain necessary data required for the proper integration of nuclear power systems into practical spacecraft systems.

The nuclear propulsion objectives are to provide the technology for development of a reusable nuclear rocket system, to extend the technology of fission propulsion to the useful physical limits for space propulsion and to explore the feasibility of fusion energy sources for space missions. Development effort on the NERVA 75,000 pound thrust flight weight engine has been deferred, but work will continue on selected long leadtime components to preserve the capability to move forward with this highly efficient rocket development when the need arises.

The objective of electrophysics research is to provide new knowledge of wave (gamma to infrared) and particle (electron - nucleus - atom - molecule) interactions underlying the advances in design and construction of magneto-plasma - dynamic fission and controlled fusion space power and propulsion systems which may pave the way for significant advances in future space vehicles.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1970	1971	1972
Nuclear power research and technology...	$16,952	$13,900	$9,320
Nuclear propulsion.....................	36,317	38,000	15,000
Electrophysics.........................	2,000	3,300	3,400
Total..............................	$55,269	$55,200	$27,720

BASIS OF FUND REQUIREMENTS:

Nuclear Power Research and Technology

One of the essential elements in the conduct of space missions is the availability of adequate on-board electric power. Nuclear energy as a self contained energy source, can satisfy a wide range of these power needs.

The primary objectives of the nuclear electric power generation effort are to obtain the experimental and analytical data needed for the evaluation and development of the energy conversion equipment and certain nuclear heat sources used in advanced nuclear electric power generating systems, as well as to obtain necessary data required for the proper integration of nuclear power systems into practical spacecraft systems.

Fiscal year 1972 effort will include continued research and technology on Brayton power systems, advanced Rankine power systems and thermionic and thermoelectric conversion systems. The small Brayton engine effort is aimed at highly reliable, long life power systems with electric output of 2 to 15 thousand watts. Research will also continue on the large Brayton engine with a range of 40-160 thousand watts for missions requiring high power levels such as direct broadcast satellites.

To satisfy even larger space power requirements, effort will continue on advanced nuclear Rankine power systems and thermionic systems technology. These systems could be used for auxiliary power or for nuclear electric propulsion missions in the 1980's and beyond. Power generation for nuclear electric propulsion systems have the potential of providing a new propulsion capability having very high specific impulse and low fuel consumption. Studies indicate that the flexibility that nuclear electric propulsion gives mission planners, particularly in trading off trip-time for payload, will significantly facilitate the design of reliable spacecraft for distant missions.

Thermoelectric systems have the potential for very long life electric power systems which could operate over a period of five to ten years. Assessment of candidate systems, operational constraints, and integration requirements, will be made and techniques and advanced concepts developed. Primary application for these systems would be for space station and lunar base missions.

Nuclear Propulsion

The overall aim of nuclear propulsion is to provide a significant increase in propulsion capability for future space activities. A major program objective has been development of a 75,000 pound thrust flight weight engine, NERVA, for incorporation in a reusable nuclear stage.

The advantages of nuclear propulsion over chemical propulsion result from its high payload performance, propulsion efficiency and versatility. In the types of missions involving high energy and large payload, specific impulse becomes an extremely important performance requirement.

The first generation nuclear rocket engine, NERVA, will provide approximately twice the specific impulse of the best chemical rockets. NERVA could be incorporated in a reusable nuclear stage as an integral part of a new capability for space transportation and used to move men, spacecraft and supplies between earth orbit and lunar orbit and between low earth orbit and geosynchronous orbit. The same engine also could be applied in single use application, e.g., as the primary propulsion for a nuclear stage on a high payload, fast trip to one of the planets. In both instances, the increased propulsion energy that can be made available by NERVA can be used for any of a variety of purposes, such as to increase payloads, reduce trip times and to provide greater reliability for the completion of the mission.

NERVA. The 75,000 pound thrust NERVA engine is a long duration, multi-cycle propulsion system which can be operated at a specific impulse of 825 seconds over a range of thrust levels. Engine development will be sharply reduced in FY 1972 with effort concentrated on only a few of the critical long lead time components including the turbopump and the graphite nozzle extension.

Nuclear Propulsion Research and Technology. Nuclear propulsion research and technology covers a broad spectrum of activities. The general aims of these activities are: (1) to provide for the continued improvement of nuclear rocket performance, (2) to provide the base of information for the development of a nuclear stage, and (3) to investigate the feasibility of advanced propulsion concepts.

Nuclear Rocket Development Station Operations. The Nuclear Rocket Development Station (NRDS) is the national site for the ground static testing of nuclear rocket reactors and engines. Overall management of the site is provided by the AEC/NASA Space Nuclear Systems Office-Nevada Extension. The funding in this area provides for NASA's share of the cost of general support and station operations. In FY 1972 the NRDS will be put on a maintenance only basis.

Electrophysics

The objective of Electrophysics research is to provide new knowledge of wave and particle interactions underlying the advances in design and construction of magneto-plasma-dynamics, fission and controlled fussion space power and propulsion systems necessary for the operation of future space vehicles.

Investigations will be continued of electron pairing phenomena to achieve higher transition temperature (Tc) conductors. Laser research will emphasize efforts to achieve higher energy radiation from uranium plasma, flowing CO_2-N_2-He gas and chemical reactions. Work will be continued, to obtain laser radiation in the transverse direction, and to explore the possibility of utilizing copper plasma for greater output.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1972 ESTIMATES

SUMMARY

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 medical data on their physical condition, (f) communication of information between various ground facilities and mission 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 instrumented ship supplemented by appropriate instrumentation aircraft and ground stations of the Department of Defense. These facilities are interconnected by a network of ground communications lines, undersea cables, high frequency radio links, and communication satellite circuits, 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 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 research aircraft.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1970	1971	1972
Operations..............................	$225,181	$217,300	$210,000
Equipment...............................	41,109	59,800	42,500
Supporting research and technology.......	11,710	12,900	11,500
Total..................................	$278,000	$290,000	$264,000

BASIS OF FUND REQUIREMENTS:

The FY 1972 request, in total, represents a decrease of nearly 10 percent from the FY 1971 level. This decrease reflects the effect of changes in certain flight mission profiles which have allowed support reductions as well as the significant effort that has been applied in reviewing support requirements of previously launched flight projects with the objective of reducing support requirements for specific programs and of identifying facility cutbacks consistent with the required support. The decrease also reflects the sustaining character of the equipment program in that the request provides for maintaining a network capability to meet only the support requirements of approved programs.

Operations

Continuing adjustments in network support requirements have resulted in an overall reduction in the funds requested for network operations. The experience gained in support of the Apollo program, along with a stretchout in schedule, has led to the closure of the tracking station at Guaymas, Mexico, and redutions in support requirements in the areas of logistics, programming, and communications services. As a result of the continuing review of scientific requirements for the acquisition of data from scientific, applications, and planetary spacecraft, further reductions in data acquisition support are underway. In addition, there has been a continuing effort to improve station operating procedures and equipment utilization at both the stations and control centers to provide more cost effective support.

The only increase within network operations is in the funding request for data processing operations. This increase is necessary to provide for the operations and logistics of the Earth Resources Technology Satellite (ERTS) data processing facility which will be required to handle large amounts of imaging data.

Equipment

The tracking and data acquisition support requirements placed on the networks establish needs for equipments 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 1972, emphasis will continue on sustaining the existing capability of the networks along with augmentations of equipment to meet the requirements of upcoming planetary programs (Pioneer G, Mariner/Venus/Mercury '73, and Helios). Some equipment additions will also be required for ERTS, RAE-B, Nimbus, ATS-F, and other approved scientific satellite programs.

Supporting Research and Technology

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. Overall, the SRT effort in FY 1972 will continue at a reduced level with continuing emphasis on studies for the Tracking and Data Relay Satellite System (TDRSS).

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1972 ESTIMATES

SUMMARY

OFFICE OF INDUSTRY AFFAIRS AND TECHNOLOGY UTILIZATION — TECHNOLOGY UTILIZATION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

This program provides for the Nation's scientific, engineering, educational and medical communities, awareness and access to new scientific and technological and managerial developments that become available as a result of the conduct of NASA's mission oriented research and development programs. This program implements the basic principle that scientific, technological and management knowledge developed with public support be made available to the public for its benefit in as expeditious and efficient a manner as possible. New developments of use to the aeronautics and space industry are applied almost automatically within that industry. These same innovations have potential benefit as well to the nonaeronautics and space community. It is the primary purpose of this program to develop and establish systems and mechanisms to identify, evaluate, publish and transfer these innovations to the general public.

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 use in the marketplace; (3) to aid the movement of new knowledge across industry, disciplinary, and regional boundaries; and (4) to contribute to the knowledge of better means of transferring technology from its points of origin to its points of potential use.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars) 1970	1971	1972
New technology identification and evaluation	650	435	625
Publication	1,020	490	665
New technology dissemination	2,775	2,585	2,230
Program evaluation	555	490	480
Total	$5,000	$4,000	$4,000

BASIS OF FUND REQUIREMENTS:

New Technology Identification and Evaluation

Technology utilization officers at NASA field installations and specialists from universities, research institutes and private industry search through selected areas of scientific and technical endeavor, and identify and document those inventions, innovations, improvements, and discoveries that have potential utility to the nonaerospace sector of the economy. These discoveries are evaluated according to potential non-aerospace use criteria by competent technical personnel at nonprofit research institutes and at NASA field installations, prior to final documentation and dissemination.

Publication

The systematic publication through announcements of single innovations to major surveys of contributions to the state-of-the-art in broad technology areas continues to be an important element of the transfer of technology. This is accomplished through preparation of reports and comprehensive surveys by private and nonprofit contractor sources. These reports are disseminated broadly through various governmental mechanisms and the private technical trade media.

New Technology Dissemination

This program element is accomplished by the employment of regional dissemination centers that store, retrieve and interpret the new technology developed by NASA and work to transfer this new technology to industry. Biomedical application teams are also employed to assist medical and clinical researchers in defining and solving medical problems by adaptation of NASA technology. In addition, government-developed computer software is evaluated and disseminated to industry. Technology applications teams are developing cooperative programs with several other agencies such as the Air Pollution Control Office and the Water Pollution Control Office of the Environmental Protection Agency, Law Enforcement Assistance Administration, Social Rehabilitation Service of HEW, Small Business Administration and others. These joint efforts are designed to bring applicable aerospace technology to bear on technical problems in areas of major national concern such as environmental quality, law enforcement and rehabilitation of the handicapped.

Program Evaluation

Independent research institute personnel are continually evaluating technology transfer mechanisms and feeding the new knowledge so gained into the Technology Utilization program.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

CONSTRUCTION OF FACILITIES

For advance planning, design, and construction of facilities for the National Aeronautics and Space Administration, and for the acquisition or condemnation of real property, as authorized by law, [$24,950,000] *$56,300,000,* to remain available until expended. *(42 U.S.C. 2451, et seq. 50 U.S.C. 511–515; Independent Offices and Department of Housing and Urban Development Appropriation Act, 1971; additional authorizing legislation to be proposed.)*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Construction of Facilities

Program and Financing (in thousands of dollars)

Identification code 27-00-0107-0-1-250	Budget plan (amounts for construction of facilities actions programed)			Costs and obligations		
	1970 actual	1971 estimate	1972 estimate	1970 actual	1971 estimate	1972 estimate
Program by activities:						
Direct program:						
1. Manned space flight	14,250	570	20,000	12,529	18,100	9,800
2. Scientific investigations in space	1,170	700	15,200	5,359	2,300	4,500
3. Space applications		1,880			1,000	2,000
4. Space research and technology		1,250		11,791	1,500	1,500
5. Aeronautical research and technology	4,767		6,500	5,287	6,000	4,700
6. Supporting activities	29,925	20,550	14,600	17,576	26,100	32,500
Total direct program costs, funded	50,112	24,950	56,300	52,542	55,000	55,000
Reimbursable program:						
3. Space applications				20		
Total program costs, funded	50,112	24,950	56,300	52,562	55,000	55,000
Change in selected resources [1]				−19,144	37,149	1,300
10 Total	50,112	24,950	56,300	33,418	92,149	56,300
Financing:						
11 Receipts and reimbursements from: Federal funds				23		
21 Unobligated balance available, start of year: For completion of prior year budget plans:						
Direct				−47,381	−67,199	
Reimbursable				−25		
Reprograming to prior year budget plans	3,121					
24 Unobligated balance available, end of year: For completion of prior year budget plans: Direct				67,199		
40 **Budget authority (appropriation)**	**53,233**	**24,950**	**56,300**	**53,233**	**24,950**	**56,300**
Relation of obligations to outlays:						
71 Obligations incurred, net				33,441	92,149	56,300
72 Obligated balance, start of year				72,998	52,142	94,291
74 Obligated balance, end of year				−52,142	−94,291	−107,591
90 Outlays				54,297	50,000	43,000

Note.—Reconciliation of budget plan to obligations:	*1970 actual*	*1971 estimate*	*1972 estimate*
Total budget plan	50,112	24,950	56,300
Deduct portion of budget plan to be obligated in subsequent years	32,106		
Add obligations of prior year budget plans	15,412	67,199	
Total obligations	33,418	92,149	56,300

[1] Selected resources as of June 30 are as follows:	*1969*	*1970*	*1971*	*1972*
Unpaid undelivered orders	54,889	35,749	72,898	74,198
Advances	30	26	26	26
Total selected resources	54,919	35,775	72,924	74,224

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1972 ESTIMATES

SUMMARY OF CONSTRUCTION OF FACILITIES BUDGET PLAN BY LOCATION
(In thousands of dollars)

Location	Fiscal Year 1970	Fiscal Year 1971	Fiscal Year 1972
Ames Research Center..............	---	---	$6,500
Goddard Space Flight Center.......	$670	$1,880	---
Jet Propulsion Laboratory.........	---	1,950	---
John F. Kennedy Space Center, NASA...........................	12,500	570	15,200
Langley Research Center...........	4,767	---	---
Manned Spacecraft Center..........	1,750	---	---
Wallops Station...................	500	---	---
Various Locations.................	26,425	16,050	31,100
Facility Planning and Design......	3,500	4,500	3,500
Total Plan......................	$50,112	$24,950	$56,300

The geographic location of NASA installation is shown on the map under the Summary information tab. Installations for which construction projects are requested in the fiscal year 1972 budget are identified thereon.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

INSTALLATION SUMMARY

CONSTRUCTION OF FACILITIES

FISCAL YEAR 19 72 BUDGET ESTIMATES

(Dollars in thousands)

NASA INSTALLATION		COGNIZANT PROGRAM OFFICE FOR INSTALLATION
Ames Research Center		Office of Advanced Research and Technology
LOCATION OF INSTALLATION	COUNTY	NEAREST CITY
Moffett Field, California	Santa Clara	Mountain View, California

INSTALLATION MISSION

Laboratory research in aerodynamics, thermodynamics, materials, structures, guidance and control, space sciences, environmental biology, life detection, life synthesis, human factors, and fundamental physics and chemistry, project management of unmanned spaceflight projects (scientific probes and satellites); development of scientific-experiment payloads for spaceflight projects managed at Ames and elsewhere.

PROJECT LINE ITEM	COGNIZANT OFFICE	FY 1959 THRU CURRENT YR	FY 1972 (Estimated)	FUTURE YEARS (Estimated)	TOTAL ALL YEARS (Estimated)
Modernization of the 40x80-foot Wind Tunnel	OART	294	6,500	-0-	6,794
TOTAL			6,500		

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

INSTALLATION SUMMARY
CONSTRUCTION OF FACILITIES
FISCAL YEAR 19 72 BUDGET ESTIMATES

(Dollars in thousands)

NASA INSTALLATION: John F. Kennedy Space Center, NASA

COGNIZANT PROGRAM OFFICE FOR INSTALLATION: Manned Space Flight

LOCATION OF INSTALLATION: Cape Kennedy and Merritt Island

COUNTY: Brevard

NEAREST CITY: Cocoa Beach, Florida

INSTALLATION MISSION

The Center conducts overall planning and supervision of the integration, test, checkout and launch of NASA space vehicle systems at the Air Force Eastern and Western Test Ranges, and Merritt Island, and provides support services for all NASA elements located in the area.

PROJECT LINE ITEM	COGNIZANT OFFICE	FY 1959 THRU CURRENT YR	FY 1972 (Estimated)	FUTURE YEARS (Estimated)	TOTAL ALL YEARS (Estimated)
Centaur Modifications to Titan III Launch area	OSSA	255	10,700	*	10,955
Alteration to Launch Complex 17	OSSA	8,186	4,500	*	12,686
*Dependent upon future year requirements.					
TOTAL			15,200		

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

INSTALLATION SUMMARY

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1972 BUDGET ESTIMATES

(Dollars in thousands)

NASA INSTALLATION		COGNIZANT PROGRAM OFFICE FOR INSTALLATION
Various Locations		Various
LOCATION OF INSTALLATION	COUNTY	NEAREST CITY
Not Applicable	Not Applicable	Not Applicable

INSTALLATION MISSION

PROJECT LINE ITEM	COGNIZANT OFFICE	FY 1959 THRU CURRENT YR	FY 1972 (Estimated)	FUTURE YEARS (Estimated)	TOTAL ALL YEARS (Estimated)
Rehabilitation and Modification of Facilities	O&M	23,017	10,000		33,017
Space Shuttle Facilities	OMSF OART	630	20,000	10,000	30,630
Power Plant Replacements	OTDA	54	600	-0-	654
Relocation of ATS Transportable Ground Station	OTDA	60	500	-0-	560
TOTAL			31,100		

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

INSTALLATION SUMMARY

CONSTRUCTION OF FACILITIES

FISCAL YEAR 19 72 BUDGET ESTIMATES

(Dollars in thousands)

NASA INSTALLATION		COGNIZANT PROGRAM OFFICE FOR INSTALLATION
All		Office of Organization and Management
LOCATION OF INSTALLATION	COUNTY	NEAREST CITY
	---	---

INSTALLATION MISSION

PROJECT LINE ITEM	COGNIZANT OFFICE	FY 1959 THRU CURRENT YR	FY 19 72 (Estimated)	FUTURE YEARS (Estimated)	TOTAL ALL YEARS (Estimated)
Facility Planning and Design	O&M	64,375	3,500		Not Applicable
TOTAL			3,500		

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

RESEARCH AND PROGRAM MANAGEMENT

For necessary expenses of research in Government laboratories, management of programs and other activities of the National Aeronautics and Space Administration, not otherwise provided for, including uniforms or allowances therefor, as authorized by law (5 U.S.C. 5901–5902); minor construction; awards; [purchase of not to exceed one and] hire, maintenance and operation of administrative aircraft; purchase (not to exceed [thirty-nine] *thirty-five* for replacement only) and hire of passenger motor vehicles; and maintenance, repair, and alteration of real and personal property; [$678,725,000, of which $10,000,000 shall be available only for use at the Mississippi Test Facility/Slidell Computer Complex and at other NASA facilities which can accommodate earth environmental studies to furnish, on a nonreimbursable basis, basic institutional and technical services to Federal agencies, resident at the complexes, in pursuit of space and environmental missions] *$697,350,000*: *Provided*, That contracts may be entered into under this appropriation for maintenance and operation of facilities, and for other services, to be provided during the next fiscal year. (*42 U.S.C. 2451, et seq., 50 U.S.C. 511–515; Independent Offices and Department of Housing and Urban Development Appropriation Act, 1971; additional authorizing legislation to be proposed.*)

GENERAL PROVISIONS

Not to exceed 5 per centum of any appropriation made available to the National Aeronautics and Space Administration by this Act may be transferred to any other such appropriation.

Not to exceed $35,000 of the appropriation "Research and Program Management" in this Act for the National Aeronautics and Space Administration shall be available for scientific consultations or extraordinary expense, to be expended upon the approval or authority of the Administrator and his determination shall be final and conclusive. (*Independent Offices and Department of Housing and Urban Development Appropriation Act, 1971.*)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Research and Program Management

Program and Financing (in thousands of dollars)

Identification code 27-00-0103-0-1-250		Budget plan: 1970 actual	Budget plan: 1971 estimate	Budget plan: 1972 estimate	Costs and obligations: 1970 actual	Costs and obligations: 1971 estimate	Costs and obligations: 1972 estimate
	Program by activities:						
	Direct program:						
	1. Manned space flight	335,571	338,490	331,100	340,675	339,992	331,100
	2. Scientific investigations in space	90,252	93,256	89,300	89,960	93,792	89,300
	3. Space applications	26,509	34,096	36,100	26,352	34,329	36,100
	4. Space research and technology	113,011	108,874	104,000	113,012	109,421	104,000
	5. Aeronautical research and technology	98,392	93,626	98,150	98,383	93,963	98,150
	6. Supporting activities	38,443	50,091	38,700	38,257	50,503	38,700
	Total direct program costs, funded	702,178	718,433	697,350	706,639	722,000	697,350
	Reimbursable program:						
	1. Manned space flight	1,295	1,859	2,000	1,249	1,859	2,000
	3. Space applications	1,023	1,152	1,100	895	1,152	1,100
	4. Space research and technology	494	689	700	504	689	700
	Total reimbursable program costs	2,812	3,700	3,800	2,648	3,700	3,800
	Total program costs, funded	704,990	722,133	701,150	709,287	725,700	701,150
	Change in selected resources [1]				−4,297	−3,567	
10	Total	704,990	722,133	701,150	704,990	722,133	701,150
	Financing:						
	Receipts and reimbursements from:						
11	Federal funds				−2,518	−3,293	−3,373
14	Non-Federal sources [2]				−294	−407	−427
25	Unobligated balance lapsing				377		
	Budget authority				**702,555**	**718,433**	**697,350**
	Budget authority:						
40	Appropriation				675,400	678,725	697,350
40	Pay increase (Public Law 91-305)				14,583		
41	Transferred to other accounts				−474	−146	
42	Transferred from other accounts				13,046	10,000	
43	**Appropriation (adjusted)**				**702,555**	**688,579**	**697,350**
44.20	**Proposed supplemental for civilian pay act increase**					**29,854**	
	Relation of obligations to outlays:						
71	Obligations incurred, net				702,178	718,433	697,350
72	Obligated balance, start of year				75,407	68,131	77,634
74	Obligated balance, end of year				−68,131	−77,634	−76,634
77	Adjustments in expired accounts				−2,243		
90	Outlays, excluding pay increase supplemental				707,210	680,530	696,896
91.20	Outlays from civilian pay act supplemental					28,400	1,454

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

	1969	*1970 adjustments*	*1970*	*1971*	*1972*
Unpaid undelivered orders	29,259	−2,272	22,849	19,282	19,282
Advances	181		22	22	22
Total selected resources	29,440	−2,272	22,871	19,304	19,304

[2] Reimbursements from non-Federal sources are receipts for services performed on Communications Satellite Corporation projects (42 U.S.C. 2473) and for personal property sold for replacement purposes (40 U.S.C. 481).

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1972 ESTIMATES

RESEARCH AND PROGRAM MANAGEMENT

SUMMARY OF OBLIGATIONS BY INSTALLATION
(In thousands of dollars)

	Fiscal Year 1970	Fiscal Year 1971	Fiscal Year 1972
MANNED SPACE FLIGHT..............	$329,836	$348,807	$332,005
John F. Kennedy Space Center, NASA.........................	97,582	97,246	95,559
Manned Spacecraft Center........	106,561	109,113	106,255
Marshall Space Flight Center....	125,693	142,448	130,191
SPACE SCIENCE AND APPLICATIONS....	$96,140	$101,268	$100,326
Goddard Space Flight Center.....	86,452	91,194	90,299
Wallops Station.................	9,688	10,074	10,027
ADVANCED RESEARCH AND TECHNOLOGY..	$213,044	$203,795	$205,338
Ames Research Center...........	37,602	39,899	39,719
Electronics Research Center.....	19,106	---	---
Flight Research Center..........	10,308	10,895	10,974
Langley Research Center.........	69,851	73,388	74,191
Lewis Research Center...........	73,895	77,094	77,866
Space Nuclear Systems Office....	2,282	2,519	2,588
SUPPORTING OPERATIONS			
NASA Headquarters..............	$63,158	$64,563	$59,681
TOTAL.........................	$702,178	$718,433[a/]	$697,350

a/ Includes $29,854 proposed supplemental to cover pay increase approved in FY 1970.

It is anticipated that a Government-wide supplemental will be requested separately for requirements in FY 1971 and FY 1972 to cover pay increase approved by the President on January 8, 1971.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1972 ESTIMATES

RESEARCH AND PROGRAM MANAGEMENT

DISTRIBUTION OF OBLIGATIONS BY FUNCTION
BY INSTALLATION
(Thousands of dollars)

FUNCTION	Total NASA	Subtotal OMSF	J. F. Kennedy Space Center, NASA	Manned Spacecraft Center	Marshall Space Flight Center	Subtotal OSSA	Goddard Space Flight Center	Wallops Station	Subtotal OART	Ames Research Center	Electronics Research Center	Flight Research Center	Langley Research Center	Lewis Research Center	Space Nuclear Systems Office	Headquarters
Personnel																
1970	$529,448	$229,473	$47,518	$78,871	$103,084	$76,377	$69,913	$6,464	$180,591	$31,865	$13,803	$8,507	$59,341	$64,982	$2,093	$43,007
1971	535,962	234,630	48,271	80,796	105,563	81,944	75,034	6,910	175,808	33,656	---	9,025	62,172	68,636	2,319	43,580
1972	530,916	230,088	47,659	78,654	103,775	82,319	75,384	6,935	177,405	33,346	---	9,064	63,029	69,575	2,391	41,104
Travel																
1970	15,195	6,638	687	3,648	2,303	2,186	2,038	148	3,502	698	325	185	1,168	941	185	2,869
1971	17,946	7,816	910	4,246	2,660	2,713	2,472	241	4,191	905	---	220	1,792	1,075	199	3,226
1972	17,061	7,334	760	4,074	2,500	2,571	2,372	199	4,115	866	---	220	1,816	1,017	196	3,041
Facilities Services																
1970	82,980	55,435	38,983	9,408	7,044	6,677	4,659	2,018	20,488	3,768	2,998	1,247	5,666	6,805	4	380
1971	90,176	65,446	36,874	9,107	19,465	6,230	4,300	1,930	17,622	4,203	---	1,351	5,656	6,412	---	878
1972	78,527	54,330	36,314	8,604	9,412	6,212	4,300	1,912	17,648	4,374	---	1,381	5,596	6,297	---	337
Technical Services																
1970	35,983	16,298	811	6,949	8,538	6,359	6,207	152	1,975	240	1,062	83	360	230	---	11,351
1971	33,654	16,077	986	7,317	7,774	5,768	5,616	152	614	122	---	68	352	72	---	11,195
1972	31,265	16,379	986	7,321	8,072	4,364	4,211	153	599	122	---	53	352	72	---	9,923
Administrative Support																
1970	38,572	21,992	9,583	7,685	4,724	4,541	3,635	906	6,488	1,031	918	286	3,316	937	---	5,551
1971	40,695	24,838	10,205	7,647	6,986	4,613	3,772	841	5,560	1,013	---	231	3,416	899	1	5,684
1972	39,581	23,874	9,840	7,602	6,432	4,860	4,032	828	5,571	1,011	---	256	3,398	905	1	5,276
Total																
1970	702,178	329,836	97,582	106,561	125,693	96,140	86,452	9,688	213,044	37,602	19,106	10,308	69,851	73,895	2,282	63,158
1971	718,433	348,807	97,246	109,113	142,448	101,268	91,194	10,074	203,795	39,899	---	10,895	73,388	77,094	2,519	64,563
1972	697,350	332,005	95,559	106,255	130,191	100,326	90,299	10,027	205,338	39,719	---	10,974	74,191	77,866	2,588	59,681

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1972 ESTIMATES

RESEARCH AND PROGRAM MANAGEMENT

DISTRIBUTION OF OBLIGATIONS BY OBJECT CLASSIFICATION
BY FUNCTION

(Thousands of Dollars)

Object Classification	Total NASA	Personnel	Travel	Facilities Services	Technical Services	Administrative Support
Fiscal Year 1970						
Personnel compensation	488,188	488,188	---	---	---	---
Personnel benefits	38,060	38,060	---	---	---	---
Benefits for former personnel	154	154	---	---	---	---
Travel & transportation of persons	17,050	170	15,195	---	---	1,685
Transportation of things	3,487	422	---	---	80	2,985
Rent, communications and utilities	43,202	---	---	19,404	10,825	12,973
Printing and reproduction	5,381	---	---	---	700	4,681
Other services	88,121	2,454	---	54,651	23,288	7,728
Supplies and materials	14,122	---	---	6,823	367	6,932
Equipment	3,289	---	---	1,080	723	1,486
Lands and structures	1,022	---	---	1,022	---	---
Grants, subsidies and contributions	28	---	---	---	---	28
Insurance claims and indemnities	74	---	---	---	---	74
Totals	702,178	529,448	15,195	82,980	35,983	38,572
Fiscal Year 1971						
Personnel compensation	490,123	490,123	---	---	---	---
Personnel benefits	40,663	40,663	---	---	---	---
Benefits for former personnel	1,780	1,780	---	---	---	---
Travel & transportation of persons	19,750	220	17,946	---	---	1,584
Transportation of things	3,802	566	---	---	85	3,151
Rent, communications, and utilities	42,648	---	---	19,516	9,472	13,660
Printing and reproduction	5,655	---	---	---	743	4,912
Other services	97,446	2,610	---	62,418	22,698	9,720
Supplies and materials	12,824	---	---	6,039	352	6,433
Equipment	2,265	---	---	812	304	1,149
Lands and structures	1,391	---	---	1,391	---	---
Grants, subsidies and contributions	51	---	---	---	---	51
Insurance claims and indemnities	35	---	---	---	---	35
Totals	718,433	535,962	17,946	90,176	33,654	40,695
Fiscal Year 1972						
Personnel compensation	484,074	484,074	---	---	---	---
Personnel benefits	41,440	41,440	---	---	---	---
Benefits for former personnel	2,036	2,036	---	---	---	---
Travel & transportation of persons	18,961	228	17,061	---	---	1,672
Transportation of things	3,651	525	---	---	59	3,067
Rent, communications, and utilities	41,043	---	---	19,241	8,238	13,564
Printing and reproduction	5,173	---	---	---	647	4,526
Other services	85,629	2,613	---	51,659	21,906	9,451
Supplies and materials	12,495	---	---	5,914	332	6,249
Equipment	1,776	---	---	727	83	966
Lands and structures	986	---	---	986	---	---
Grants, subsidies and contributions	51	---	---	---	---	51
Insurance claims and indemnities	35	---	---	---	---	35
Totals	697,350	530,916	17,061	78,527	31,265	39,581

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1972 ESTIMATES

RESEARCH AND PROGRAM MANAGEMENT

DISTRIBUTION OF OBLIGATIONS BY OBJECT CLASSIFICATION BY INSTALLATION

(Thousands of dollars)

:ification	Total NASA	Subtotal OMSF	J. F. Kennedy Space Center, NASA	Manned Spacecraft Center	Marshall Space Flight Center	Subtotal OSSA	Goddard Space Flight Center	Wallops Station	Subtotal OART	Ames Research Center	Electronics Research Center	Flight Research Center	Langley Research Center	Lewis Research Center	Space Nuclear Systems Office	HDQTRS.
:AR 1970																
:sation	488,188	211,875	43,861	72,975	95,039	70,432	64,497	5,935	166,968	29,563	12,618	7,859	54,778	60,248	1,902	38,913
ts	38,060	16,262	3,344	5,493	7,425	5,442	4,981	461	12,869	2,258	948	601	4,265	4,606	191	3,487
er personnel	154	---	---	---	---	---	---	---	154	5	149	---	---	---	---	---
rtation of	17,050	8,095	1,817	3,905	2,373	2,296	2,071	225	3,761	705	344	200	1,384	945	183	2,898
f things	3,487	1,685	1,213	363	109	1,131	984	147	482	33	114	9	236	88	2	189
ions, and	43,202	21,644	7,928	7,118	6,598	7,410	6,969	441	11,225	3,005	2,101	207	2,607	3,305	---	2,923
:oduction	5,381	3,580	2,535	655	390	202	152	50	412	10	50	8	258	86	---	1,187
	88,121	57,148	32,644	13,212	11,292	5,757	4,610	1,147	12,575	1,539	2,473	1,060	3,987	3,512	4	12,641
:rials	14,122	7,884	3,488	2,358	2,038	2,149	1,092	1,057	3,581	397	244	228	1,973	739	---	508
	3,289	1,018	331	368	319	988	791	197	899	85	64	104	284	362	---	384
:res	1,022	578	414	113	51	331	304	27	113	2	1	32	78	---	---	---
& contributions	28	---	---	---	---	---	---	---	---	---	---	---	---	---	---	28
and indemnities	74	67	7	1	59	2	1	1	5	---	---	---	1	4	---	---
	702,178	329,836	97,582	106,561	125,693	96,140	86,452	9,688	213,044	37,602	19,106	10,308	69,851	73,895	2,282	63,158
:AR 1971																
ation	490,123	214,699	44,211	73,989	96,499	75,274	68,918	6,356	161,908	30,960	---	8,293	57,225	63,314	2,116	38,242
s	40,663	17,522	3,564	5,920	8,038	6,132	5,620	512	13,166	2,606	---	689	4,578	5,090	203	3,843
:r personnel	1,780	832	150	288	394	---	---	---	132	35	---	---	27	70	---	816
:rtation of	19,750	9,214	1,943	4,516	2,755	2,835	2,511	324	4,437	920	---	220	2,010	1,087	200	3,264
things	3,802	1,734	1,186	412	136	1,320	1,174	146	405	74	---	9	242	80	---	343
ns, and																

s	40,663	17,522	3,564	5,920	8,038	6,132	5,620	512	13,166	2,606	---	---				
er personnel	1,780	832	150	288	394	---	---	---	132	35	---	---	27	70	---	816
ortation of	19,750	9,214	1,943	4,516	2,755	2,835	2,511	324	4,437	920	---	220	2,010	1,087	200	3,264
things	3,802	1,734	1,186	412	136	1,320	1,174	146	405	74	---	9	242	80	---	343
ons, and	42,648	21,024	8,218	7,698	5,108	7,896	7,441	455	9,852	3,303	---	199	2,850	3,500	---	3,876
oduction	5,655	3,955	2,890	650	415	172	121	51	363	10	---	8	260	85	---	1,165
	97,446	70,730	31,186	12,911	26,633	5,080	3,880	1,200	9,577	1,379	---	1,228	3,820	3,150	---	12,059
erials	12,824	7,400	3,408	2,140	1,852	2,038	1,138	900	2,896	300	---	158	2,025	413	---	490
	2,265	961	217	278	466	310	206	104	587	62	---	75	150	300	---	407
ures	1,391	716	257	309	150	210	185	25	465	250	---	15	200	---	---	---
s & contributions	51	1	---	1	---	---	---	---	---	---	---	---	---	---	---	50
and indemnities	35	19	16	1	2	1	---	1	7	---	---	1	1	5	---	8
	718,433	348,807	97,246	109,113	142,448	101,268	91,194	10,074	203,795	39,899	---	10,895	73,388	77,094	2,519	64,563
EAR 1972																
isation	484,074	210,635	43,659	72,220	94,756	75,112	68,748	6,364	161,826	30,532	---	8,223	57,460	63,429	2,182	36,501
its	41,440	17,518	3,619	5,919	7,980	6,314	5,800	514	13,754	2,502	---	801	4,850	5,392	209	3,854
rmer personnel	2,036	471	31	---	440	287	287	---	1,203	247	---	---	377	579	---	75
ortation of	18,961	8,819	1,852	4,335	2,632	2,694	2,411	283	4,369	880	---	220	2,042	1,030	197	3,079
of things	3,651	1,628	1,180	354	94	1,395	1,257	138	415	85	---	10	240	80	---	213
tions, and	41,043	20,959	8,063	7,724	5,172	6,694	6,237	457	10,051	3,501	---	200	2,850	3,500	---	3,339
production	5,173	3,735	2,635	700	400	173	121	52	363	10	---	8	260	85	---	902
	85,629	60,068	30,751	12,516	16,801	4,998	3,775	1,223	9,495	1,377	---	1,216	3,811	3,091	---	11,068
aterials	12,495	7,144	3,352	2,140	1,652	2,048	1,157	891	2,900	325	---	175	2,000	400	---	403
	1,776	555	201	192	162	447	368	79	585	60	---	100	150	275	---	189
ctures	986	453	200	153	100	163	138	25	370	200	---	20	150	---	---	---
ies & contributions	51	1	---	1	---	---	---	---	---	---	---	---	---	---	---	50
ms and indemnities	35	19	16	1	2	1	---	1	7	---	---	1	1	5	---	8
	697,350	332,005	95,559	106,255	130,191	100,326	90,299	10,027	205,338	39,719	---	10,974	74,191	77,866	2,588	59,681

Personnel benefits	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	
Benefits for former personnel	1,780	832	150	288	394	---	---	---	132	35	---	---	27	70	
Travel and transportation of persons	19,750	9,214	1,943	4,516	2,755	2,835	2,511	324	4,437	920	---	220	2,010	1,087	
Transportation of things	3,802	1,734	1,186	412	136	1,320	1,174	146	405	74	---	9	242	80	
Rent, communications, and utilities	42,648	21,024	8,218	7,698	5,108	7,896	7,441	455	9,852	3,303	---	199	2,850	3,500	
Printing and reproduction	5,655	3,955	2,890	650	415	172	121	51	363	10	---	8	260	85	
Other services	97,446	70,730	31,186	12,911	26,633	5,080	3,880	1,200	9,577	1,379	---	1,228	3,820	3,150	
Supplies and materials	12,824	7,400	3,408	2,140	1,852	2,038	1,138	900	2,896	300	---	158	2,025	413	
Equipment	2,265	961	217	278	466	310	206	104	587	62	---	75	150	300	
Lands and structures	1,391	716	257	309	150	210	185	25	465	250	---	15	200	---	
Grants, subsidies & contributions	51	1	---	1	---	---	---	---	---	---	---	---	---	---	
Insurance claims and indemnities	35	19	16	1	2	1	---	1	7	---	---	1	1	5	
Totals	718,433	348,807	97,246	109,113	142,448	101,268	91,194	10,074	203,795	39,899	---	10,895	73,388	77,094	2
FISCAL YEAR 1972															
Personnel compensation	484,074	210,635	43,659	72,220	94,756	75,112	68,748	6,364	161,826	30,532	---	8,223	57,460	63,429	2
Personnel benefits	41,440	17,518	3,619	5,919	7,980	6,314	5,800	514	13,754	2,502	---	801	4,850	5,392	
Benefits for former personnel	2,036	471	31	---	440	287	287	---	1,203	247	---	---	377	579	
Travel & transportation of persons	18,961	8,819	1,852	4,335	2,632	2,694	2,411	283	4,369	880	---	220	2,042	1,030	
Transportation of things	3,651	1,628	1,180	354	94	1,395	1,257	138	415	85	---	10	240	80	
Rent, communications, and utilities	41,043	20,959	8,063	7,724	5,172	6,694	6,237	457	10,051	3,501	---	200	2,850	3,500	
Printing and reproduction	5,173	3,735	2,635	700	400	173	121	52	363	10	---	8	260	85	
Other services	85,629	60,068	30,751	12,516	16,801	4,998	3,775	1,223	9,495	1,377	---	1,216	3,811	3,091	
Supplies and materials	12,495	7,144	3,352	2,140	1,652	2,048	1,157	891	2,900	325	---	175	2,000	400	
Equipment	1,776	555	201	192	162	447	368	79	585	60	---	100	150	275	
Lands and structures	986	453	200	153	100	163	138	25	370	200	---	20	150	---	
Grants, subsidies & contributions	51	1	---	1	---	---	---	---	---	---	---	---	---	---	
Insurance claims and indemnities	35	19	16	1	2	1	---	1	7	---	---	1	1	5	
Totals	697,350	332,005	95,559	106,255	130,191	100,326	90,299	10,027	205,338	39,719	---	10,974	74,191	77,866	2

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1972 ESTIMATES

RESEARCH AND PROGRAM MANAGEMENT

DISTRIBUTION OF OBLIGATIONS BY OBJECT CLASSIFICATION BY INSTALLATION

(Thousands of dollars)

Object Classification	Total NASA	Subtotal OMSF	J. F. Kennedy Space Center, NASA	Manned Spacecraft Center	Marshall Space Flight Center	Subtotal OSSA	Goddard Space Flight Center	Wallops Station	Subtotal OART	Ames Research Center	Electronics Research Center	Flight Research Center	Langley Research Center	Lewis Research Center	Space Nu Syste Offic
FISCAL YEAR 1970															
Personnel compensation	488,188	211,875	43,861	72,975	95,039	70,432	64,497	5,935	166,968	29,563	12,618	7,859	54,778	60,248	1,9
Personnel benefits	38,060	16,262	3,344	5,493	7,425	5,442	4,981	461	12,869	2,258	948	601	4,265	4,606	1
Benefits to former personnel	154	---	---	---	---	---	---	---	154	5	149	---	---	---	-
Travel & transportation of persons	17,050	8,095	1,817	3,905	2,373	2,296	2,071	225	3,761	705	344	200	1,384	945	1
Transportation of things	3,487	1,685	1,213	363	109	1,131	984	147	482	33	114	9	236	88	
Rent, communications, and utilities	43,202	21,644	7,928	7,118	6,598	7,410	6,969	441	11,225	3,005	2,101	207	2,607	3,305	-
Printing and reproduction	5,381	3,580	2,535	655	390	202	152	50	412	10	50	8	258	86	-
Other services	88,121	57,148	32,644	13,212	11,292	5,757	4,610	1,147	12,575	1,539	2,473	1,060	3,987	3,512	
Supplies and materials	14.122	7,884	3,488	2,358	2,038	2,149	1,092	1,057	3,581	397	244	228	1,973	739	-
Equipment	3,289	1,018	331	368	319	988	791	197	899	85	64	104	284	362	-
Lands and structures	1,022	578	414	113	51	331	304	27	113	2	1	32	78	---	-
Grants, subsidies & contributions	28	---	---	---	---	---	---	---	---	---	---	---	---	---	-
Insurance claims and indemnities	74	67	7	1	59	2	1	1	5	---	---	---	1	4	-
Totals	702,178	329,836	97,582	106,561	125,693	96,140	86,452	9,688	213,044	37,602	19,106	10,308	69,851	73,895	2,2
FISCAL YEAR 1971															
Personnel compensation	490,123	214,699	44,211	73,989	96,499	75,274	68,918	6,356	161,908	30,960	---	8,293	57,225	63,314	2,
Personnel benefits	40,663	17,522	3,564	5,920	8,038	6,132	5,620	512	13,166	2,606	---	689	4,578	5,090	2
Benefits for former personnel	1,780	832	150	288	394	---	---	---	132	35	---	---	27	70	-
Travel and transportation of persons	19,750	9,214	1,943	4,516	2,755	2,835	2,511	324	4,437	920	---	220	2,010	1,087	2
Transportation of things	3,802	1,734	1,186	412	136	1,320	1,174	146	405	74	---	9	242	80	-
Rent, communications, and utilities	42,648	21,024	8,218	7,698	5,108	7,896	7,441	455	9,852	3,303	---	199	2,850	3,500	-

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1972 ESTIMATES

JOHN F. KENNEDY SPACE CENTER

MISSION:

The Kennedy Space Center was established at Cape Kennedy, Florida, as a separate Center within NASA in July 1962. It serves as the primary Center within NASA for the test, checkout, and launch of space vehicles. This presently includes launch of manned and unmanned vehicles at the Kennedy Space Center, the Air Force Eastern Test Range, and the Air Force Western Test Range. The Center is now concentrating on Apollo manned launches, preparations for Skylab launches, design of Space Shuttle launch facilities, as well as research and operational unmanned launches. The Kennedy Space Center is specifically responsible for:

1. Launch vehicle checkout and preparation.

2. Spacecraft and payload checkout and preparation.

3. Launch facility design, construction, maintenance, and operations, including advanced planning and studies leading to development of new launch operation concepts and techniques, including design of Space Shuttle launch facilities.

4. Final integration and integrated checkout of vehicle, spacecraft and launch facilities, and the conduct of actual launch operations.

5. Operation and coordination of supporting facilities, ground support equipment, and tracking and data acquisition and logistics support required for operation of all NASA activities at the Eastern and Western Test Ranges.

6. Technical and administrative support services for all NASA elements located in the area.

In fulfilling its assigned programs, the Kennedy Space Center has developed into a highly flexible "space port" capable of handling a wide variety of launch activities for present and future manned and unmanned space missions.

DESCRIPTION:

The Kennedy Space Center is situated approximatley 50 miles east of Orlando, Florida, in northeast Brevard County.

The total land area occupied by the installation is 87,760 acres, including 83,783 acres owned by NASA. In addition to the land area occupied, the state of Florida has dedicated to the United States exclusive use rights to some 53,553 acres of State-owned submerged lands.

In addition to the operation and maintenance of all facilities at the Kennedy Space Center, the Center is responsible for certain facilities within the national Eastern Test Range launch area. The total capital investment at the Kennedy Space Center, including fixed assets in progress and contractor-held facilities at various locations as of June 30, 1970, was $1,005,148,000.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Dollars in Thousands)		
	1970	1971	1972
Authorized permanent positions, end of year..........................	2,779	2,681	2,544
Research and Program Management........	$97,582	$97,246	$95,559

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1972 ESTIMATES

MANNED SPACECRAFT CENTER

MISSION:

The Manned Spacecraft Center (MSC) was established in November 1961, in Houston, Texas, as NASA's primary Center for the design, development, and manufacture of manned spacecraft, and for selection and training of astronaut crews and the conduct of space flight missions. The MSC mission further embraces an engineering, development, and operations capability to support and to generate the knowledge required to advance the technology of manned space flight. Engineering and development efforts focus on applied research and development in the area of space research, space physics, life systems, and test and evaluation. Space science efforts are devoted to experiments in flights, scientific lunar exploration, research on returned lunar material, space environment studies, and development of a capability for surveying earth resources from space. The medical capabilities include experiments in flight, flight crew monitoring, and development of physiological requirements for spacecraft systems.

MSC is now engaged in Apollo Lunar Exploration and is proceeding with necessary spacecraft modifications for limited extension of exploration capabilities. Spacecraft are also being modified to support the requirements of the Skylab program. The Center's mission also involves the Earth Resources program as conducted by MSC through the Earth Resources Laboratory located at the Mississippi Test Facility. MSC is responsible for:

1. The design, development, and fabrication of the manned spacecraft including the command and service modules, and the lunar module.

2. Overall program management and control of the spacecraft including module integration, testing, and qualification.

3. Conduct of a program of spacecraft environmental testing.

4. Selection and training of astronauts and preparation of primary and backup crews for each mission.

5. Operation of the Mission Control Center and control of the space flight missions from lift-off to recovery.

6. Development of scientific and medical experiments to be flown on manned space flight missions.

7. Operation of the Lunar Receiving Laboratory, which provides a central complex where samples of materials brought to earth by lunar exploration teams are received, quarantined, processed, undergo limited experiments, and are distributed to the scientific community for further analysis.

8. Development and exploitation of aeronautical and aerospace photographic and remote sensor systems to provide and interpret scientific data on the physical sciences with emphasis on geography, geology, oceanography and hydrology.

9. Conduct of research investigations in the Mississippi-Louisiana-Gulf area in the application of remotely sensed data obtained from aircraft and satellites, and dissemination of this knowledge to potential users or agencies charged with specific responsibilities for operational activities.

In the period ahead, MSC will also participate in the NASA program to produce a preliminary design and design verification of a space shuttle engine and air frame, and a space station module.

DESCRIPTION:

The Manned Spacecraft Center is located two miles east of the town of Webster, Texas. The site is approximately 20 miles southeast of downtown Houston and 25 miles northwest of Galveston, Texas. Total NASA-owned land at Houston consists of 1,620 acres. The Center also occupies an additional 55,889 acres at the White Sands Test Facility, Las Cruces, New Mexico. The total capital investment of the Manned Spacecraft Center, including fixed assets in progress and contractor-held facilities at various locations, and the White Sands Test Facility, as of June 30, 1970, was $748,579,000.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Dollars in Thousands)		
	1970	1971	1972
Authorized permanent positions, end of year..........................	4,249	4,120	3,935
Research and Program Management.........	$106,561	$109,113	$106,255

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1972 ESTIMATES

MARSHALL SPACE FLIGHT CENTER

MISSION:

The Marshall Space Flight Center (MSFC) at Huntsville, Alabama, became a part of NASA in July 1960. Marshall serves as NASA's primary center for the design, development, and testing of large launch vehicles and space transportation systems, and is engaged in the program management and payload integration of the Skylab Flights. MSFC also directs activities at the Michoud Assembly Facility (MAF) at New Orleans, Louisiana; the Slidell Computer Facility at Slidell, Louisiana; and the Mississippi Test Facility (MTF) in Bay St. Louis, southwest Mississippi. The Center is involved in the direction and management of the following ongoing programs:

1. The Saturn V program, which provides the nation's only launch vehicle for manned lunar landing missions and very large payloads, such as the Skylab Workshop.

2. The Skylab program, including development of ground support equipment and cluster modules such as the Orbital Workshop, Apollo Telescope Mount, Airlock Module, and Multiple Docking Adapter, management of selected experiments, and overall systems engineering and integration of the total Skylab cluster.

3. The Saturn IB program, which serves as a launch vehicle for earth orbital manned missions.

4. The Lunar Roving Vehicle, which will provide mobility for lunar exploration.

5. The Space Shuttle main engine, a high thrust, throttleable liquid hydrogen, liquid oxygen fueled rocket engine capable of many reuses. The Center is also associated with other centers in directing the preliminary design and technology verification of the Space Shuttle vehicle.

In carrying out its management responsibilities for these programs, the Marshall Space Flight Center has developed the capability to:

1. Design and develop large launch space vehicle systems, including vehicle systems test and integration, tailored to manned and unmanned payload requirements.

2. Design and develop scientific payloads, space stations, and systems required for ongoing and future space exploration.

3. Develop and integrate scientific experiment payload packages to be flown on Saturn/Apollo vehicles and Skylab or subsequent post-Apollo missions.

4. Conduct systems engineering and overall systems integration of vehicles and payloads as assigned.

5. Conduct technical and program management of industrial programs involving space vehicles, payloads and systems.

In support of its assigned mission, the Marshall Center also maintains an in-depth capability to perform research and development in a wide range of scientific and technical disciplines, and to conduct studies of future launch vehicle and space systems such as the Space Shuttle. Its capability for research and for the management of large industrial programs gives the Center a highly flexible base for ongoing and future space programs.

DESCRIPTION:

Operations at the Marshall Space Flight Center are conducted at three primary locations:

The main Marshall Space Flight Center site is near Huntsville, Alabama, on Army property at the Redstone Arsenal. The Center occupies 1,797 acres under a nonrevocable use permit from the Army. The capital investment as of June 30, 1970, was approximately $619,214,000 Certain facilities such as the Redstone Arsenal Air Field and some utilities are used jointly by NASA and the Army. The Huntsville location has deepwater access via the Tennessee, Ohio, and Mississippi Rivers.

The Michoud Assembly Facility is located 15 miles east of New Orleans, Louisiana. The main facility occupies 891 acres. The Slidell Central Computer Facility, a satellite facility 20 miles to the northeast, occupies 14 additional acres bringing the total acreage to 905. The capital investment as of June 30, 1970, was approximately $159,874,000.

The Michoud Facility provides 3,559,256 square feet of space, including the main assembly plant, covering an area of 43 acres under one roof. The Facility is located on the Gulf Intra-Coastal Waterway and has deep-water access via the Mississippi River.

The Mississippi Test Facility is located in southwest Mississippi, approximately 50 miles northeast of New Orleans, Louisiana. Total land area is 138,800 acres of which 13,358 acres make up the actual test area owned by NASA. The remaining 125,442 acres are held as a buffer zone. In the buffer area, 7,568 acres are owned by NASA, and 117,874 acres are under restrictive easements. Capital investment for the Mississippi Test Facility as of June 30, 1970, was approximately $276,771,000. Test stands include a dual-position stand for testing the Saturn V first stage (S-IC), and two stands for testing the 1,000,000 pound thrust Saturn V second stage (S-II). The site has deepwater access via the Pearl River and the Intra-Coastal Waterway.

The total capital investment of the Marshall Space Flight Center and its installations at Mississippi and Louisiana, including fixed assets in progress and contractor-held facilities at various locations, as of June 30, 1970, was $1,055,859,000.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Dollars in Thousands)		
	1970	1971	1972
Authorized permanent positions, end of year........................	6,002	5,804	5,507
Research and Program Management......	$125,693	$142,448	$130,191

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1972 ESTIMATES

GODDARD SPACE FLIGHT CENTER

MISSION:

The Goddard Space Flight Center, established in 1959 as the first major United States installation devoted to the investigation and exploration of space, conducts a wide-ranging program of experimentation in space science and applications. The Goddard Center has developed many diverse capabilities: the management of complex satellite projects; the development of wholly integrated spacecraft, ranging from systems engineering to development, integration, and testing; the development and operation of satellite tracking networks; data acquisition and analysis; and scientific research to include both theoretical studies and the development of many significant scientific experiments flown in satellites.

The majority of the Goddard Center's personnel are located at Greenbelt, Md.; other personnel are located at the Goddard Institute for Space Studies in New York City, and throughout the world, managing the operation of satellite tracking and communications network stations.

Goddard is responsible for the management of communications and earth observation satellite programs, such as the Applications Technology, Nimbus, and Earth Resources Technology satellites; the management of scientific satellite projects which include the Orbiting Solar (OSO) and the Orbiting Astronomical (OAO) Observatories and the Explorer series; project management of NASA's Delta launch vehicle; management and operation of two worldwide tracking and data acquisition networks, the Space Tracking and Data Acquisition Network and the Manned Space Flight Network; and the development of the sounding rocket program.

Major Goddard activities during the year were concerned with work in the following areas:

International Satellites - An increasingly important mission for the Center is its responsibility for carrying out the international cooperative space program under NASA auspices. During the year, two communications satellites, NATO-1 and Skynet-2, were launched for the North Atlantic Treaty Organization and United Kingdom respectively. Additionally, numerous sounding rocket launchings were conducted in cooperation with scientists throughout the world, often from foreign launch sites.

Applications Satellites - Goddard is the primary NASA Center for weather, communications and earth resources satellite efforts. In addition to launchi ITOS-1 and Nimbus-4 during the year, the Center began work on two advanced pr grams, Earth Resources Technology Satellites (ERTS) and Applications Technolo Satellites F&G (ATS F&G). The ERTS satellites will investigate the Earth's resources from space while the ATS F&G satellites will carry advanced meteoro logical, communications, air traffic control and scientific experiments.

Sounding Rockets - During 1970 more than 160 sounding rocket launchings, primarily at the Wallops Station, were conducted by Goddard, bringing to 1,400 the number of launchings in the program since 1959.

Tracking and Data Acquisition - The Goddard-managed Space Tracking and Data Acquisition Network provided communications and tracking coverage for all of NASA's scientific and applications satellites launched during the year. The Manned Space Flight Network provided global tracking support for one Apollo manned flight during the year.

DESCRIPTION:

The Goddard Space Flight Center, located 15 miles northeast of Washington, D.C., at Greenbelt, Maryland, is situated on a 554-acre main site. Three additional nearby plots of 639 acres comprise the remote site area and contai the Goddard Antenna Test Range, the Goddard Optical Facility, the Propulsion Research Facility, the Magnetic Fields Component Test Facility, the Attitude Control Test Facility, and the Network Training and Test Facility.

The total capital investment for the Goddard Space Flight Center, including fixed assets in progress and contractor-held facilities at various locations as of June 30, 1970, was $628,794,000 (including capital type facilities of the MSF and STADAN network and other supporting activities including equipment aboard ships and aircraft).

SUMMARY OF RESOURCES REQUIREMENTS:

	(Dollars in Thousands)		
	1970	1971	1972
Authorized permanent positions, end of year............................	4,412	4,412	4,187
Research and Program Management...........	$86,452	$91,194	$90,299

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1972 ESTIMATES

WALLOPS STATION

MISSION:

Wallops Station is responsible for planning and conducting applied research and development with emphasis on scientific payload development, instrumentation, facilities and techniques utilized in rocket borne experiments, aeronautical and terminal area research projects and ecological studies.

Wallops Station prepares, assembles, launches, tracks and acquires scientific information from space vehicles. Its facilities are utilized by the scientists and engineers from the laboratories and research centers of NASA, other governmental agencies, colleges and universities, and the worldwide scientific community. Wallops Station personnel assist these scientific research teams with their projects; develop, as necessary, special types of instrumentation and equipment to complete the mission; and manage NASA research projects.

Research at Wallops Station is directed toward gathering information about the earth's atmosphere and it's near space environment. The Station utilizes launch vehicles ranging in size from the small Arcas and Hasp meteorological rockets to the 72 foot Scout rocket with orbital capability in obtaining scientific data about the atmosphere and the near space environment. Thirteen satellites have been launched. Wallops Station has launched more than 7,500 research vehicles consisting of from one to seven stages in the quest for scientific knowledge.

Wallops facilities are utilized for many other research projects, such as space component tests, helicopter and aircraft drop tests, helicopter and aircraft noise abatement projects, anti-skid tests on grooved runways, V/STOL terminal air research, collision avoidance programs, laser and radar tracking of aircraft and satellites.

Wallops Station exercises project management responsibility for several NASA sponsored projects such as Orbiting Frog Otolith (OFO), the Experimental Inter-American Meteorological Rocket Network (EXAMETNET), the German-American barium project, a Bio-Space Technology Training Program for bio-scientists, operation of remote site launching and tracking facilities, operation of NASA's portable range facilities for sounding rockets, and an Arctic launch site at Point Barrow, Alaska.

The Station is also responsible for a portion of the National Sounding Rocket Program. This requires program interface with the scientific, university and international community; engineering support including analytical, feasibility, and design studies, payload, vehicles and recovery system engineering, test and evaluation; and data analysis and reporting.

A portion of the Station's effort is devoted to NASA's program of international cooperation in space research. Foreign countries are provided with training programs for their personnel, assistance in activation of launch sites, and with technical assistance and advice in launching experiments and in operation of their ranges. Representatives of eighteen countries have visited Wallops Station to observe operations or seek assistance in establishing sounding rocket facilities of their own.

Wallops Station is involved in establishing the Chesapeake Bay area as a multidisciplinary ecological test site for developing the applications of remote sensing from aircraft and space platforms. As part of the program the Station is working closely with user groups to develop remote sensing analysis and monitoring techniques for studying the ecology of the area.

DESCRIPTION:

The Station includes three separate areas on the Atlantic Coast of Virginia's eastern shore: the main base (formerly Chincoteague Naval Air Station), the Wallops Island launching site and the Wallops mainland site. The administrative offices, range control center, support shops, and main telemetry buildings are located on the main base. Wallops Island is about seven miles southeast of the main base and is connected to the mainland by a causeway and bridge. The island is about five miles long and only one-half mile wide at its widest point. Located on the island are rocket storage buildings, blockhouses, assembly shops and the launch sites. The Wallops mainland site is a one-half mile strip west of the island which houses the radar and optical tracking sites. The Eastville, Va., down range tracking site is located about 50 miles south of the Wallops Station.

Wallops Station, totaling 6,561 acres, consists of 2,313 acres on the main base; 3,000 acres on Wallops Island, 108 acres on the mainland tracking site; and 1,140 acres of unusable marsh land. The Eastville tracking site consists of an additional 53 acres of government-owned property. The total capital investment, including fixed assets in progress and contractor-held facilities at various locations, as of June 30, 1970, was $110,364,000.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Dollars in Thousands)		
	1970	1971	1972
Authorized permanent positions, end of year	488	488	462
Research and Program Management	$9,688	$10,074	$10,027

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1972 ESTIMATES

AMES RESEARCH CENTER

MISSION:

The programs at the Ames Research Center are directed at research and development in the fields of aeronautics, space science and spacecraft technology as well as applications to national needs of the new science and technology growing out of the aerospace program. Specifically, the Center's major responsibilities are concentrated in five areas: Aeronautics, Space Shuttle/Station, Life Sciences, Planetary Science and Astrophysics and the Pioneer Project.

The aeronautical research program at Ames is among the most important R&D efforts at the Center. To provide a guide for pursuing our experimental research, emphasis is placed on theoretical analyses as a basis for the prediction and understanding of fluid flows that is intended to lead to a much stronger role of the computer in the design of aeronautical vehicles throughout the speed range. Efforts are under way to exploit the great potential for using computational fluid dynamics in the future in place of certain types of more costly and time consuming wind tunnel experiments. In addition to the more basic areas, the Center is also a major contributor to V/STOL technology. VTOL and STOL aircraft are important in both civil and military aviation. Success in these applications will depend upon efficient flight and upon the ability to land and take-off quickly and precisely from small areas with safety and regularity under all-weather conditions. Research investigations are being carried out on specific concepts to achieve these broad objectives. This research involves systematic analytical studies and wind tunnel investigations to define and evaluate concepts, study of the flight characteristics of the concepts using flight simulators and finally flight verification with flight vehicles of the technological advances indicated in the research program.

Military aircraft development programs historically have been supported through investigations in the Center's wind tunnels and simulators, many of which have unique test capabilities. This activity will be continued at a high level because it is vital to specific aircraft programs and because it affords insight into problems requiring further research for application to the design of future aircraft.

The Space Shuttle/Station programs are being supported in a number of areas at Ames. Past research at the Center has contributed significantly to the solution of the problem of the survival of spacecraft during the very high aerodynamic heating attendant to high speed entry into the earth's atmosphere. The heat protection systems for a relatively highly maneuverable reusable craft such as the Space Shuttle presents a very different problem from that of previous spacecraft which followed essentially a ballistic trajectory and were designed on the basis of a single mission. Thermal protection system research is one area of space shuttle support being carried out at Ames. Other areas involve studies of the aerodynamic performance, stability and control of various booster and orbiter vehicle concepts under consideration, the definition of dynamic loads and vehicle response to be expected, and the guidance, control and piloting problems to be encountered in landing such vehicles. Studies are also being made to help provide a definition of research to be conducted in a space station, the design of the life support systems, a better understanding of the space station environmental effects on human performance and the effects of long term exposure to weightlessness on the physiology of humans.

Research in the life sciences is conducted in three major areas: (1) basic research in the physiological and behavioral sciences concerned with obtaining an understanding of the effects of aeronautical and space flight stresses upon man; (2) research in long-term advanced life support systems and in the human factors aspects of the relationships between man and the machines which transport and support him in a hostile environment; and (3) studies in exobiology oriented towards the prediction, detection, and study of extraterrestrial fossils, chemicals, and life forms.

Research in space science includes studies of solar physics, planetary environments and geophysics. The studies pertain to magnetic fields and plasmas in space, the composition and structure of planets and of planetary and stellar atmospheres, and cratering mechanics in natural materials to aid in understanding the structure of lunar surfaces. Also of concern is the planet earth and how the technology that has been developed in the space program can be used to improve our understanding of the earth and the conservation of its resources. The studies are both theoretical in nature and experimental using laboratory equipment, sounding rockets and experiments carried on satellites and space probes. Experiments are also conducted on a specially outfitted aircraft which serves as an airborne laboratory to provide, for example, a platform for an infrared telescope for astronomical observations which are highly degraded from surface locations by the filtering effects of the atmosphere. Researchers throughout the scientific community are invited to participate in studies conducted from the airborne laboratory.

Ames has flight project management responsibility for the Pioneer Project. Pioneer provides scientific observations of phenomena in interplanetary space from an unmanned spacecraft. Four Pioneer spacecraft are currently in separate orbits about the sun near the earth's orbit and all regularly provide information on solar radiation. One of these is in its sixth year of operation. Pioneer F and G spacecraft are being readied for the study of interplanetary fields and particles beyond the earth's radius, the asteroid belt and the environment of Jupiter.

In carrying out its mission, Ames works closely with the aerospace and educational communities and with other Government agencies. A number of cooperative or joint programs are currently in progress with the Department of Transportation.

DESCRIPTION:

The Ames Research Center was established in 1940, and is located at the southern end of San Francisco Bay on land contiguous to the U.S. Naval Air Station, Moffett Field, California. Its physical plant comprises many specialized facilities for aerospace research in the physical sciences as well as the space sciences and life sciences, all of which are included in the mission of the Center. These include wind tunnels, entry-heating simulators, and free-flight ballistic test facilities capable of conducting tests at speeds up to and above earth escape speed as well as laboratories equipped to study solar and geophysical phenomena, life synthesis, life detection, and life environmental factors. The Ames Research Center occupies about 365 acres of land. Certain other facilities, such as the utilities and airfield runways, are used jointly by NASA and the Department of the Navy. The capital investment at the Ames Research Center, including fixed assets in progress and contractor-held facilities at various locations as of June 30, 1970, was $256,217,000. Also housed at the Ames Research Center is the U.S. Army Air Mobility, Research and Development Laboratory. Personnel from this Laboratory work closely with Ames personnel on research of mutual interest.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Dollars in Thousands) 1970	1971	1972
Authorized permanent positions, end of year..........................	1,972	1,922	1,824
Research and Program Management........	$37,602	$39,899	$39,719

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1972 ESTIMATES

ELECTRONICS RESEARCH CENTER

MISSION:

The Electronics Research Center, established in September 1964, was closed in 1970 following a redirection of the nation's space program undertaken during the fiscal year 1971 budget process.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Dollars in Thousands)		
	1970	1971	1972
Authorized permanent positions, end of year	600	---	---
Research and Program Management	$19,106	---	---

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1972 ESTIMATES

FLIGHT RESEARCH CENTER

MISSION:

The Flight Research Center, established in 1947, conducts aeronautical and space related research using a variety of aerospace vehicles. The work includes effort on problems of take-off, landing, low-speed flight, supersonic and hypersonic flight, and re-entry to verify predicted characteristics and to identify unexpected problems in actual flight.

The current and projected programs at this Center include: aeronautical projects concerning general aviation, STOL research, subsonic and supersonic transport research; space vehicle systems projects in which the flight behavior of advanced re-entry vehicles including M2-F2, HL-10, and X-24A heavyweight lifting bodies is studied; and electronic systems projects such as display, guidance, and control in advanced flight missions and improvements on systems and sensors used in biomedical monitoring, tracking, and data acquisition.

Most important of the facilities and special equipment for conducting programs at the Flight Research Center are the aircraft. They range from general aviation aircraft for handling qualities investigations to supersonic aircraft, such as the YF-12A, used for various research investigations having application to both civil and military aviation. Special purpose vehicles such as lifting bodies, STOL, variable stability aircraft, or airborne simulators, are contractor procured or developed in-house. Specialized laboratory facilities are available to complement the flight activities with proper preliminary research and testing. Simulation equipment is used to guide and assist in the performance of productive flight activities. A two-station radar for tracking and data acquisition is operated to support the flight activity.

DESCRIPTION:

The Flight Research Center, Edwards, California, is 65 air miles northeast of Los Angeles. The Center is located at the north end of Edwards Air Force Base on 218 acres of land leased from the Air Force. Utilities are provided by the Air Force on a reimbursable basis. The Center is adjacent to Rogers Dry Lake, a 55-square-mile area with a complex of runways varying in length from 5 to 11 miles.

The physical plant consists of an office-laboratory building with adjoining shops, a flight maintenance hangar, a calibration hangar, and a high temperature loads calibrations facility. Auxiliary buildings include warehouses, an auxiliary power systems building, communications building, and an aircraft maintenance dock. The main station of the two-station radar range operated by the Center is located on the third floor of the office-laboratory building. The total capital investment of the Flight Research Center, including fixed assets in progress, and contractor-held facilities at various locations, as of June 30, 1970, was $63,228,000.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Dollars in Thousands)		
	1970	1971	1972
Authorized permanent positions, end of year...........................	535	535	508
Research and Program Management..........	$10,308	$10,895	$10,974

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1972 ESTIMATES

LANGLEY RESEARCH CENTER

MISSION:

The Langley Research Center strives to maintain the leadership of the United States in aeronautics and space activities through the conduct of a broadly based research and technology development program to identify and investigate the fundamental technical problems confronting the advancement of flight in the atmosphere and in space. It attempts to discover and to assess opportunities for the exploitation of important new flight systems and through its research program to improve the technological base for the design, construction, and operation of advanced aircraft and space vehicles. It manages the execution of nationally significant flight projects. Through its granting and contracting capabilities it involves elements of the nation's entire research community, especially among the nation's universities, in its research programs. It disseminates the implications of its research results for the nation's entire industrial base.

Langley is directing an increasing and substantial portion of its research programs to the development of advanced concepts and new technology on which future aircraft with increased performance, range, and greater safety and economy can be based. Special emphasis is placed on the application of the revolutionary supercritical wing concept to the development of an advanced transport which maximizes cruise efficiency to improve aircraft productivity and decrease operating costs. In 1971 the practical construction of this wing and the performance of an aircraft with this wing at near full scale will be investigated. In 1972 the investigation will be extended to examine a more complete aircraft with realistic flight controls and high lift devices. Increased emphasis is being placed on the development of a technological base to support a national V/STOL aircraft construction program and to evolve systems for optimum terminal area instrument operation and air traffic control integration.

Emphasis will continue on the improvement of the supersonic flight capabilities for both transport and military aircraft. Configurations are being studied that attempt to maximize the favorable interference effects of aerodynamics, with advanced structures and propulsion. The advanced research program is also aimed at the technology required for aircraft whose performance extends into the hypersonic speed range. The evolution of materials and structural systems for critical temperature environments is in progress and practical methods for active cooling of high heat areas of aircraft surfaces are being developed. Work is also proceeding on the development of hypersonic ramjet engine technology.

Other programs at the Langley Center are focused on the critical problems of aircraft propulsion noise and sonic boom alleviation, the detection of clear air turbulence and aircraft trailing vortices, the improvement of landing gears and improved traction and control under adverse weather conditions.

In support of general aviation, Langley will continue its studies to identify problems and their resolution for current designs, to consolidate data and techniques for new designs, to collect data to update load requirements, and to develop new devices for high lift, control systems and gust-alleviation to improve operational capabilities. Simplified low-cost electronic systems to aid stability, navigation communication and collision warning are under development.

A large portion of the Center's skills and resources is directed to the management of important space flight projects. Langley has overall management responsibility for the NASA Viking project which plans to orbit and soft land unmanned instrumented vehicles on Mars in 1976. The project will provide a detailed study of Martian geophysics, atmospheric characteristics and surface properties. Especially significant are its experiments to indicate the presence of life-forms. The support of Viking and other national space flight efforts is based on extensive experience and continuing contributions to advanced technology in such areas as atmosphere entry heat shielding, space vehicle recovery systems, rocket propulsion, instrumentation and electronic equipment, and spacecraft sterilization.

Space technology programs have been expanded to support the selection and development of manned systems such as the space shuttle and space station/base. They include mission flight mechanics, trajectory selection, vehicle configuration and performance, loads, structures, and cryogenic tankage, refurbishable thermal protection systems, on-board power systems, and life support systems, and the development and integration of mission experiments.

Contributions will continue to be made to the technology of automated spacecraft, such as space telescopes, sensors and data handling for earth resources satellites, payloads for micrometeoroid and radiation environment surveys as well as the definition of the upper atmosphere. The Langley Center is responsible for providing crucial technology as well as experiments for the Apollo and Skylab programs. It is also responsible for the acquisition, operation, and improvement of the Scout launch vehicle in its application to national and international satellite experiments.

The Center's ground based research program includes comprehensive investigations of the effects of the environment on space vehicles including heat, vacuum, noise, micrometeoroid and radiation; the development and application of advanced composite and polymeric materials to structures and thermal control systems; and improved technology for entry communication blackout alleviation, horizon sensing, antenna and power amplifiers, batteries, high capacity computer memories, logic circuits and other advanced microelectronic devices.

Langley will continue its pioneering role in the definition of man's capabilities and adaptation for performance of space missions by work on projects relating to rendezvous and docking, extra vehicular operations, space assembly and maintenance and complex experiments.

DESCRIPTION:

The Langley Research Center, Hampton, Virginia, is located approximately 100 air miles south of Washington, D.C. The Center occupies 773 acres of Government-owned land, divided into two areas by the runway facilities of Langley Air Force Base. The West Area consists of 750 acres, 430 owned by NASA and 320 under permit from the Air Force. The East Area comprises 23 acres under Air Force permit. Runways, some utilities, and certain other facilities are used jointly by NASA and the Air Force. In addition, there are 110 acres of NASA-owned land located in the City of Newport News, Virginia, 3,277 acres under permit from the Air Force, and 9 acres under lease. The total acreage presently owned, under permit or leased, is 4,169. The total capital investment at the Langley Research Center, including fixed assets in progress, and contractor-held facilities at various locations as of June 30, 1970, was $402,968,000.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Dollars in Thousands)		
	1970	1971	1972
Authorized permanent positions, end of year	3,872	3,790	3,596
Research and Program Management	$69,851	$73,388	$74,191

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1972 ESTIMATES

LEWIS RESEARCH CENTER

MISSION:

The Lewis Research Center's principal mission is research and technology in the areas of aircraft and spacecraft propulsion, and power generation systems for spacecraft. The emphasis is predominantly on research and technology; however, the entire spectrum of activities is undertaken from basic research to development. The scope of technology ranges from work on individual components through complete systems. Most of the critical areas which limit the performance of engines and power systems are the subjects of in-house research effort at this Center. Research by commercial and university laboratories is also conducted under contracts directed by Lewis Research Center personnel.

The Lewis Center is responsible for the Centaur booster project and for the SERT (Space Electric Rocket Test) project. Large contracts are directed on the Quiet Engine (for aircraft) and the Brayton Cycle Nuclear Electric Generating System for spacecraft. There is also considerable supporting in-house research effort on these projects.

Some examples of major research and technology activities are discussed in the following paragraphs:

Aircraft engines for future subsonic and supersonic aircraft will incorporate high compressor pressure ratios and high turbine inlet temperatures. A large part of the aeronautics research effort at Lewis is directed toward solving the problems imposed by these two factors. Among these research efforts are: slotted compressor blades to increase the pressure rise per blade row, cooled turbine blades, high-speed bearings and seals for operation at high temperature, engine inlets, engine exhaust nozzles, combustor configurations, and high energy fuels. A flight test program is being conducted with an F-106 airplane to determine the interaction of engine inlets and exhaust nozzles with wings and fuselage at transonic speeds. These flight tests complement wind tunnel tests which have limited capability in predicting the engine-airframe interactions at transonic speeds.

Lewis is supporting a series of advanced research and technology projects on subsonic aircraft. These projects are: the Advanced Technology

Experimental Transport (ATET), the lift-fan transport for VTOL applications, and the externally-blown airplane flaps for STOL applications. The engine technology for these applications requires new engine configurations for which the technology has not yet been established. One element of the in-house program is, for instance, to determine the effects of cross flow on high-pressure ratio lift fans for V/STOL aircraft in experiments being conducted in the low-speed return passage of the 8- by-6 Foot Supersonic Wind Tunnel.

High performance engines are presenting an increased requirement for finding means to reduce engine noise. Lewis is conducting in-house research to provide the technology required and to develop prototype noise reducing components. A quiet engine development contract is being managed by Lewis to provide a turbo-fan engine that will incorporate the technology being developed both at Lewis and under contract programs.

The problems of high flight Mach number aircraft engines are also being investigated. This research spans the problems of inlets, combustion, nozzles, and engine systems. A new facility nearing completion at Plum Brook will extend the capability to allow experiments on engines of practical size.

Contributions to rocket technology continue to flow from Lewis. Relatively small scale chemical rockets are used to study the problems of combustion instability, fuel-oxidant mixing, regenerative cooling of nozzles, ablative nozzles, nozzle insulating coatings, and spacecraft surface degradation due to rocket jet impingement.

For future deep space missions a number of potentially attractive propulsion systems are receiving serious consideration; however, insufficient data exists upon which to base a selection. One of the systems under consideration utilizes space storable propellants. Lewis has undertaken a program to provide the necessary engine performance data. The program will demonstrate various propellant combinations with flight-type systems to provide the base of technology and hardware that is required to reduce the cost of later flight hardware development.

A full-scale Centaur vehicle was installed and operated in the Spacecraft Propulsion Research Facility. This vehicle was equipped with a prototype tank pressurizing system replacing the current pump system for feeding the propellants to the engine. Work will continue during the coming year on the development of this pressurizing system.

Electric rockets for deep space propulsion have benefited greatly from the work in the Electric Propulsion Research Building and the newer Electric Propulsion Laboratory. These buildings contain many large vacuum tanks where the space environments essential to electric propulsion research are approximated.

Many devices for power generation in space are being studied. The solar cell converts sunlight directly into electricity. Batteries and fuel cells convert stored chemicals into electricity. For a large and sustained power supply, however, an adaptation of the familiar turbine driven generator seems most practical. To achieve the tremendous weight reduction necessary will require intensive research and development. Instead of steam, the turbines will be driven by liquid metal vapor (Rankine cycle) or by heated gas (Brayton cycle). The only way to reject the waste heat is by direct radiation to space, so very large radiators will be required. High rotative speeds to reduce weight produce requirements for new designs of compressors, turbines, bearings and electric generators. The heat source will probably be a nuclear reactor.

Various problems in connection with the development of nuclear power systems and nuclear rockets are conducted at the Plum Brook Station. A 60-megawatt thermal reactor facility is used to determine the effects of radiation on materials, on various electronic, hydraulic, and mechanical control systems, and on items of equipment.

A 28 million dollar Space Power Facility has been placed in operation at Plum Brook where nuclear powered electric generating systems can be operated under simulated space environment conditions for long periods of time. The first system to be installed was a compressor-turbine unit for a Brayton cycle electric power generating system.

Another type of electric generator and another source of energy are more distant prospects. A stream of ionized plasma flowing through a coil will generate electricity in that coil (magnetohydrodynamics). The success of this effort and of related activities depends largely on the development of superconducting electric magnets. The Lewis Research Center has been a leader in this field, and has constructed a magnet with a field of 150,000 gauss over a twelve-inch bore. A new facility for conducting research on plasma turbulence, diffusion and heating is under construction. Known as the "Bumpy Torus" it will utilize twelve superconducting magnets to compress a stream of deuterium plasma and force it to flow in a roughly circular path, thus avoiding the large entering and leaving losses encountered with existing open-end facilities. Data obtained with this facility may aid in the ultimate development of a controlled fusion reaction device.

The performance of propulsion and power generation systems, launch vehicles, spacecraft, and practically all hardware is paced by physical limitations of available materials. The Center has maintained a substantial materials research effort aimed at raising these limitations and improving component and system performance. Activity covers the entire temperature range of materials usage going from the cryogenic temperature of liquified gases to the high temperatures encountered in the rocket nozzles of aircraft engine combustors and turbine wheels. Materials research includes both fundamental studies of what makes materials strong or weak and the development of new materials. "Super" alloys, corrosion resistant coatings, ultra pure tungsten, and composites made of metal whiskers, fibers, or sintered granules are among the many concepts being investigated.

The NASA Aerospace Safety Institute is located at the Lewis Center. The Institute's staff of specialists surveys the research needs and directs research efforts in this field. A data bank of research information is being compiled and cataloged for ready access. A computer system and data retrieval methods are being established to provide the safety information to requestors.

DESCRIPTION:

The Lewis Research Center occupies two sites in north central Ohio. The older one was established in 1941 on 200 acres adjacent to the Cleveland-Hopkins International Airport. The original area has been expanded to 364 acres. Here there are over 90 buildings, including two large supersonic wind tunnels, two zero gravity research facilities (free drop shafts, one of which is an underground evacuated shaft 477 feet deep in which zero gravity durations of about 10 seconds are obtained), a large Propulsion Systems Laboratory in which full-scale engines are operated under simulated high-altitude conditions, three rocket laboratories, five materials research buildings, eighteen major space simulation facilities ranging from four to thirty feet in diameter, a 50-foot diameter Space Power Chamber 120 feet long in which altitudes up to 100,000 feet are simulated, an Energy Conversion Laboratory, an Instrument Research Laboratory, a High Energy Fuels Laboratory, a Chemistry Laboratory, an Engine Research Building containing 64 test cells and covering nearly four acres, four office buildings, machine shops and other service buildings.

A newer site, established in 1956, is located south of Sandusky, Ohio, about fifty miles west of Cleveland, on land formerly occupied by the Plum Brook Ordnance Works. Known as the Plum Brook Station, it occupies 7,837 acres of which 7,787 are owned by the Government and fifty are in easements.

There are over 200 buildings on the Plum Brook site, 55 built by the NASA and the rest by the former tenants. The major facilities include a Reactor Facility, an Altitude Rocket Test Facility, a Cryogenic Propellant Research Facility, Heat Transfer Facility, a Spacecraft

Dynamics Research Facility, a Rocket Pump Laboratory, a Rocket Turbine Laboratory, a Rocket Turbo-pump Laboratory, a Rocket Systems Hydraulic Laboratory and a Fluorine Pump Laboratory. The latest major research facilities to be completed are the Spacecraft Propulsion Research Facility to test the ignition and operation of full-scale rocket engines after a prolonged shut-down period in a space environment, and the Space Power Facility for testing full-scale nuclear powered electric generating systems. Nearing completion is a Hypersonic Tunnel Facility in which burning ramjet engines can be operated at speeds up to Mach 7. The research programs at Plum Brook are under the technical direction of personnel located at Cleveland. They are conducted at the larger site because of the need for large separation distances to minimize hazards.

The total capital investment of the Lewis Research Center including fixed assets in progress, and contractor-held facilities at various locations, as of June 30, 1970, was $398,051,000, of which $115,315,000 represents facilities located at the Plum Brook Station.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Dollars in Thousands) 1970	1971	1972
Authorized permanent positions, end of year......................	4,201	4,087	3,879
Research and Program Management.....	$73,895	$77,094	$77,866

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1972 ESTIMATES

SPACE NUCLEAR SYSTEMS OFFICE

MISSION:

The joint AEC-NASA Space Nuclear Systems Office is responsible for planning and directing programs to establish the technology and development of flight qualified nuclear propulsion and nuclear electric power systems for use in space.

Important aspects of these functions include: (1) the development of the 75,000 pound thrust NERVA engine, (2) the planning and management of the program to develop a reusable nuclear stage, (3) planning and management of various programs to advance nuclear propulsion technology, (4) the development of nuclear electric power systems, and (5) the planning and management of programs to advance the technology of nuclear electric power systems.

DESCRIPTION:

The Space Nuclear Systems Office is a joint AEC-NASA office and was established under Interagency Agreement to manage all aspects of the space nuclear power and space nuclear propulsion programs.

The office consists of a Headquarters group located at AEC Headquarters, Germantown, Maryland and three extensions, located in Ohio, New Mexico and Nevada.

The Space Nuclear Systems Office is charged with the responsibility for the management of the Nuclear Rocket Development Station (NRDS). The Nuclear Rocket Development Station is located on a 78,000 acre site adjacent to the AEC's Nevada Test Site approximately 90 miles northwest of Las Vegas in southern Nevada, and is the national site for the static ground testing of reactors, engines and eventually of vehicles associated with nuclear rocket development.

The total capital investment of NASA-funded facilities, including fixed assets in progress and contractor-held facilities at various locations as of June 30, 1970, was $53,172,000.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Dollars in Thousands) 1970	1971	1972
Authorized permanent positions, end of year..........................	114	114	108
Research and Program Management.........	$2,282	$2,519	$2,588

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1972 ESTIMATES

NASA HEADQUARTERS

MISSION:

The mission of the National Aeronautics and Space Administration Headquarters is to plan and provide executive direction for the programs authorized by the Congress, and to implement the national objectives stated in the National Aeronautics and Space Act of 1958, as amended. The principal statutory functions are:

1. To conduct research into, and for the solution of, problems of flight within and outside the earth's atmosphere and to develop, construct, test, and operate aeronautical and space vehicles for research purposes.

2. To conduct activities required for the exploration of space with manned and unmanned vehicles.

3. To arrange for participation by the scientific community in planning scientific measurements and observations to be made through use of aeronautical and space vehicles, and conduct or arrange for the conduct of such measurements and observations.

4. To provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof.

The following offices at Headquarters assist management in carrying out the technical aspects of this mission:

Office of Manned Space Flight - Responsible for all NASA activities directly involving manned space flight missions. Programs include:

Apollo -- Based on the demonstrated national capability for manned space exploration, to conduct scientific exploration of the moon through lunar orbital and lunar surface operations.

Space Flight Operations - To expand capabilities to conduct scientific, technological and applied operations in space through flights of increasing duration and complexity, initially using Apollo hardware or derivatives of Apollo hardware; development of a fully reusable space transportation system; and progressing to an orbital space station.

Advanced Missions - To plan a broad program of explorations which will achieve and maintain a balanced program of space operations and exploration for the United States.

The Office of Manned Space Flight has launch responsibility for major manned and unmanned missions. The three installations primarily concerned with the manned space flight programs are: the George C. Marshall Space Flight Center, including Mississippi Test Facility, Michoud Assembly Facility, and Slidell where a computer facility is located; the Manned Spacecraft Center, including NASA activities at the White Sands Test Facility; and the John F. Kennedy Space Center, NASA, including NASA activities at the Eastern and Western Test Ranges.

Office of Space Science and Applications - Responsible for the NASA automated space flight program directed toward scientific investigations of the solar system utilizing ground based, airborne, and space techniques including sounding rockets, earth satellites, and deep space probes; for scientific experiments to be conducted by man in space and for the scientific training of astronauts; for the research and development of space flight applications in such areas as meteorology, communications, navigation, geodesy, and earth resources surveys, and for the support of operational systems using these developments; and for the development, procurement and use of light and medium class launch vehicles.

The Office of Space Science and Applications has over-all institutional responsibility for NASA installations primarily involved in space science and applications programs. These are the Goddard Space Flight Center, Wallops Station, the Jet Propulsion Laboratory (a Government-owned facility operated for NASA by the California Institute of Technology), and the NASA Pasadena Office, a component field activity of Headquarters.

Office of Advanced Research and Technology - Responsible for the planning, direction, execution, evaluation, documentation, and dissemination of the results of all NASA research and technology programs that are conducted primarily to demonstrate the feasibility of a concept, structure, component, or system and which may have general application to the nation's aeronautical and space objectives. This office is also responsible for coordinating NASA's total program of supporting research and technology related to carrying out specific flight missions in order to avoid unnecessary duplication and to insure an integrated and balanced agency research program.

In addition, this office has over-all institutional responsibility for the research centers primarily involved in carrying out NASA's advanced research programs. These installations are: the Ames Research Center, the Flight Research Center, the Langley Research Center, the Lewis Research Center, and the Space Nuclear Systems Office.

Office of Tracking and Data Acquisition - Responsible for the development, implementation, and operation of tracking, data acquisition, command, communications, and data processing facilities, systems and services required for NASA flight missions. This office is also responsible for agency-wide coordination of the management of automatic data processing systems and services. In addition, this office provides for centralized planning and systems management for the administrative communications at NASA installations.

The NASA Pasadena Office - Pasadena, California, is a component field activity of the NASA Headquarters Office of Space Science and Applications. Its responsibilities are to negotiate and administer NASA contracts with the California Institute of Technology for the operation of the Jet Propulsion Laboratory; provide patent and technology utilization services as they relate to prime and subcontracts at the Jet Propulsion Laboratory; and perform such additional procurement, contract administration, communications, and other functions as may be assigned by the Associate Administrator for Space Science and Applications.

DESCRIPTION:

The NASA Headquarters is located at 400 Maryland Avenue, S.W., Washington, D.C., and also occupies other buildings in the District of Columbia and nearby Virginia. Except for some office space leased in the District of Columbia and a storage area in Virginia, personnel occupy Government-owned buildings. The NASA Pasadena Office is physically located at the Jet Propulsion Laboratory in Pasadena, California.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Dollars in Thousands)		
	1970	1971	1972
Authorized Permanent Positions, end of year........................	2,126	1,897	1,800
Research and Program Management........	$63,158	$64,563	$59,681

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1972 ESTIMATES

SUMMARY OF APPROPRIATION BUDGET PLANS BY INSTALLATION

(In millions of dollars)

Installation	Research and Development			Construction of Facilities			Research and Program Management			Total		
	1970	1971	1972	1970	1971	1972	1970	1971	1972	1970	1971	1972
John F. Kennedy Space Center, NASA.....	267.0	182.6	196.5	12.5	.6	15.2	97.6	97.2	95.6	377.1	280.4	307.3
Manned Spacecraft Center...............	1,019.7	612.4	459.2	1.7	---	---	106.6	109.1	106.2	1,128.0	721.5	565.4
Marshall Space Flight Center...........	732.3	618.6	624.5	---	---	---	125.7	142.4	130.2	858.0	761.0	754.7
Goddard Space Flight Center............	432.0	463.9	445.2	.7	1.9	---	86.4	91.2	90.3	519.1	557.0	535.5
Wallops Station........................	9.9	9.2	9.7	.5	---	---	9.7	10.1	10.0	20.1	19.3	19.7
Jet Propulsion Laboratory..............	161.4	152.0	207.8	---	2.0	---	---	---	---	161.4	154.0	207.8
Ames Research Center...................	64.7	81.3	67.1	---	---	6.5	37.6	39.9	39.7	102.3	121.2	113.3
Electronics Research Center............	7.3	---	---	---	---	---	19.1	---	---	26.4	---	---
Flight Research Center.................	10.9	12.6	20.6	---	---	---	10.3	10.9	11.0	21.2	23.5	31.6
Langley Research Center................	106.7	103.8	206.5	4.8	---	---	69.9	73.4	74.2	181.4	177.2	280.7
Lewis Research Center..................	111.6	132.4	134.6	---	---	---	73.9	77.1	77.9	185.5	209.5	212.5
Space Nuclear Systems Office...........	33.6	35.3	13.3	---	---	---	2.3	2.5	2.6	35.9	37.8	15.9
NASA Headquarters:	(153.3)	(150.9)	(132.7)	(---)	(---)	(---)	(63.1)	(64.6)	(59.7)	(216.4)	(215.5)	(192.4)
Headquarters..........................	153.3	150.9	132.7	---	---	---	61.3	63.1	58.4	214.6	214.0	191.1
NASA Pasadena Office..................	---	---	---	---	---	---	1.8	1.5	1.3	1.8	1.5	1.3
Various Locations......................	---	---	---	26.4	16.0	31.1	---	---	---	26.4	16.0	31.1
Facility Planning and Design...........	---	---	---	3.5	4.5	3.5	---	---	---	3.5	4.5	3.5
Total Budget Plan......................	3,110.4	2,555.0	2,517.7	50.1	25.0	56.3	702.2	718.4	697.4	3,862.7	3,298.4	3,271.4

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1972 ESTIMATES

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

(Thousands of dollars)

PROGRAM OFFICE	Total	Kennedy Space Center	Manned Spacecraft Center	Marshall Space Flight Center	Goddard Space Flight Center	Jet Propulsion Laboratory	Wallops Station	Ames Research Center	Electronics Research Center	Flight Research Center	Langley Research Center	Lewis Research Center	Space Nuclear Systems Office	NASA Headquarters
Office of Manned Space Flight														
1970......................	2,029,967	267,040	996,790	714,441	200	869	30	457	7	---	1,762	800	---	47,571
1971......................	1,431,100	179,585	592,275	599,875	200	470	---	6,525	---	---	650	25	---	51,495
1972......................	1,286,475	193,400	445,890	595,405	---	175	175	8,380	---	300	5,970	---	---	36,780
Office of Space Science and Applications														
1970......................	519,529	---	14,166	2,663	217,916	87,328	1,682	32,566	596	---	49,477	48,773	---	64,362
1971......................	565,700	2,995	13,812	4,655	251,731	68,382	2,894	40,485	---	---	43,400	67,664	---	69,682
1972......................	750,400	3,075	12,000	15,740	251,506	133,779	3,300	24,410	---	---	154,445	78,587	---	73,558
Office of University Affairs														
1970......................	7,000	---	---	---	---	---	---	---	---	---	---	---	---	7,000
1971......................	---	---	---	---	---	---	---	---	---	---	---	---	---	---
1972......................	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Office of Advanced Research and Technology														
1970......................	270,931	---	8,705	13,683	9,540	20,938	1,734	31,644	6,651	8,980	54,632	62,075	33,568	18,781
1971......................	264,200	---	6,282	13,644	6,753	18,854	100	34,288	---	10,720	58,553	64,758	35,300	14,948
1972......................	212,825	---	1,300	13,095	4,535	18,890	---	34,265	---	18,750	45,105	56,005	13,325	7,555
Office of Tracking and Data Acquisition														
1970......................	278,000	---	---	1,560	204,367	52,258	6,456	---	---	1,875	880	---	---	10,604
1971......................	290,000	---	---	400	205,200	64,300	6,250	---	---	1,850	1,250	---	---	10,750
1972......................	264,000	---	---	300	189,200	55,000	6,250	---	---	1,500	950	---	---	10,800
Office of Technology Utilization														
1970......................	5,000	---	---	---	---	---	---	---	---	---	---	---	---	5,000
1971......................	4,000	---	---	---	---	---	---	---	---	---	---	---	---	4,000
1972......................	4,000	---	---	---	---	---	---	---	---	---	---	---	---	4,000
Total Budget Plan														
1970......................	3,110,427	267,040	1,019,661	732,347	432,023	161,393	9,902	64,667	7,254	10,855	106,751	111,648	33,568	153,318
1971......................	2,555,000	182,580	612,369	618,574	463,884	152,006	9,244	81,298	---	12,570	103,853	132,447	35,300	150,875
1972......................	2,517,700	196,475	459,190	624,540	445,241	207,844	9,725	67,055	---	20,550	206,470	134,592	13,325	132,693

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
RECORDED VALUE OF CAPITAL TYPE PROPERTY
(In-House and Contractor-Held)
As of June 30, 1970
(In Thousands of Dollars)

	Real Property							
Reporting Installation	Land	Buildings	Other Structures and Facilities	Leasehold Improvements	Total	Equipment 3/	Fixed Assets in Progress	Grand Total
OFFICE OF MANNED SPACE FLIGHT	112,012	731,073	750,593	---	1,593,678	1,191,479	24,429	2,809,586
Kennedy Space Center	72,173	285,847	415,583	---	773,603	222,097	9,448	1,005,148
KSC - Florida	72,173	285,847	415,583	---	773,603	74,515	9,448	857,566
Western Test Range Operations Division Lompoc, California	---	---	---	---	---	3,832	---	3,832
Various Locations 1/	---	---	---	---	---	143,750	---	143,750
Manned Spacecraft Center	9,029	172,787	53,158	---	234,974	500,607	12,998	748,579
MSC - Houston, Texas	5,459	138,756	29,749	---	173,964	207,624	12,998	394,586
White Sands Test Facility WSTF - Las Cruces, New Mexico	---	8,712	17,797	---	26,509	28,346	---	54,855
Various Locations 1/	3,570	25,319	5,612	---	34,501	264,637	---	299,138
Marshall Space Flight Center	30,810	272,439	281,852	---	585,101	468,775	1,983	1,055,859
MSFC - Huntsville, Alabama	95	111,324	48,501	---	159,920	221,967	1,832	383,719
Michoud Assembly Facility MAF - New Orleans, Louisiana	7,504	63,908	25,361	---	96,773	40,694	151	137,618
Mississippi Test Facility MTF - Bay St. Louis, Mississippi	19,648	65,673	168,249	---	253,570	23,201	---	276,771
Slidell Computer Facility SCF - Slidell, Louisiana	63	4,450	823	---	5,336	16,920	---	22,256
Various Locations 1/	3,500	27,084	38,918	---	69,502	165,993	---	235,495
OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY	7,454	529,965	219,616	140	757,175	426,706	40,334	1,224,215
Ames Research Center	2,374	170,901	3,302	1	176,578	73,617	6,022	256,217
ARC - Moffett Field, California	2,374	170,763	3,288	-	176,425	69,526	6,022	251,973
Various Locations 1/	---	138	14	1	153	4,091	---	4,244
Electronics Research Center 2/	1,573	18,468	1,716	---	21,757	28,255	567	50,579
ERC - Cambridge, Massachusetts	1,573	18,468	1,716	---	21,757	28,255	567	50,579
Various Locations 1/	---	---	---	---	---	---	---	---
Flight Research Center	---	7,726	2,222	---	9,948	52,914	366	63,228
FRC - Edwards, California	---	7,726	2,222	---	9,948	50,347	---	60,661
Various Locations 1/	---	---	---	---	---	2,567	---	2,567
Langley Research Center	116	121,891	143,955	---	265,962	122,671	14,335	402,968
LaRC - Hampton, Virginia	110	106,521	143,930	---	250,561	112,909	14,335	377,805
Various Locations 1/	6	15,370	25	---	15,401	9,762	---	25,163
Lewis Research Center	3,391	191,979	61,493	139	257,002	122,032	19,017	398,051
LeRC - Cleveland, Ohio	322	112,400	39,947	139	152,808	56,993	11,399	221,200
Plum Brook Station PBS - Sandusky, Ohio	2,970	75,415	17,895	---	96,280	11,417	7,618	115,315
Various Locations 1/	99	4,164	3,651	---	7,914	53,622	---	61,536
Space Nuclear Propulsion Office	---	19,000	6,928	---	25,928	27,217	27	53,172
NRDS - Jackass Flats, Nevada	---	19,000	6,928	---	25,928	4,351	23	30,302
Various Locations 1/	---	---	---	---	---	22,866	4	22,870
OFFICE OF SPACE SCIENCE AND APPLICATIONS	3,779	163,372	134,407	723	302,281	648,250	20,095	970,626
Goddard Space Flight Center	1,640	87,283	62,798	303	152,024	474,147	2,623	628,794
GSFC - Greenbelt, Maryland	1,301	69,704	13,080	299	84,384	158,623	2,623	245,630
Tracking Stations (Excl DSNS) 4/	339	17,491	49,673	---	67,503	270,966	---	338,469
Various Locations 1/	---	88	45	4	137	44,558	---	44,695
Jet Propulsion Laboratory	1,067	53,864	28,401	420	83,752	131,587	16,129	231,468
JPL - Pasadena, California	1,067	44,667	6,813	420	52,967	99,460	16,129	168,556
Tracking Stations (DSNS) 4/	---	9,197	21,588	---	30,785	32,127	---	62,912
Wallops Station	1,072	22,225	43,208	---	66,505	42,516	1,343	110,364
WS - Wallops Island, Virginia	1,072	22,225	43,208	---	66,505	42,073	1,343	109,921
Various Locations 1/	---	---	---	---	---	443	---	443
NASA Pasadena Office	---	---	---	---	---	---	---	---
NPO - Pasadena, California	---	---	---	---	---	---	---	---
OTHER								
NASA Headquarters	---	---	---	---	---	32,077	---	32,077
Washington, D.C.	---	---	---	---	---	5,561	---	5,561
Various Locations 1/	---	---	---	---	---	26,516	---	26,516
GRAND TOTAL	123,245	1,424,410	1,104,616	863	2,653,134	2,298,512	84,858	5,036,504

1/ Includes Capital Type Property in Possession of Contractors at Various Locations.
2/ Disestablished June 30, 1970.
3/ Includes Contractor-Held Special Test Equipment.
4/ DSNS - Deep Space Network Stations.

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1972 ESTIMATES

JET PROPULSION LABORATORY

The Jet Propulsion Laboratory (JPL) is a Government-owned facility managed and operated by the California Institute of Technology under a contract with NASA. The cost of operating the Laboratory is funded from the Research and Development appropriation, except for the lease or purchase of administrative aircraft and the purchase of passenger motor vehicles which are funded from the Research and Program Management appropriation and are included in the NASA Headquarters budget presentation. The Research and Program Management type costs are presented for purpose of comparison only and are not a part of the NASA Research and Program Management budget.

MISSION:

The Jet Propulsion Laboratory performs a variety of engineering, scientific, and management missions including:

1. Project management of complete automated spacecraft systems for planetary exploration.

2. Operation of the Deep Space Network including tracking and data acquisition activities required by planetary flights, as well as backup to the Manned Space Flight Network.

3. A continuing program of supporting research and technology.

Specific examples of the Jet Propulsion Laboratory's activity in these areas are:

Planetary Exploration - The Mariner series of automated spacecraft was designed at the Jet Propulsion Laboratory. The Laboratory has been responsible for the project management of all Mariner missions including the integration, assembly, and testing of the spacecraft. Five of these spacecraft have been successfully launched since 1962--two to Venus and three to Mars--providing a wealth of scientific information on these planets. The program revealed the unsuspected existence of craters on Mars (Mariner IV). Two more missions to the planets are planned for 1971 (Mars) and 1973 (Venus and Mercury).

In 1975, the Viking mission consisting of two launches to Mars is planned. Each spacecraft will consist of an orbiter and a lander. The

Langley Research Center has responsibility for the over-all Viking project management and development of the lander, while JPL has responsibility for development of the orbiter, spacecraft navigation, and tracking and data acquisition. The spacecraft will orbit Mars, separate a lander capsule which will enter the Martian atmosphere and soft land on the surface of the planet. Orbital, entry, and landed science data will be collected and transmitted to earth. The primary functions of the orbiter is to provide site surveillance data for use in selecting the exact landing site for the lander capsule, and to serve as a relay station to record and transmit to earth data received from the lander. At other times, the orbiter will conduct its own science experiments, including the transmission of pictures of the Martian surface back to earth, infrared radiometry to determine surface temperatures, infrared spectrometry to detect water vapor, and radio experiments to obtain data to improve planetary navigation capabilities and provide measurements of radio propagation properties and Mars atmospheric data.

The Jet Propulsion Laboratory will have management responsibility for the Outer Planets Missions, a proposed new start in the FY 1972 Research and Development budget--which will send automated spacecraft to the farthest boundary of our solar system to gather scientific data on Jupiter, Saturn, Uranus, Neptune and Pluto. The 1970's presents rare opportunities for the exploration of these planets by the gravity assist swing-by method. This method exploits the unusual alignment of these planets during this period--an alignment that will not be repeated for 179 years--by capitalizing on the gravitational pull of each planet to propel the spacecraft toward succeeding planets, thereby permitting the exploration of several of these planets by each spacecraft. The economic advantages of this method are readily apparent.

The development of the Outer Planets spacecraft requires stretching the state of the art in several areas of technology, including radioisotope thermoelectric power; built-in self testing, repair and adaptive capability which will assure reliable performance of the spacecraft for ten years; higher navigational accuracy, and greater platform stability. Development of the technology necessary for the success of these missions commenced in 1969 and has progressed to the point where the feasibility of the spacecraft design concept is proven. Launches are planned during both the 1976-1977 and 1979 opportunities.

Supporting Research and Technology - The Jet Propulsion Laboratory maintains a strong program of supporting research and technology, and advanced development. Much of the knowledge gained from active research in such areas as fluid physics, electrophysics, materials, applied mathematics, and guidance and control will continue to be applied to problems in space exploration.

Another activity of considerable importance is the development and fabrication of scientific experiments to be flown on vehicles other than Jet Propulsion Laboratory spacecraft. These include high-altitude balloons, Aerobee rockets, NASA aircraft, and earth orbiters. The scientific teams involved in these experiments frequently include faculty members of various universities and staff members from NASA field installations.

Tracking and Data Acquisition - The Jet Propulsion Laboratory is responsible for the design and operation of NASA's worldwide Deep Space Network. The Deep Space Network is comprised of the Space Flight Operations Facility in Pasadena--the nerve center of the network--and tracking and data acquisition stations located in California, Spain, South Africa and Australia. The Deep Space Network provides support to Jet Propulsion Laboratory managed flight missions, to all manned Lunar Missions, and to projects such as Pioneer and Helios which are managed by other NASA installations.

DESCRIPTION:

The Jet Propulsion Laboratory is located in Pasadena, California, approximately 20 miles north of downtown Los Angeles. Subsidiary facilities are located at Goldstone, California (tracking and data acquisition), Edwards Air Force Base, Muroc, California (solid propellant formulation and testing), and Table Mountain, California (open air testing and astronomy).

At Pasadena, the Laboratory occupies 175.5 acres of land of which 145.9 acres are owned by NASA and 29.6 acres are leased. At Goldstone, facilities are located on land occupied under permit from the Army. At Edwards Air Force Base, facilities are located on land occupied under permit from the Air Force. Facilities at Table Mountain are located on land occupied under permit from the Forest Service of the Department of Agriculture. The capital investment of the Jet Propulsion Laboratory, including the Deep Space Network, fixed assets in progress and contractor-held facilities, as of June 30, 1970, was $231,468,000.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Dollars in Thousands) 1970	1971	1972
Authorized permanent positions, end of year	4,200	4,200	3,990
Research and Program Management type costs	$87,600	$94,820	$91,057

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1972 ESTIMATES

SUMMARY OF AERONAUTICAL RESEARCH AND TECHNOLOGY
OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY

	(Millions of dollars) 1970	1971	1972
Appropriation			
Research and Development................	95.7	102.0	110.0
Construction of Facilities..............	4.8	----	6.5
Research and Program Management.........	98.4	93.6	98.2
Total................................	198.9	195.6	214.7
Number of direct positions (end year) associated with Aeronautical Research and Technology.......................	3,927	3,894	3,901

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Automatic Data Processing Equipment

General Statement

The uses of computers by NASA are divided into two categories: Category A, general purpose use, and Category B, special purpose use. Category A uses include all equipments that can service multiple users. Within this category continuous improvements in management and programming techniques, coupled with the experience gained on third generation computers, have resulted in past reductions of the number of computers in this category. These reductions were accomplished while still taking care of the increasing requirements for data processing services. Numbers of Category A computers for FY 1971 reflect a slight increase due to the addition and use of remote processing devices to the basic systems. The areas of use for our Category A computers are:

(a) The science and engineering area, which includes all the research calculations, engineering computations, and detailed analysis of scientific data.

(b) The data reduction area, which includes the processing necessary to get experimental and operations data into a useable form for the experimenter.

(c) Mission control, which includes not only the active mission control computations but also those mission support activities necessary for effective control.

(d) The simulation area, which covers that part of digital data processing that actually replaces analog simulation functions.

(e) The business and administration area, which covers both business data processing and engineering support data processing such as master configuration lists for our large systems.

The Category B uses, or special purpose applications of computers, are primarily small computers integrated into overall operational systems in such a way as to make it impracticable to use them for other functions. Most of our instrumentation facilities, including wind tunnels, utilize small computers within the total system as control or data acquisition devices, but these represent only a minor part of the instrumentation facilities supported.

The use of small separate computers ("mini" computers) to perform many special tasks in complex physical systems is accelerating rapidly due to the cost per computational capacity of these devices which has been declining dramatically in the past several years. Not only does the use of these small computers result in lower overall system costs but the versatility and range of the overall system has been enhanced. As a result, NASA is experiencing a rapid growth in numbers of installed computers but at a modest increase in cost. To illustrate this phenomena, Figure 1 is shown. In our present inventory, one percent of our installed costs of computers represent 15% of the number of computers as compared with 11% as of last year. This trend will become even more evident in later years and has implications on management philosophies for ADP in general.

Figure 2 reflects the capital value of the ADP equipment which was installed as of June 30, 1970. The figures show the capital value of both NASA-owned and leased equipment. Figure 3 reflects the average employment of ADP personnel, both Civil Service and contractor, at each installation. The inventory of our Category A, general purpose, computers by installation is shown in Figure 4. The table at the bottom of Figure 4 reflects the total inventory of computers with a breakdown between general purpose and special purpose.

Lease, maintenance, and purchase costs of ADP equipment by installation are shown in Figure 5. A narrative explanation of funding highlights follow.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PERCENTAGE DISTRIBUTION OF COMPUTERS AND CAPITAL VALUES BY SIZE

AS OF JUNE 30, 1970

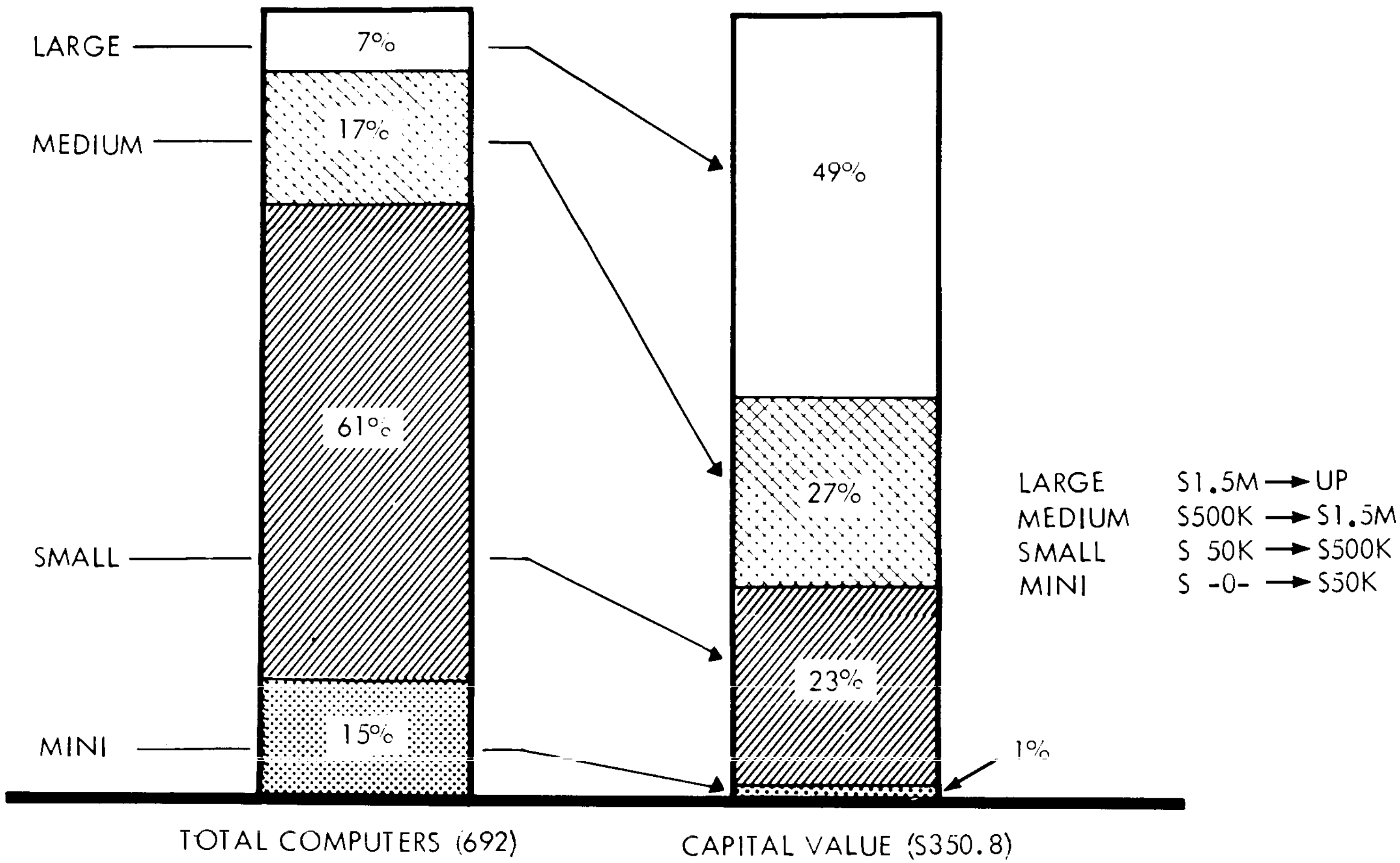

Figure 1

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Capital Value of Owned and Leased ADP Equipment
on Hand June 30, 1970

(In thousands of dollars)

	NASA-Owned Equipment	Leased Equipment	Total Capital Value
Office of Manned Space Flight....	$120,894	$14,594	$135,488
Kennedy Space Center...........	15,720	2,321	18,041
Manned Spacecraft Center.......	72,432	11,891	84,323
Marshall Space Flight Center...	32,742	382	33,124
Office of Space Science and Applications....................	$134,672	$28,326	$162,998
Goddard Space Flight Center....	102,010	14,213	116,223
Jet Propulsion Laboratory......	29,913	14,113	44,026
Wallops Station................	2,749	---	2,749
Office of Advanced Research and Technology..................	$44,520	$3,853	$48,373
Ames Research Center...........	11,958	1,455	13,413
Flight Research Center.........	1,947	1,324	3,271
Langley Research Center........	17,063	1,058	18,121
Lewis Research Center..........	13,552	16	13,568
Headquarters.....................	$2,407	$1,496	$3,903
TOTAL........................	$302,493	$48,269	$350,762

Figure 2

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Automatic Data Processing Personnel
(Average Employment for the Fiscal Year)

	FY 1970		FY 1971		FY 1972	
	Civil Service	Contractor	Civil Service	Contractor	Civil Service	Contractor
Office of Manned Space Flight..	400	2,386	397	2,069	398	1,917
Kennedy Space Center.........	68	396	66	318	66	311
Manned Spacecraft Center.....	177	1,354	180	1,105	181	986
Marshall Space Flight Center.	155	636	151	646	151	620
Office of Space Science and Applications.................	798	1,254	837	1,389	844	1,403
Goddard Space Flight Center..	523	939	523	1,060	523	1,065
Jet Propulsion Laboratory....	249a/	278	288a/	280	295a/	284
Wallops Station..............	26	37	26	49	26	54
Office of Advanced Research and Technology...............	339	263	343	395	346	403
Ames Research Center.........	59	103	61	150	61	150
Flight Research Center.......	18	18	19	18	18	18
Langley Research Center......	130	136	131	207	135	217
Lewis Research Center........	132	6	132	20	132	18
Headquarters..................	22	70	19	80	19	76
Total......................	1,559	3,973	1,596	3,933	1,607	3,799

a/ Employees of JPL.

Figure 3

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

End of Fiscal Year Inventory of Computers

(General Purpose - Category A - Computers by Installation)

	FY 1970	FY 1971	FY 1972
Office of Manned Space Flight	67	73	73
Kennedy Space Center	7	7	7
Manned Spacecraft Center	24	24	24
Marshall Space Flight Center	36	42	42
Office of Space Science and Applications	48	50	48
Goddard Space Flight Center	24	25	23
Jet Propulsion Laboratory	23	24	24
Wallops Station	1	1	1
Office of Advanced Research and Technology	30	36	39
Ames Research Center	13	16	17
Flight Research Center	1	1	1
Langley Research Center	7	8	10
Lewis Research Center	9	11	11
Headquarters	4	4	3
Total General Purpose (Category A)	149	163	163
Breakdown by Category of Equipment:			
Category A (General Purpose)	149	163	163
Category B (Special Purpose)	543	620	669
TOTAL	692	783	832

Figure 4

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Summary of Automatic Data Processing Equipment Funding
(In thousands of dollars)

	FY 1970				FY 1971				FY 1972			
	Lease	Maint.	Purch.	Total	Lease	Maint.	Purch.	Total	Lease	Maint.	Purch.	Total
Office of Manned Space Flight......	$12,070	$3,539	$24,772	$40,381	$7,268	$4,047	$951	$12,266	$7,362	$4,105	$385	$11,352
Kennedy Space Center.............	860	542	144	1,546	1,048	585	300	1,933	1,048	585	---	1,633
Manned Spacecraft Center.........	5,698	2,997	14,927	23,622	5,948	3,057	620	9,625	6,042	3,099	385	9,526
Marshall Space Flight Center.....	5,512	---	9,701	15,213	272	405	31	708	272	421	---	693
Office of Space Science and Applications.....................	8,884	4,674	15,110	28,668	8,429	5,163	21,973	35,565	6,999	5,795	11,668	24,462
Goddard Space Flight Center......	4,895	3,796	9,965	18,656	5,027	4,018	11,892	20,937	5,359	4,403	7,881	17,643
Jet Propulsion Laboratory........	3,953	823	4,505	9,281	3,390	1,012	9,876	14,278	1,628	1,233	3,522	6,383
Wallops Station..................	36	55	640	731	12	133	205	350	12	159	265	436
Office of Advanced Research and Technology...................	2,531	1,642	11,603	15,776	1,996	2,077	9,553	13,626	3,119	2,442	17,042	22,603
Ames Research Center.............	1,218	481	6,199	7,898	760	623	1,535	2,918	1,507	692	2,951	5,150
Electronics Research Center......	492	121	259	872	---	---	---	---	---	---	---	---
Flight Research Center...........	266	63	191	520	410	63	295	768	610	63	---	673
Langley Research Center..........	411	796	4,173	5,380	688	1,145	2,634	4,467	777	1,391	6,711	8,879
Lewis Research Center............	67	181	781	1,029	138	246	5,089	5,473	225	296	7,380	7,901
Space Nuclear Systems Office.....	77	---	---	77	---	---	---	---	---	---	---	---
Headquarters......................	410	74	76	560	590	68	64	722	593	68	---	661
Total........................	$23,895	$9,929	$51,561	$85,385	$18,283	$11,355	$32,541	$62,179	$18,073	$12,410	$29,095	$59,578
Breakdown by Appropriation:												
Research and Development.........	13,091	9,264	51,020	73,375	8,834	10,426	32,473	51,733	9,858	11,504	29,095	50,457
Research and Program Management..	10,804	665	541	12,010	9,449	929	68	10,446	8,215	906	---	9,121
Breakdown by Category of Equipment:												
Category A.......................	21,627	4,956	41,617	68,200	15,880	6,113	17,944	39,937	15,396	6,694	16,063	38,153
Category B.......................	2,268	4,973	9,944	17,185	2,403	5,242	14,597	22,242	2,677	5,716	13,032	21,425

Figure 5

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Automatic Data Processing Equipment Funding Highlights

Manned Spacecraft Center

The primary UNIVAC 1108 computer systems within the Computation and Analysis Division have been reconfigured to improve efficiency and increased input/output flexibility without an increase in costs.

Marshall Space Flight Center

An augmentation of realtime data reduction capability is being planned during FY 1972 to support Skylab telemetry processing.

Goddard Space Flight Center

The implementation of the Earth Resources Technology Satellite (ERTS) data management system was begun in FY 1971. Funds will also be applied in FY 1972 to acquire additional computers for upgrading all stations of the Satellite Tracking Network (STADAN) for support of the new, more sophisticated unmanned spacecraft, especially the ERTS.

Jet Propulsion Laboratory

Funds have been used in FY 1971 to purchase the existing leased UNIVAC 1108 computer and peripheral components, thereby reducing the lease costs in FY 1972. During both FY 1971 and 1972, funds will be used to purchase numerous "mini" and several small computers to be added to the Deep Space Network (DSN) in support of the advanced missions. These "mini" computers will enable the network to use the telemetry decoding and tracking techniques that are required for deep space missions to Jupiter.

Ames Research Center

Purchase funds will be used during FY 1971 for augmentation of the IBM 360/67 time-shared computer to provide for remote processors at the wind tunnels and the various research labs. Purchase funds in both fiscal years 1971 and 1972 will be utilized for implementation of aeronautics simulation computer equipment.

Flight Research Center

A large scale leased computer system to replace the existing general purpose system is planned for installation during the latter part of 1972.

Langley Research Center

Purchase funds for the phased expansion of the CDC 6000 central computer complex will be used during fiscal years 1971 and 1972 with completion of this expansion anticipated by the end of FY 1972. Several "mini" and small computers will be acquired for dedicated wind tunnel computations and research support applications. Several computers for the equipment test and checkout system for the Viking project are planned for purchase in FY 1972.

Lewis Research Center

Purchase funds in FY 1971 have been utilized for the duplex of the IBM 360/67 time-shared system. Purchase of a large scale general purpose computer to replace existing second generation computers, is planned for FY 1972 with installation in the succeeding year.

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