National Aeronautics and Space Administration

BUDGET ESTIMATES

FISCAL YEAR 1970

Volume I

SUMMARY DATA

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1970 ESTIMATES

SUMMARY DATA

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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GENERAL STATEMENT

The National Aeronautics and Space Administration was established on October 1, 1958, pursuant to the National Aeronautics and Space Act of 1958, approved on July 29, 1958. The Act states that the policy and purpose of the United States activities in space will be: to conduct space and aeronautical activities for peaceful purposes for the benefit of all mankind. These activities should contribute materially to: the expansion of human knowledge in the atmosphere and space; the improvement and usefulness of aeronautical and space vehicles; the development and operation of space vehicles; the establishment of long-range studies, 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.

A total program of $3,878,000,000 is requested to support current and proposed programs. However, the amount of appropriations requested is $3,760,527,000, reflecting application of $117,473,000 of the 1969 appropriation reserved from apportionment pursuant to the Revenue and Expenditure Control Act of 1968 (Pub.L. 90-364, 82 Stat. 251).

The industrial community, under contracts with the NASA, will continue to carry forward the prime design, development, and fabrication effort of the NASA program. Specific elements of the activity will continue to be pursued within NASA installations, other government agencies, universities, and research contractors which have the necessary level of expertise in special areas of engineering and science. The major elements of the program fall within 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; 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 system, stars and space environment; compiling new knowledge in astronomy; planetary and interplanetary studies and experiments on the effects of space environment on living organisms; and (2) the adapting of space technology so acquired for the direct benefit of mankind in areas such as weather, communications, navigation, traffic control, geodesy, meteorology, and earth resources.

ADVANCED RESEARCH AND TECHNOLOGY: A continuing program to provide the technological base for significant future aerospace missions.

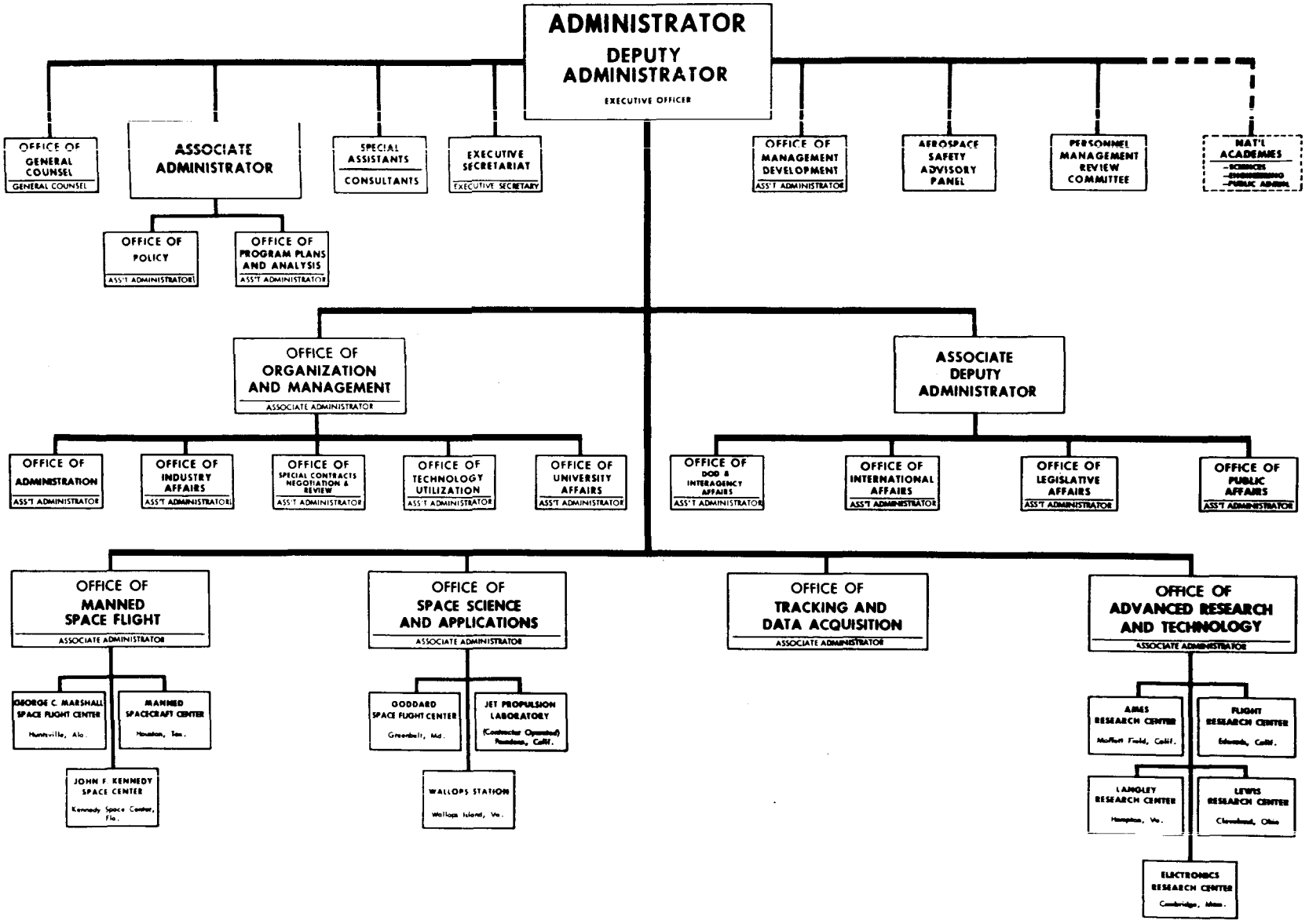
TRACKING AND DATA ACQUISITION: A program for providing the support required by the worldwide NASA manned and unmanned space flight programs.

Detailed justification of the FY 1970 budget estimate for the total program of $3,878,000,000 is provided in the following three volumes:

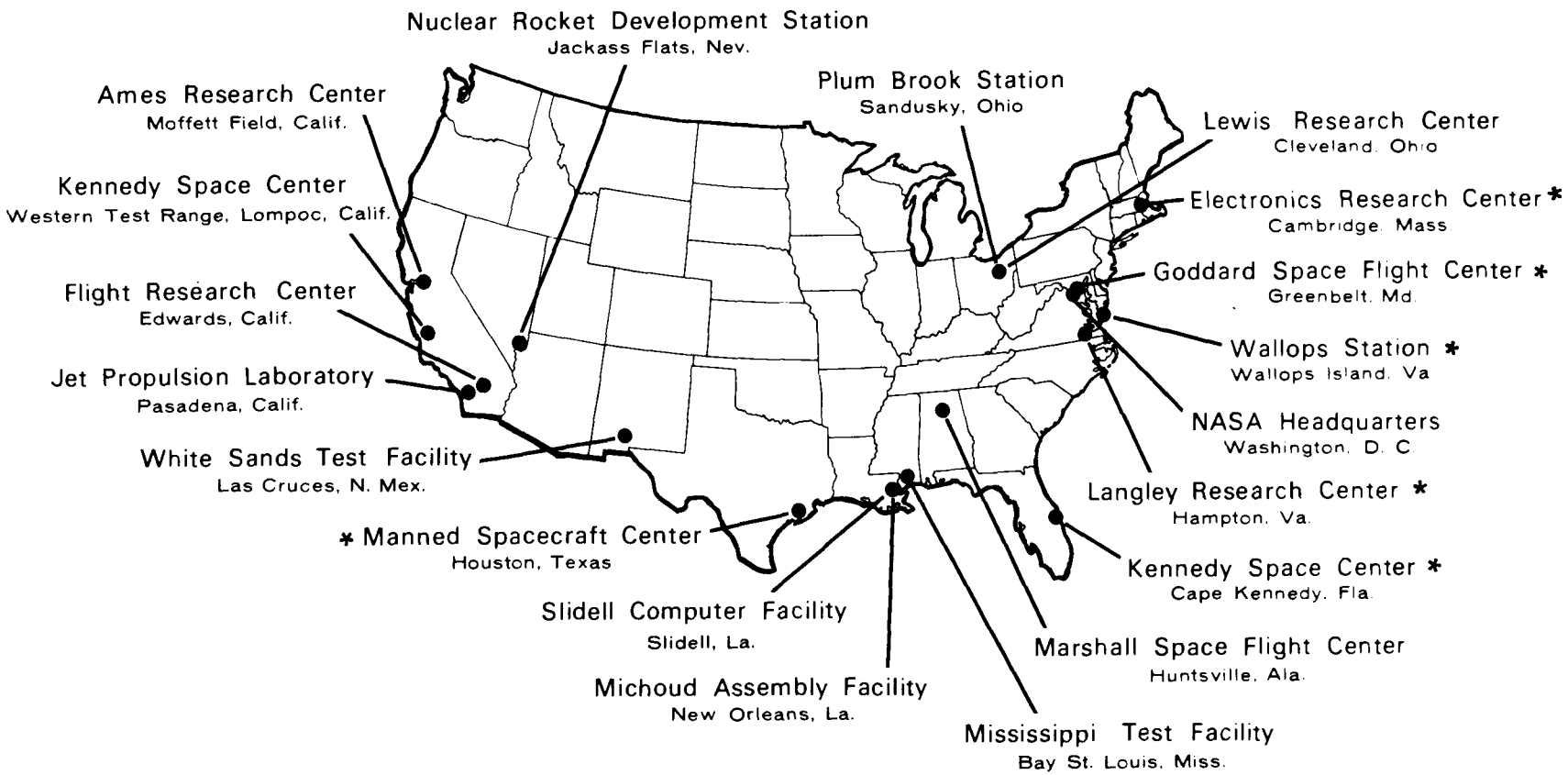
Volume	Amount
II Research and Development	$3,168,900,000*
III Construction of Facilities	58,200,000
IV Research and Program Management	650,900,000
TOTAL	$3,878,000,000*

* Includes application of $117,473,000 of FY 1969 appropriation noted on the previous page.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION



NASA INSTALLATIONS



* Indicates Installations for which construction projects are requested in the Fiscal Year 1970 budget estimates

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1970 ESTIMATES

SUMMARY OF APPROPRIATIONS

(In thousands of dollars)

Appropriation	P.L. 90-131 Fiscal Year 1968	P.L. 90-550 Fiscal Year 1969	Fiscal Year 1970
Research and Development.....	$3,925,000	$3,370,300	$3,051,427
Construction of Facilities.....	35,900	21,800	58,200
Research and Program Management..	628,000	603,173	650,900
TOTAL.....	$4,588,900	$3,995,273	$3,760,527

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1970 ESTIMATES

SUMMARY OF APPROPRIATIONS (ADJUSTED)

(In thousands of dollars)

	Total	Research and Development	Construction of Facilities	Research and Program Management
FISCAL YEAR 1968				
National Aeronautics and Space Administration Appropriation Act, 1968 (81 Stat. 384).....	$4,588,900	$3,925,000	$35,900	$628,000
NASA Appropriation Transfers (81 Stat. 385)....	---	-13,450	+1,900	+11,550
Transfer to "Operating Expenses, Public Buildings Service," General Services Administration (81 Stat. 349).....	-127	---	---	-127
Appropriation (adjusted).....	$4,588,773	$3,911,550	$37,800	$639,423
FISCAL YEAR 1969				
Independent Offices and Department of Housing and Urban Development Act, 1969 (82 Stat. 945).....	$3,995,273	$3,370,300	$21,800	$603,173
NASA Appropriation Transfers (82 Stat. 945)....	---	-59,268	+13,900	+45,368
Transfer to "Operating Expenses, Public Buildings Service," General Services Administration (82 Stat. 943).....	-280	---	---	-280
Appropriation (adjusted).....	$3,994,993	$3,311,032	$35,700	$648,261
FISCAL YEAR 1970				
Appropriation request.....	$3,760,527	$3,051,427	$58,200	$650,900

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1970 ESTIMATES

SUMMARY OF BUDGET PLAN BY APPROPRIATION BY BUDGET ACTIVITY

(In thousands of dollars)

APPROPRIATION TITLE	TOTAL	MANNED SPACE FLIGHT	SCIENTIFIC INVESTI-GATIONS IN SPACE	SPACE APPLI-CATIONS	SPACE TECHNOLOGY	AIRCRAFT TECHNOLOGY	SUPPORTING ACTIVITIES
Fiscal Year 1968.....	$4,639,750	$3,154,922	$510,902	$130,535	$379,801	$136,284	$327,306
Research and development..	3,966,952	2,809,230	438,452	110,332	237,688	81,400	289,850
Construction of facilities	33,505	21,340	3,595	---	2,115	3,170	3,285
Research and program management.....	639,293	324,352	68,855	20,203	139,998	51,714	34,171
Fiscal Year 1969.....	$3,877,520	$2,510,175	$406,208	$124,939	$336,551	$150,200	$349,447
Research and development..	3,193,559	2,177,500	329,983	105,039	193,665	94,900	292,472
Construction of facilities	35,700	10,414	1,925	---	386	---	22,975
Research and program management.....	648,261	322,261	74,300	19,900	142,500	55,300	34,000
Fiscal Year 1970.....	$3,878,000*	$2,339,250	$489,044	$169,601	$340,238	$161,467	$378,400
Research and development..	3,168,900*	2,007,700*	409,549	148,601	190,350	100,700	312,000
Construction of facilities	58,200	14,250	1,595	---	8,088	4,767	29,500
Research and program management.....	650,900	317,300	77,900	21,000	141,800	56,000	36,900

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

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1970 ESTIMATES

SUMMARY OF BUDGET PLAN

OFFICE OF MANNED SPACE FLIGHT PROGRAMS

	(Thousands of dollars)		
	1968	1969	1970
Research and Development	$2,809,230	$2,177,500	$2,007,700
Apollo.....	2,556,030	2,025,000	1,651,100
Space flight operations.....	253,200	150,000	354,100
Advanced missions.....	---	2,500	2,500
Construction of Facilities	21,340	10,414	14,250
Kennedy Space Center.....	19,342	7,364	12,500
Manned Spacecraft Center.....	750	1,333	1,750
Marshall Space Flight Center.	823	---	---
Michoud Assembly Facility....	425	400	---
Various locations.....	---	1,317	---
Research and Program Management	315,098	312,028	307,450
Kennedy Space Center.....	93,131	97,669	97,501
Manned Spacecraft Center.....	95,737	97,998	97,748
Marshall Space Flight Center.	126,230	116,361	112,201
TOTAL, MANNED SPACE FLIGHT.	$3,145,668	$2,499,942	$2,329,400

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1970 ESTIMATES

SUMMARY OF BUDGET PLAN

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

	(Thousands of dollars)		
	1968	1969	1970
SPACE SCIENCE AND APPLICATIONS PROGRAMS AND PROJECTS			
Research and Development	$552,850	$438,416	$558,800
Physics and astronomy.....	139,500	125,116	119,600
Lunar and planetary exploration.....	147,500	81,800	146,800
Bioscience.....	41,800	32,700	32,400
Space applications.....	99,500	98,600	135,800
Launch vehicle procurement...	124,550	100,200	124,200
Construction of Facilities	3,595	1,925	1,595
Goddard Space Flight Center..	565	---	670
John F. Kennedy Space Center, NASA.....	2,290	1,650	---
Wallops Station.....	740	275	500
Various locations.....	---	---	425
Research and Program Management	77,073	82,510	88,053
Goddard Space Flight Center..	68,305	73,490	79,024
Wallops Station.....	8,768	9,020	9,029
TOTAL, SPACE SCIENCE AND APPLICATIONS.....	$633,518	$522,851	$648,448
UNIVERSITY AFFAIRS PROGRAM			
Research and Development			
Sustaining university program	$ 10,000	$ 9,000	$ 9,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1970 ESTIMATES

SUMMARY OF BUDGET PLAN

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY PROGRAMS
OFFICE OF TRACKING AND DATA ACQUISITION PROGRAMS
OFFICE OF TECHNOLOGY UTILIZATION PROGRAM

	(Thousands of dollars)		
	1968	1969	1970
ADVANCED RESEARCH AND TECHNOLOGY PROGRAMS AND PROJECTS			
Research and Development	$315,022	$285,171	$290,400
Basic research.....	21,465	21,000	21,400
Space vehicle systems.....	34,100	31,700	30,000
Electronics systems.....	38,057	34,771	35,000
Human factor systems.....	19,828	19,700	23,600
Space power and electric propulsion systems.....	43,735	42,200	39,900
Nuclear rockets.....	54,000	32,000	36,500
Chemical propulsion.....	37,037	28,900	25,100
Aeronautical vehicles.....	66,800	74,900	78,900
Construction of Facilities	5,285	386	12,855
Ames Research Center.....	3,170	386	---
Electronics Research Center...	---	---	8,088
Langley Research Center.....	---	---	4,767
Lewis Research Center.....	2,115	---	---
Research and Program Management	189,059	193,924	195,600
Ames Research Center.....	33,781	34,036	34,050
Electronics Research Center...	15,352	17,237	18,566
Flight Research Center.....	9,469	9,680	9,615
Langley Research Center.....	62,213	62,947	63,308
Lewis Research Center.....	66,222	67,845	68,061
Space Nuclear Propulsion Office.....	2,022	2,179	2,000
TOTAL, ADVANCED RESEARCH AND TECHNOLOGY.....	$509,366	$479,481	$498,855

	(Thousands of dollars)		
	1968	1969	1970
TRACKING AND DATA ACQUISITION PROGRAMS AND PROJECTS			
Research and Development			
Tracking and data acquisition....	$275,850	$279,672	$298,000
Construction of Facilities	1,930	21,975	17,000
Jet Propulsion Laboratory.....	1,930	---	---
Various Locations.....	---	21,975	17,000
TOTAL, TRACKING AND DATA ACQUISITION.....	$277,780	$301,647	$315,000
TECHNOLOGY UTILIZATION - Research and Development	$ 4,000	$ 3,800	$ 5,000

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1970 ESTIMATES

NUMBER OF PERSONNEL POSITIONS

	Fiscal Year 1968	Fiscal Year 1969	Fiscal Year 1970
MANNED SPACE FLIGHT.....	13,961	13,285	13,035
John F. Kennedy Space Center, NASA.....	2,917	2,921	2,881
Manned Spacecraft Center.....	4,604	4,383	4,303
Marshall Space Flight Center....	6,440	5,981	5,851
SPACE SCIENCE AND APPLICATIONS....	4,316	4,731	4,900
Goddard Space Flight Center.....	3,822	4,243	4,412
Wallops Station.....	494	488	488
ADVANCED RESEARCH AND TECHNOLOGY..	12,040	11,577	11,533
Ames Research Center.....	2,083	1,974	1,956
Electronics Research Center.....	794	844	900
Flight Research Center.....	566	539	534
Langley Research Center.....	4,037	3,885	3,849
Lewis Research Center.....	4,452	4,235	4,195
Space Nuclear Propulsion Office.	108	100	99
SUPPORTING OPERATIONS			
NASA Headquarters.....	2,154	2,152	2,132
TOTAL PERMANENT POSITIONS.....	32,471	31,745	31,600
POSITIONS OTHER THAN PERMANENT.....	2,170	2,193	2,193
TOTAL POSITIONS.....	34,641	33,938	33,793

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, [supplies, materials, equipment;] 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, [$3,370,300,000] *$3,051,427,000,* 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, 1969; additional authorizing legislation to be proposed.*)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT

Program and Financing (in thousands of dollars)

Identification code 27-00-0108-0-1-251	Budget plan (amounts for research and development actions programed)			Costs and obligations		
	1968 actual	1969 estimate	1970 estimate	1968 actual	1969 estimate	1970 estimate
Program by activities:						
Direct program:						
1. Manned space flight:						
(a) Gemini	----------	----------	----------	4,808	----------	----------
(b) Apollo	2,556,030	2,025,000	1,651,100	2,489,182	2,310,000	1,675,000
(c) Apollo applications	253,200	150,000	345,100	127,551	216,000	369,000
(d) Advanced manned mission studies	----------	2,500	11,500	3,933	4,000	10,000
2. Scientific investigations in space:						
(a) Physics and astronomy	155,981	144,191	134,958	177,902	158,800	135,200
(b) Lunar and planetary exploration	156,874	97,770	166,151	169,177	113,000	152,500
(c) Bioscience	42,800	34,300	34,000	43,812	37,000	34,000
(d) Launch vehicle development and support	82,797	53,722	74,440	99,627	60,000	70,050
3. Space applications	110,332	105,039	148,601	107,628	107,000	141,800
4. Space technology	237,688	193,665	190,350	245,096	217,200	203,950
5. Aircraft technology	81,400	94,900	100,700	70,694	87,000	96,400
6. Supporting activities:						
(a) Tracking and data acquisition	275,850	279,672	298,000	285,002	295,000	321,700
(b) Sustaining university program	10,000	9,000	9,000	40,473	26,000	23,000
(c) Technology utilization	4,000	3,800	5,000	4,320	4,000	5,000
Total direct program costs, funded	3,966,952	3,193,559	3,168,900	3,869,205	3,635,000	3,237,600
Reimbursable program:						
1. Manned space flight:						
(a) Gemini	----------	----------	----------	1	84	----------
(b) Apollo	212	615	555	261	709	555
(c) Apollo applications	371	306	----------	12	665	----------
2. Scientific investigations in space:						
(a) Physics and astronomy	8,412	5,744	494	8,132	11,292	494
3. Space applications	21,215	32,656	34,601	35,386	65,257	34,601
4. Space technology	31,619	25,379	28,300	34,748	26,455	28,300
5. Aircraft technology	5,368	2,800	2,550	3,234	7,423	2,550
6. Supporting activities:						
(a) Tracking and data acquisition	598	500	500	243	678	500
(c) Technology utilization	----------	----------	----------	42	4	----------
Total reimbursable program costs	67,795	68,000	67,000	82,059	112,567	67,000
Total program costs, funded	4,034,747	3,261,559	3,235,900	3,951,264	3,747,567	3,304,600
Change in selected resources [1]	----------	----------	----------	−69,980	−174,860	−68,700
10 Total	4,034,747	3,261,559	3,235,900	3,881,284	3,572,707	3,235,900

RESEARCH AND DEVELOPMENT—Continued

Program and Financing (in thousands of dollars)—**Continued**

Identification code 27-00-0108-0-1-251	Budget plan (amounts for research and development actions programed)			Costs and obligations		
	1968 actual	1969 estimate	1970 estimate	1968 actual	1969 estimate	1970 estimate
Financing:						
Receipts and reimbursements from:						
11 Federal funds	−63,233	−56,000	−59,200	−63,233	−56,000	−59,200
14 Non-Federal sources [2]	−1,535	−12,000	−7,800	−1,535	−12,000	−7,800
Adjustment to prior year reimbursable orders	−3,027					
21 Unobligated balance available, start of year:						
For completion of prior year budget plans				−160,362	−311,148	
Available to finance new budget plans			−117,473	−56,352		−117,473
23 Unobligated balance transferred to other accounts				600		
Reprograming from prior year budget plans	−55,402					
24 Unobligated balance available, end of year:						
For completion of prior year budget plans				311,148		
Available to finance new budget plans		117,473			117,473	
Budget authority	**3,911,550**	**3,311,032**	**3,051,427**	**3,911,550**	**3,311,032**	**3,051,427**
Budget authority:						
40 Appropriation	3,925,000	3,370,300	3,051,427	3,925,000	3,370,300	3,051,427
41 Transferred to other accounts	−13,450	−59,268		−13,450	−59,268	
43 **Appropriation (adjusted)**	**3,911,550**	**3,311,032**	**3,051,427**	**3,911,550**	**3,311,032**	**3,051,427**
Relation of obligations to outlays:						
71 Obligations incurred, net				3,816,516	3,504,707	3,168,900
72 Obligated balance, start of year				1,573,457	1,443,923	1,428,630
74 Obligated balance, end of year				−1,443,923	−1,428,630	−1,362,530
90 Outlays				3,946,050	3,520,000	3,235,000

Note.—Reconciliation of budget plan to obligations:	*1968 actual*	*1969 estimate*	*1970 estimate*
Total budget plan	4,034,747	3,261,559	3,235,900
Deduct portion of budget plan to be obligated in subsequent years	258,989		
Add obligations of prior year budget plans	105,526	311,148	
Total obligations	3,881,284	3,572,707	3,235,900

[1] Selected resources as of June 30 are as follows:	*1967*	*1968 adjustments*	*1968*	*1969*	*1970*
Stores	39,097	−5,735	35,357	35,357	35,357
Unpaid undelivered orders	1,043,395		969,409	794,549	725,849
Advances	10,112		12,123	12,123	12,123
Total selected resources	1,092,604	−5,735	1,016,889	842,029	773,329

[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 1970 ESTIMATES

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

BUDGET ACTIVITY	OFFICE/PROGRAM	Fiscal Year 1968	Fiscal Year 1969	Fiscal Year 1970
	MANNED SPACE FLIGHT.....	$2,809,230	$2,177,500	$2,007,700
1b	Apollo.....	2,556,030	2,025,000	1,651,100
1c&d	Space flight operations.....	253,200	150,000	354,100**
1d	Advanced missions.....	---	2,500	2,500
	SPACE SCIENCE AND APPLICATIONS.....	552,850	438,416	558,800
2a	Physics and astronomy.....	139,500	125,116	119,600
2b	Lunar and planetary exploration.....	147,500	81,800	146,800
2c	Bioscience.....	41,800	32,700	32,400
3	Space applications.....	99,500	98,600	135,800
*	Launch vehicle procurement....	124,550	100,200	124,200
	UNIVERSITY AFFAIRS			
6b	Sustaining university program.	10,000	9,000	9,000
	ADVANCED RESEARCH AND TECHNOLOGY.....	315,022	285,171	290,400
4&5	Basic research.....	21,465	21,000	21,400
4	Space vehicle systems.....	34,100	31,700	30,000
4&5	Electronics systems.....	38,057	34,771	35,000
4&5	Human factor systems.....	19,828	19,700	23,600
4	Space power and electric propulsion systems.....	43,735	42,200	39,900
4	Nuclear rockets.....	54,000	32,000	36,500
4	Chemical propulsion.....	37,037	28,900	25,100
5	Aeronautical vehicles.....	66,800	74,900	78,900
6a	TRACKING AND DATA ACQUISITION...	275,850	279,672	298,000
6c	TECHNOLOGY UTILIZATION.....	4,000	3,800	5,000
	TOTAL BUDGET PLAN.....	$3,966,952	$3,193,559	$3,168,900**

*Funds for the procurement of launch vehicles are statistically distributed to unmanned flight programs (e.g., Physics and Astronomy, Space Vehicle Systems).
**Includes application of $117,473 which has been reserved from apportionment pursuant to the Revenue and Expenditure Control Act of 1968 (Pub. L. 90-364, 82 Stat. 251).

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1970 ESTIMATES

NEW RESEARCH AND DEVELOPMENT PROJECTS

The fiscal year 1970 budget estimates contain $56,200,000 for the following projects.

Lunar and Planetary Exploration Program

Mariner-Mercury 1973..... $3,000,000

The objectives of the Mariner-Mercury 1973 mission are to obtain scientific data on the planets Mercury and Venus from a Mariner spacecraft as it flies past each planet. By utilizing a gravitational swingby maneuver at Venus, the launch vehicle energy required to reach Mercury is reduced by a factor exceeding 3:1. More importantly, a launch in 1973 will permit the acquisition of data from two planets by the same spacecraft during the same flight. Relatively little is known of Mercury, the last terrestrial planet to be explored. Therefore, this mission will permit the first close-up measurements of the planet's surface characteristics and properties of its atmosphere. Although the experiments will emphasize Mercury, they will also be used to collect additional data on Venus such as the acquisition of television pictures which have not been attempted on previous Venus missions.

The Mariner spacecraft for the 1973 Venus/Mercury mission will be based upon the design of the Mariner-Mars 1969 spacecraft. The funds requested for FY 1970 will provide for system design and long lead time developments, especially the scientific instruments.

Planetary Explorers..... $8,000,000

The Planetary Explorer spacecraft is a small, relatively inexpensive, planetary orbiter which will serve to complement the larger and more complex Mariner spacecraft series in exploring Mars and Venus and their space environment efficiently and economically. Its magnetic cleanliness and 50 lb. payload capability makes it an ideal carrier for instruments to measure both planetary and interplanetary particle and field environments, as well as for planetary upper-atmosphere experiments. A block of 5 flights will provide for exploration and near-continuous orbital monitoring of the planets Venus and Mars, with single launches to Venus in 1972, 1973, and 1975, and to Mars in 1973 and 1975.

These missions will be matched to the requirements of specific experiments, and provide increased flexibility, faster response to new discoveries, and flight opportunities for additional qualified scientists to further enhance the scientific return of the planetary exploration program.

Funds requested for FY 1970 will be used for the detailed design of the spacecraft. A structural test model and thermal control model for the Venus 1972 version will also be built and tested during this time.

Space Applications Program

Synchronous Meteorological Satellite (SMS)..... $3,600,000

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 larger areas and in much less time than heretofore possible, and (4) provide capability for rapid dissemination of processed meteorological data to local meteorologists.

Feasibility and project definition studies were completed in FY 1968. FY 1970 funds are required to undertake the design and development of two SMS satellites, planned for launch in 1971 and 1972, capable of continuous weather observation, analysis of cloud motions through observations that will permit derivation of important wind fields, and for obtaining other significant meteorological data from synchronous altitude.

Earth Resources Technology Satellites (ERTS)...$14,100,000

The objectives of the Earth Resources Technology Satellites are to: (1) assess the practical value of remote sensing of earth resources from space; (2) compare the capabilities in earth resources data acquisition of a space system versus aircraft; (3) determine whether, and in what configuration, an operational space-assisted user-oriented earth resources survey system should be pursued; (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 operational system requirements and costs. It is planned to design, develop, launch and test spacecraft capable of conducting a variety of selected experiments in the earth resources disciplines. A definition and preliminary design study is being conducted in FY 1969. Starting in FY 1970, effort will be initiated on procurement of two spacecraft and associated sensors for launch in 1971 and 1972. These missions will result in a major advancement in our understanding of the overall subject of earth resources survey from space.

Nuclear Rockets Program

NERVA Development..... $27,500,000

The objective of this joint NASA-AEC project is to provide a rocket propulsion system for application to advanced orbital, lunar and planetary missions. System analysis, design, and development of this nuclear engine through pre-flight rating tests is planned. The engine will have a specific impulse of approximately 825 seconds, a thrust of approximately 75,000 pounds (1500 megawatts reactor power) and will include the capability for multiple cycles of operation, long duration operation, and high reliability. A nuclear stage using this type of engine would be capable of performing a wide variety of high energy and high payload space missions beyond the performance potential of chemical rockets.

Initiation of full-scale development, including final engine design, procurement, fabrication and testing of component development hardware; procurement of long lead items; and test stand modifications is planned for FY 1970. Pre-flight rating test completion is planned for mid-calendar year 1977.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1970 ESTIMATES

SUMMARY

OFFICE OF MANNED SPACE FLIGHT APOLLO PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

From its inception, the Apollo program has focused on developing and demonstrating a basic national capability to conduct manned space operations around the earth and moon, and on the moon. The development of the Apollo spacecraft, the Saturn launch vehicles and the associated operations base, with the construction of the ground facilities required to achieve this, has brought together the largest and most varied scientific and engineering team ever assembled for a peaceful program. This partnership of industry, universities, and government has advanced the Apollo program to the point where the national goal of manned lunar landing and return during 1969 is within reach. The accomplishment of this goal will be a decisive demonstration of the Nation's ability to conduct complex space operations, and will provide a sound foundation for a new and increasingly productive era in space flight. The flight hardware being produced, the specialized skills of the workforce, the nationwide complex of laboratory, manufacturing, test, and launch facilities, and the technology created in Apollo, establish a versatile and powerful national asset.

Saturn/Apollo flights began in October 1961 when a Saturn I demonstrated the propulsion concept of clustering large liquid fueled engines. Seven years later, in October 1968, after fifteen successful flights, the Apollo phase of the Saturn I/IB series of launches was concluded with the completion of the Apollo 7 mission. The Apollo 5 mission, using a Saturn IB, resulted in the initial flight test of the Lunar Module. This unmanned test, in January 1968, verified the ascent and descent stage propulsion systems, including restart and throttle operations, and qualified the Lunar Module for manned flight testing.

Apollo 7, the first manned Apollo mission, was launched from Cape Kennedy on October 11, 1968 and added a number of "firsts" to the history of manned space flight. It was the first American flight with a three-man crew in one spacecraft. It was the first manned mission where the spacecraft had its own propulsion system, a 20,500 pound thrust engine, for major maneuvers in earth orbit. It was the first manned demonstration of the spacecraft and ground support communications system required for deep space operations; the first test of the television equipment planned for a manned lunar mission; and the first use of an advanced on-board computer capable of controlling the spacecraft's attitude and velocity.

The first Apollo Saturn V, an unmanned development test flight designated Apollo 4, was launched on November 9, 1967. During this Apollo 4 mission,

the Saturn V vehicle launched an Apollo Command and Service Module into a high elliptical orbit to test the systems and to verify the heatshield's ability to withstand the intense heat of re-entry from lunar distances. The major test objectives were achieved, and the 6 million individual parts in the complex Saturn V performed reliably. The second unmanned flight test of the Saturn V occurred on April 4, 1968. During this Apollo 6 mission, the "POGO" phenomenon (longitudinal oscillations) developed, causing unacceptably high stresses in the space vehicle. Additionally, igniter fuel lines in the upper stages ruptured, resulting in a premature shutdown of two engines on the second stage, and the failure of the third stage engine to restart. Despite these difficulties, the Saturn V placed the Apollo spacecraft into orbit around the earth. The resolution of anomalies that occurred in Apollo 6 by a government and industry task team under the direction of the Marshall Space Flight Center is considered an outstanding technical achievement. The POGO and fuel line rupture problems were resolved through an extensive program of flight data analysis, mathematical modeling using computers, and ground testing, and the Saturn V launch vehicle was determined to be ready for manned flight.

In the history of man, the flight of Apollo 8 will be chronicled as the first time man ever escaped the bondage of his planet, flew to another celestial body and orbited around it, and safely returned to earth. On December 21, 1968, the first manned Saturn V launch vehicle sent the Apollo crew of Astronauts Borman, Lovell and Anders into a completely successful ten orbit mission around the moon. The lunar orbits at sixty nautical miles provided future Apollo crews with valuable information on lunar lighting, lunar features and landmarks, and confirmed man's ability to acquire reference points for guidance purposes. The mission tested the operation of the tracking and communication systems at lunar distances, and provided valuable data on perturbations in lunar orbit that are thought to be the consequence of concentrations of heavy metals beneath the lunar surface. The incorporation of these perturbations into the calculations for rendezvous and docking during later lunar missions will be of great assistance in assuring the success of these maneuvers. The flight was a demonstration of the capability of the spacecraft to function and support man in the hostile environment of space 233,000 miles from the earth; of the accuracy of the guidance and navigation systems; of its ability to maneuver and change course; and of the heatshield's and spacecraft's structures capacity to withstand the forces and heat at the high speed of earth re-entry from lunar distances.

On Apollo 9, the fourth Saturn V will launch an Apollo Command and Service Module and Lunar Module into orbit around the earth to perform the rendezvous and docking maneuvers that will be required for a landing mission. For the first time, the Command and Service Module will dock with the Lunar Module, and two of the three Apollo crew members will transfer to the Lunar Module. The reliability and performance of this module will be evaluated during these manned simulations of lunar operations. The following mission, Apollo 10, is planned as the last major step before a manned lunar landing may be attempted. This mission will be an operational checkout of the complete Apollo spacecraft in orbit around the moon, including rendezvous and docking.

The success of these two missions, Apollo 9 and 10, will provide the experience to attempt the initial lunar landing. It should be recognized that although this mission sequence leading to the initial lunar landing represents the primary plan, alternate Apollo planning recognizes that a requirement for additional missions prior to the landing attempt may become apparent as the program proceeds. For this eventuality, the program has the capability to repeat any mission as required to establish a sound basis for moving to the next step in the mission sequence.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1968	1969	1970
Spacecraft	$1,034,700	$ 902,800	$ 653,800
Saturn V	853,965	534,453	496,700
Lunar exploration	---	---	11,000
Operations	545,765	546,400	489,600
Saturn IB	101,100	41,347	---
Engine development	20,500	---	---
Total	$2,556,030	$2,025,000	$1,651,100

BASIS OF FUND REQUIREMENTS:

Spacecraft

The Apollo spacecraft consists of three modules: the Command Module, the Service Module, and the Lunar Module. The Command Module is a double-shelled, conical shaped spacecraft containing systems for communications; environmental control; guidance and navigation, stabilization and control for inflight and re-entry manuevering; thermal protection against the heat of re-entry; and earth landing systems. Providing the living and crew station quarters, it is the only hardware used during a mission that is recovered. The Service Module is a cylindrical structure storing most of the spacecraft consumables such as oxygen, hydrogen, and propulsion fuels. The Service Module contains the main spacecraft propulsion system providing 20,500 pounds of thrust; the reaction control system for secondary propulsion and maneuvering; the electrical power system; and elements of the communication and environmental control systems. The Lunar Module is a self-contained vehicle consisting of a descent stage and an ascent stage with a two-man cabin. The module serves as a base of operations on the surface of the moon. Each stage is equipped with its own engine - the descent stage engine provides the decelerating force necessary for a soft landing; the ascent stage engine launches the two astronauts up from the surface of the moon to the orbiting Command and Service Module. Eleven Command and Service Modules will be in various stages of production and factory checkout during FY 1970.

During FY 1970, eleven Command and Service Modules and seven Lunar Modules will be in various stages of production and checkout. Funds also provide for spacecraft integration, checkout, and reliability, test operations, crew

equipment, space suits, logistics, instrumentation, and scientific equipment.

Saturn V

The Saturn V launch vehicle, this country's most powerful rocket, possesses nearly five times the thrust of the Saturn IB. Comprised of three propulsion stages and an instrument unit, the Saturn V can launch payloads of nearly 145 tons into low earth orbit, or payloads of 50 tons to the moon. The project includes fifteen flight vehicles for a planned series of unmanned qualification flights, manned lunar landing simulations and manned lunar landing. Manufacturing, systems installation, test and checkout of the last seven vehicles will be underway in FY 1970. FY 1970 funds also provide a quick response capability for resolving any Saturn V problems encountered in the flight missions, and for engineering support activity required for flight evaluation. Five Saturn V launches are planned for the budget year.

Lunar Exploration

The activities and developments necessary to expand the capabilities and usefulness of basic Apollo hardware to conduct extended exploration of the moon are being studied intensively. Man's capabilities to conduct such an exploration must be enhanced by extending his lunar staytime beyond the one-day capability in present Apollo hardware, and by expanding the radius of his exploration through the use of astronaut mobility aids and the development of lunar traverse vehicles. FY 1970 funding will be used for the definition of modifications to Apollo hardware, new system requirements and experiments.

Operations

Operations consists of crew training, launch, flight and recovery, and the program wide technical and Department of Defense support required for manned space flights. Included in the Apollo portion of operations is funding of the basic capability to conduct manned flight together with activities necessary for specific Apollo missions. The associated operations project included in Space Flight Operations funds only those efforts unique to that program.

The two principal centers for launch, flight control and recovery activities are the Kennedy Space Center, Florida and the Manned Spacecraft Center, Texas. The Kennedy Space Center is responsible for checkout of both the launch vehicles and the spacecraft; maintenance and operation of the launch facilities; final integration and integrated checkout of the space vehicle which includes the launch vehicle payload; the operation and coordination of supporting facilities, ground support equipment and logistics support; and the conducting of the launch. The Manned Spacecraft Center (MSC) in Houston is the headquarters for all crew, flight, and recovery operations. The astronauts are based at this Center along with most of their essential training equipment. Also at MSC is the Mission Control Center with its highly sophisticated computer complex and extensive communications links to the tracking network and other worldwide data sources.

Technical operations provides for the systems engineering needed for the integrated technical support, review, and analysis of the entire Apollo program; the supporting development necessary for product improvement; for the contractor administration, audit, and property administration services provided by the Department of Defense on a reimbursable basis; and for the nonrecurring maintenance and rehabilitation of government owned industrial plants. In FY 1970 systems engineering services provide functional and performance standards for Apollo developed hardware; technical integration and evaluation; technical documentation; and overall trajectory analysis. Funding for supporting development will concentrate on engineering efforts to improve Manned Space Flight hardware. The nature of these efforts vary widely, extending from alternative subsystems to new subsystems to new material fabrication and testing. Effort in FY 1970 will be devoted to those promising areas highlighted in previous work with new tasks focusing on applied systems development.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1970 ESTIMATES

SUMMARY

OFFICE OF MANNED SPACE FLIGHT — SPACE FLIGHT OPERATIONS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Space Flight Operations program is directed toward increasing the scientific, technical, and economic return on this nation's investment in technology; launch, production, and operations facilities; the scientific, engineering and management skills and expertise; operational techniques; and hardware equipment developed in the Gemini and Apollo programs. Continued use of this national capability is an essential element as this nation continues its industrial and technical growth and maintains its role as a technological leader of the world. The focus for the Space Flight Operations program is the development and operation of a manned space station that can be launched in the mid-1970's.

Initial Space Flight Operations will be conducted in Apollo Applications, which is built on the strong base of flight experience, ground facilities, and trained manpower developed in the Apollo program. Apollo Applications employs the Saturn I Workshop, the Apollo Telescope Mount, and basic space vehicle hardware developed and procured in Apollo. This basic hardware is being modified to meet the unique requirements of the Apollo Applications missions and to capitalize on the Apollo developed capability by accomplishing a limited but carefully selected spectrum of scientific, technological and medical investigations. The project is a progressive step toward the establishment of a long-term space flight operations capability in the Space Station, and furnishes information which will be used to reach sound decisions on the content and configuration of our future operations in the space environment.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1968	1969	1970
Apollo applications	$253,200	$150,000	$308,800
Space station	---	---	9,000
Operations	---	---	36,300
Total program plan	$253,200	$150,000	$354,100
Application of funds reserved from apportionment pursuant to the Revenue and Expenditure Control Act of 1968 (Pub. L. 90-364, 82 Stat. 251)			-117,473
Budget authority requested			$236,627

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BASIS OF FUND REQUIREMENTS:

Apollo Applications

Apollo Applications consists of three basic missions and relies primarily on hardware developed and produced for the Apollo program. The mission objectives include:

1. Obtaining information on how best to sustain or improve the effectiveness of man in space in terms of biomedical considerations, living conditions, mobility, and work station designs.

2. Effecting long duration operations. Since the quantity of data return and other accomplishments is generally directly proportional to the duration of the flight, the value and economy of each mission can be greatly enhanced by increasing the amount of time that can be devoted to productive activities.

3. Conducting scientific, technical, and applications tasks with the purpose of assessing, experimenting with, and increasing man's capabilities for performing these tasks; as well as the acquisition of useful data and results.

4. Providing information to support the effort in developing the long duration Space Station of the mid-1970's.

The Saturn I Workshop mission planned for flight in 1971 requires the launch of two Saturn IB vehicles to establish and begin operation of a large volume workshop in earth orbit. An unmanned flight, consisting of a Saturn IB with an Airlock Module, and a Docking Adapter, will be launched first. A second Saturn IB launch, occurring approximately one day later, will be manned and will rendezvous with the S-IVB stage of the first flight. The experiments planned on this mission are chiefly devoted to determining and evaluating task performance of men in space over extended periods of time, and include habitability experiments, medical evaluations of the effect of long duration space flight on the crew, engineering experiments and various technology and scientific experiments, including earth science observations.

The Workshop revisit mission uses a single Saturn IB launch of a three-man Command and Service Module to rendezvous and dock with the Workshop stored in orbit at the completion of the previous mission. This mission is the first flight test of the concept of reusing a habitable space structure after a period of several months of untended operation in orbit. Its planned duration of 56 days is the next step in the progressive extension of mission length to systematically test and evaluate the ability of both man and equipment to function effectively for long periods of time in space.

The third mission, planned for early 1972, uses the Workshop as a base of operations for a manned solar observatory. A Saturn IB will launch a three-man Apollo Command and Service Module configured for a 56-day mission. After the Command and Service Module rendezvous and docks with the Workshop, the

crew enters and reactivates the Workshop and prepares for the operational phase of the mission. Later, a second Saturn IB launches the unmanned Apollo Telescope Mount (ATM) which will rendezvous and dock with the Workshop. The ATM incorporates high resolution solar telescopes and spectrographs for observing dynamic phenomena on the surface and in the corona of the sun.

Backup hardware will be provided for both the Workshop (with Docking Adapter and Airlock) and the Apollo Telescope Mount, including a second set of experiments for the Workshop and Solar Astronomy missions. The backup flight hardware will provide program assurance in the event of a malfunction or failure in the primary missions.

Funding in FY 1970 will cover storage and maintenance costs required for the Saturn IB's provided by Apollo and for continuing production effort on vehicles # 213 and 214; detailed engineering, fabrication, and certification testing of modified spacecraft subsystems to qualify them for long duration missions; and start of assembly of flight spacecraft. FY 1970 funds will also be used in extensive development and qualification tests of components and subsystems of the Saturn I Workshop; the Airlock Module; Multiple Docking Adapter; and the ATM. Fabrication of flight hardware will be initiated during the year.

Space Station

The Space Station system will consist of the station itself, experiments, supporting modules and logistic systems for personnel transfer and resupply. Based on the findings of completed advanced studies, a selection of detailed objectives and program constraints is being made and industry is being asked to prepare preliminary designs of station and logistic systems configurations. After completion of these contractual efforts, a comprehensive in-house analytical review will be conducted, to refine concepts, develop preliminary design specifications, define support requirements, and assess preliminary manufacturing and test requirements. Funds requested in 1970 are for continuing definition studies, preliminary engineering and necessary supporting work.

Operations

Operations include efforts at the Kennedy Space Center and the Manned Spacecraft Center that are directly involved with prelaunch, launch, flight, crew, and recovery planning activities and the technical operations needed for integrated technical support, review, and analysis of the Apollo Applications missions. FY 1970 funds are required for mission planning and analysis; initiation of procurement for an ATM simulator; trainer modifications to Apollo Application configurations; maintenance of Saturn IB launch capability including equipment and systems in storage, by keeping it in a condition of good repair to permit reactivation to support Apollo Applications launches; modification of launch check-out equipment to accommodate Apollo Applications unique hardware; test planning and procedures for check-out of previously deactivated equipment and systems as well as Apollo Applications unique hardware and documentation planning for reactivation of launch complexes for Apollo Applications.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1970 ESTIMATES

SUMMARY

OFFICE OF MANNED SPACE FLIGHT — ADVANCED MISSIONS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objectives of the Advanced Missions program are to examine advanced manned space flight program concepts, including logical extensions of the national space capability through analysis of present hardware systems for growth potential; to develop requirements for future systems; to provide guidance for research and technology activities; and to provide technical information and cost data upon which future program decisions can be based.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars) 1968	1969	1970
Advanced missions studies.....	$ ---	$2,500	$2,500
Total.....	$ ---	$2,500	$2,500

BASIS OF FUND REQUIREMENTS:

Advanced Missions Studies

Advanced studies provide for future manned space flight program planning. The studies utilize the capabilities of industry to perform conceptual designs and provide technical trade-off data to supplement in-house activities. During FY 1969, emphasis is being placed on support of the Space Station definition effort.

FY 1970 funding will be used as follows:

a. Rescue and Escape - Studies will be undertaken to examine and identify methods and systems for astronaut escape and rescue on lunar orbit and lunar surface missions. Conceptual design of manned and unmanned earth based rescue systems will be studied for low earth and geosynchronous orbit missions. The impact of the projected use of such systems on the design and operation of Space Stations and lunar surface shelters and vehicles will be assessed.

b. Advanced Lunar Studies - Studies will be conducted on advanced studies which have the potential for utilization in the latter half of the 1970's. The studies will be concerned with spacecraft systems required to transport personnel and cargo to the moon and systems to provide shelter and support

for exploration activities. System synthesis studies will provide planning data applicable to development of an early lunar station using Apollo system derivatives.

c. Advanced Space Station Studies - Advanced Space Station studies will include identification of advanced mission requirements and operational modes for a semipermanent space station. New modules required for second generation payloads and systems required for missions in synchronous orbit will be examined. The implications of deep space missions for these modules and systems may also be examined.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1970 ESTIMATES

SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS — PHYSICS AND ASTRONOMY PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Physics and Astronomy program is directed to increase human knowledge of the earth's space environment, the sun, the stars, and more distant celestial bodies. Research is being conducted under this program to investigate the earth's upper atmosphere and ionosphere; the magnetosphere and the interplanetary medium; the sun, the stars, and galaxies; cosmic dust; cosmic rays and other physical and astronomical phenomena found beyond the earth's atmosphere.

Techniques used to gather information on these phenomena range from theoretical and laboratory research through aircraft, balloon and sounding rocket flights to small Explorer spacecraft, large automated orbiting observatories, and manned spacecraft. Research groups involved in this program are located at NASA field centers, other government laboratories, universities, and industrial laboratories. Opportunities are also extended to scientists in other nations to participate in the program through flight experiments on NASA spacecraft and cooperative sounding rocket and satellite projects.

The data generated in this program are made widely available to the scientific and technical community in order to further advance future scientific research, and to contribute to education and the advance of technology.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1968	1969	1970
Supporting research and technology/advanced studies..	$22,904	$19,900	$19,600
Data analysis.....	2,900	3,400	3,700
Sounding rockets.....	20,000	20,100	20,100
Solar observatories.....	11,332	12,000	14,800
Astronomical observatories.....	44,768	36,900	28,600
Geophysical observatories.....	20,064	13,200	6,800
Explorers.....	17,532	19,616	26,000
Total.....	$139,500	$125,116	$119,600

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology/ Advanced Studies

The Supporting Research and Technology project provides for the research required to support a firm foundation for space physics and astronomy. This project provides for advanced technological development of experiments and spacecraft components for future flight programs, the support of theoretical and laboratory research, and the conduct of scientific flight research using balloons and aircraft. The program is carried out by universities, nonprofit and industrial research centers, NASA centers and other Government agencies.

Data Analysis

The objective of this project 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. After processing and cataloging, the availability of the data is made known to the world scientific community through periodic announcements by the NSSDC.

The funding in FY 1970 provides for a continuation of the data collection effort of the NSSDC. As the holdings improve, the usefulness of the NSSDC to the scientific community is being reflected in an increase in the requests for data. The FY 1970 funding also provides for modest support of correlative studies which utilize data from several separate investigations as well as new approaches to the analysis of available data.

Sounding Rockets

Sounding rockets offer a uniquely effective means of conducting scientific studies at altitudes between 80 and 1,000 miles. These rockets are relatively small, inexpensive vehicles capable of carrying a wide variety of instrumentation to conduct studies in planetary atmospheres, ionospheric physics, energetic particles, astronomy, and solar physics. Sounding rocket flights are extremely useful in developing instrumentation for later use on satellites. The usefulness of sounding rockets for astronomical observations of the sun and stars in the X-ray and ultraviolet regions of the spectrum have been greatly increased by the development of accurate attitude control systems capable of spatial pointing accuracies of one arc second.

FY 1970 funds will continue the current sounding rocket program of 100 to 125 flights per year. It is expected to utilize the recent advancements in attitude control, together with additional improvements in the altitude capability of the Aerobee series of rockets, to provide for greater program emphasis in the astronomy and solar physics disciplines.

Solar Observatories

The Orbiting Solar Observatory (OSO) is a spin-stabilized satellite designed to continuously point at the sun and scan the celestial sphere. Observations of solar and astronomical events are recorded and transmitted to ground based stations for analysis and dissemination in appropriate scientific publications by the Principal Investigators. OSO-I and OSO-II were launched in 1962 and 1965, respectively, and obtained over 8,600 hours of scientific data including the first long duration observations of the X-ray and ultraviolet spectra of the sun. OSO-I proved that it was practicable to orbit a highly complex spacecraft with independent scientific instruments which obtained useful scientific data. OSO-III and OSO-IV were launched in 1967 and each is still providing 7.5 hours a day of real time scientific data. Data from OSO-III showed that the center of the galaxy is a source of gamma rays of energy greater than 50 million electron volts.

In FY 1970, funds will provide for continued analysis and publication of scientific results based on data obtained from OSO-IV; orbital operation and data analysis of OSO-F; completing ground testing for launch preparations and initial data analysis for OSO-G; design, development, and initial manufacture of spacecraft and experiment instrument components on OSO-H; and initial development on OSO-I, J, K.

Astronomical Observatories

The Orbiting Astronomical Observatory (OAO) project is designed to develop and use 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. The early experiments in the OAO project will provide exploratory sky mapping surveys in the ultraviolet, with later experiments providing high resolution studies of faint objects. The first mission, launched in 1966 by an Atlas Agena vehicle, failed to achieve its mission objectives, but did provide a test of major subsystems and identified weaknesses in the observatory system. Based on the knowledge gained from the first flight and a thorough review of the project, the OAO system was revised. After two years of intensive redesign, development and testing effort, OAO-II was launched successfully on December 7, 1968 by an Atlas Centaur vehicle. Data from the two scientific experiments are now being processed and analyzed.

FY 1970 funds will provide for completion of the OAO-B observatory tests and prelaunch operations, as well as support for launch, in-orbit operations, and processing and analysis of data from the scientific experiment. Funds will also be used on the OAO-C mission for qualification tests of the experiment; acceptance tests of the flight experiment; modification, integration, and test of the spacecraft; and initiation of the observatory tests.

Geophysical Observatories

The Orbiting Geophysical Observatory (OGO) project has as a primary objective the accomplishment of a coordinated series of scientific studies of the earth's environment and the effect of solar activity on that environment. Five observatories have been launched at approximately one year intervals, starting with OGO-I in 1964. These missions and the planned OGO-F mission cover the period from minimum to maximum activity of the current sunspot cycle, and provide for widely spaced measurements throughout the earth's magnetosphere as well as the nearby interplanetary medium. OGO-1 and III are still transmitting data, although in a spin stabilized mode. OGO-IV and V continue to operate in the original three-axis stabilization mode. Operations of the OGO-II satellite were discontinued in November 1967 after two years in orbit. The five OGO spacecraft have carried 105 experiments and accumulated over one million hours of experiment operation.

FY 1970 funds provide for operational support for data acquisition, and data analysis for OGO-IV, V, and F.

Explorers

Explorers are small special purpose satellites designed and instrumented to provide for specialized scientific investigations and are flown in the unique orbits required for these investigations. The Explorer class spacecraft and their experiments are developed by NASA installations, universities, industry and cooperating foreign countries. They are used for investigations of the earth's atmosphere, ionosphere, and magnetosphere; exploration of the magnetospheric boundary region and interplanetary space; and astronomical observations of the sun and other celestial objects.

The early Explorer satellites have been responsible for many of the discoveries made in the earth's environment during the past decade. With the continuous development of launch vehicle capability and instrumentation, they have become versatile and sophisticated tools for specialized space investigations as well as explorations. Launched by the Scout and Delta vehicles, they provide a flexibility to conduct specific tasks without the design and orbit compromises inherent in large observatories.

FY 1970 funds provide for launching of the magnetospheric boundary and interplanetary space explorer IMP-G; flight qualification and launch preparation of the Radio Astronomy Explorer RAE-B, a radiation belt study on the Small Scientific Satellite SSS-A, and five cooperative satellites; and continued development of other approved Explorer missions.

In FY 1970 it is planned to initiate Atmosphere Explorer missions (C and D) which were deferred in FY 1969. These require onboard propulsion needed to maintain the low orbital altitudes necessary to investigate the lower boundary and energy balance of the upper atmosphere on a global basis. Additional Small Scientific Satellites, Small Astronomy Satellites, and interagency and International Cooperative Satellites are also planned to investigate phenomena discovered in the earth's environment and to provide sky surveys in wave length regions not visible from the ground.

SCHEDULE OF LAUNCHES

Project	Mission	Calendar Year
Solar Observatories	OSO F	1969
	OSO G	1969
	OSO H	1971
	OSO I	1973
	OSO J	1974
	OSO K	1975
Astronomical Observatories	OAO B	1969
	OAO C	1971
Geophysical Observatories	OGO F	1969
Explorers (including International Cooperative Satellites)	1 Scout, 2 Deltas	1969
	8 Scouts, 3 Deltas	1970
	4 Scouts, 2 Deltas	1971
	4 Scouts, 1 Delta	1972
	4 Scouts, 1 Delta	1973
	1 Scout, 1 Delta	1974
Sounding Rockets	100-125 launches per year	

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1970 ESTIMATES

SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS

LUNAR AND PLANETARY EXPLORATION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objective of the Lunar and Planetary Exploration program is the scientific exploration of our solar system utilizing manned and automated spacecraft supported by earth-based research. The current program places emphasis on planning the further exploration of the moon by manned systems and on 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 through more comprehensive missions to the outer planets and to the asteroids and comets. The ultimate achievement of these objectives will provide data to better explain the origin, history, and mechanisms of development of our solar system, thereby increasing our understanding of the evolution of the earth and the processes that control its environment.

The fundamental scientific objectives of the lunar exploration program are to understand the moon's origin, evolutionary history, relationship to the earth and the solar system, and processes of formation. Projects now completed have advanced considerably our knowledge of the moon and provided a wealth of data which aided and will continue to aid in unraveling the mysteries of our nearest neighbor. The Ranger project, the first step in this effort, provided the first close up picture of the moon's surface through the thousands of lunar photographs its spacecraft transmitted to earth. The subsequent Lunar Orbiter project provided the large scale detailed photographs of the moon required for the selection and certification of sites for the Apollo manned lunar landing missions. The Surveyor project, by demonstrating the soft landing of a complex spacecraft, verified the ability of Apollo to land on the lunar surface. In addition, Surveyor made valuable contributions to our knowledge of the moon by taking hundreds of high resolution photographs of the lunar terrain, measuring lunar surface bearing strength and by making the first rudimentary chemical analysis of lunar materials. The initial phase of lunar exploration came to a close with the successful completion of the Surveyor project.

The next phase of our exploration of the moon will be conducted by men in the Apollo program currently approaching fruition. The initial landings and the subsequent modifications to the systems necessary for comprehensive exploration of the moon are funded under the Manned Space Flight program. However, a manned exploration of this scope requires a very solid foundation of scientific research if it is to be an effective program. Funding requested

under the Supporting Research and Technology and Data Analysis projects will provide the science planning which will serve as the base for conducting meaningful exploration of the moon.

The planetary and interplanetary programs have experienced a high degree of success beginning with the Mariner II flyby of Venus and continuing with the most recent successful launching of the Pioneer IX spacecraft into an orbit around the Sun. The Mariner II mission in 1962, the first flyby mission to Venus, provided new data on the magnetic and atmospheric characteristics of the planet. The Mariner IV mission to Mars in 1965 provided the first close up photography of the planet's cratered surface and showed that its atmospheric density was very low compared to the earth. Mariner V, launched in June 1967, made more precise measurements of Venus' ionosphere, magnetosphere, and atmosphere. Pioneer IX, launched in November 1968, is the latest in the current series of spacecraft designed to measure the interplanetary medium. Earlier missions provided data enabling a better understanding of the mechanisms related to the propagation through space of solar disturbances, the effect of these disturbances on terrestrial phenomena, and the relationship between solar activity and solar and cosmic rays.

The next phase of the Planetary program includes a series of missions to Mars, Venus, and Mercury, and the first mission to the vicinity of Jupiter. Two Mariner flyby missions to Mars are scheduled for 1969 to be followed by two Mariner orbiters in 1971. In 1973, a single Mariner spacecraft will be used to study both Venus and Mercury. The Viking project, utilizing the orbiter/lander team approach found so successful in exploring the moon will be launched to Mars. This project, combining a lander and a Mariner class orbiter, will be launched to Mars by the Titan/Centaur launch vehicle in 1973. Pioneer E is scheduled for launch in 1969 for further interplanetary studies. Modification of the successful Pioneer spacecraft design will permit missions beyond Mars to the vicinity of Jupiter; Pioneer F and G launches are scheduled for the 1972 and 1973 Jovian opportunities.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1968	1969	1970
Supporting research and technology/ advanced studies.....	$19,800	$20,600	$24,600
Data analysis.....	600	2,600	2,700
Pioneer.....	6,000	5,000	18,200
Mariner-Mars 1969.....	62,850	27,200	4,900
Mariner-Mars 1971.....	---	18,300	45,400

SUMMARY OF RESOURCES REQUIREMENTS: (cont'd)

	(Thousands of Dollars)		
	1968	1969	1970
Mariner-Mercury 1973.....	---	---	3,000
Viking.....	---	8,100	40,000
Planetary explorers.....	---	---	8,000
Advanced planetary missions technology.....	12,000	---	---
Surveyor.....	33,000	---	---
Lunar orbiter.....	9,500	---	---
Mariner-Venus 1967.....	3,400	---	---
Voyager.....	350	---	---
Total.....	$147,500	$81,800	$146,800

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology/Advanced Studies

Supporting Research and Technology provides for support of flight missions by conceiving and developing science experiments and engineering capabilities and by conducting studies that define the objectives and requirements of various long range flight mission possibilities. Data obtained from ground based activities supported by this program are combined with flight results to yield significant advancement in our knowledge of the moon and solar system. The advanced technical development part of this program is oriented toward initiating technological development of future subsystems, components, techniques and processes that may have application to long range spacecraft concepts and providing the laboratory research required to determine the feasibility of alternative design concepts for future, more complex missions to the planets. Areas of interest are new telecommunication and data automation techniques and concepts, and increased reliability and lifetime of components. The advanced studies program identifies and evaluates long range potential missions in terms of new information to be gained from the planets.

During FY 1970, effort in the lunar science area will largely be devoted to increasing our scientific knowledge of the moon, continuing laboratory investigations and theoretical studies related to the moon and drawing on data from ground based research and from Ranger, Surveyor, Lunar Orbiter, Apollo 8 and subsequent Apollo missions. Research in the advanced technical development program will concentrate in the areas of Jupiter flyby and Grand Tour missions; provide more emphasis to the critical technologies for Venus probes and buoyant Venus stations; and develop concepts for an advanced Mars lander in the later 1970's.

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 are obtained by scientific instruments aboard the spacecraft and 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 1970, the Lunar Data Analysis project will support continuing Lunar Orbiter photographic analysis. This analysis will emphasize geographical areas outside the Apollo landing zone, primarily for scientific interest. The balance of the funds requested will support analysis of data obtained in early Apollo lunar orbital and landing missions. The purpose of these analyses will also focus on potential Lunar Exploration mission requirements. The Planetary Data Analysis project will continue to support the reduction of data from the Mariner IV, Mariner V, and Pioneer missions; and also from earth upper atmosphere experiments. It will provide the results for the use of the scientific community in advancing the knowledge of mankind in general.

Pioneer

The objectives of the Pioneer project are to provide for the continuing investigation of the interplanetary medium and the propagation of solar and galactic phenomena in this medium; and to provide initial exploration of the remote regions of the solar system in order to increase knowledge of the origin and evolution of the earth, sun, and planets, and the dynamic processes that shape the terrestrial environment.

The current series of Pioneer spacecraft weigh about 140 pounds each and are launched by the Thrust-Augmented Improved Delta. The first three of these, Pioneers VI, VII, and VIII were launched successfully in 1965, 1966, and 1967 respectively; all three continue to operate successfully. Pioneer IX was successfully launched on November 8, 1968. All spacecraft subsystems are performing normally, and all on-board scientific instruments are transmitting valuable scientific information on the interplanetary medium. Pioneer IX and Pioneer E, to be launched in 1969, are essential elements of our network of deep space "weather stations". The experiments for these Pioneers are designed to measure the solar wind flow, magnetic fields, and the electron density in space; and to observe the energy spectra, fluxes, and direction of solar and galactic cosmic rays. The opportunity to perform these experiments on widely separated spacecraft in deep space is providing unique and valuable scientific information about the sun and its influence on the solar system. The combination of measurements from the four widely separated stations enable us to detect and estimate the paths of solar storms.

This information helps forecasters to provide advance warning of radiation dangers to spacecraft and of variations in the protective magnetic envelope of the earth which affects the long range radio communication of the world.

In FY 1969, the development of Pioneer F and G was initiated to be launched into trajectories permitting the exploration of the environment of interplanetary space between one and five Astronomical Units (AU) from the sun, including the asteroid belt and the magnetosphere of Jupiter. (One AU is equal to the mean earth-to-sun distance, 92,000,000 miles.) With this type of trajectory, we should be able to study the hazardous region of the asteroid belt and 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 is in the vicinity of Jupiter, instruments will measure the properties of charged particles, magnetic fields, and radio frequency emissions. Data from these measurements will be used to study the composition and dynamics of the atmosphere surrounding the planet and its interaction with the interplanetary medium. It will also be used to analyze the thermal balance of Jupiter and the source of energy which the planet seems to have. These missions will require modifications to the spacecraft to compensate for the lessening of solar radiation as a power source and the more demanding communications and thermal conditions. New experiment instrumentation will also be required to make measurements in the asteroid belt and near Jupiter. Also in FY 1969, NASA initiated, as part of the Pioneer project, a cooperative project with West Germany, Helios, for measurements of the interplanetary medium to within 0.3 AU of the sun.

FY 1970 funds will be used for design and development work on the spacecraft and the selected experiments for Pioneer F and G. Operational support for the five active Pioneer spacecraft and for data analysis will continue. U.S. experiments for Helios will be selected and begun.

Mariner

The objective of the Mariner program is to conduct the early exploration of the planets with automated spacecraft in the medium weight class, about 1000 pounds. The Mariner spacecraft represents the tool in the Planetary program for remote observations, from an attitude controlled spacecraft of the other planets in the solar system. Mariner II 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 IV flight past Mars on July 14, 1965. Mariner IV's primary objective was to conduct initial close up scientific observations of Mars and its environment. The objective was achieved and included pictures of the planet showing a cratered surface similar to that of the moon. Although close up pictures of Mars were the primary goal, valuable information on the planet's atmosphere and ionosphere was also acquired. On October 19, 1967, Mariner V 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, improving and significantly augmenting the data acquired five years earlier by Mariner II. According to Mariner V,

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Venus is a hot planet with a thick lower atmosphere - mostly carbon dioxide. The heavy atmosphere is surrounded by a sphere of hydrogen analogous to that of earth.

The next step in the scientific exploration of the planets consists of two Mariner spacecraft to flyby Mars in early August 1969 to provide data on the planet's physical, chemical, and thermal properties. These spacecraft will be instrumented to transmit more data from scientific instruments during this one opportunity than has been transmitted by all previous planetary missions combined. The science instruments consist of two television cameras, an infrared spectrometer, infrared radiometer, and an ultraviolet spectrometer. In addition to these flight instruments, it is also planned to conduct a planetary occultation experiment making use of the spacecraft's radio equipment, and a celestial mechanics experiment using the tracking data.

The scientific investigation of Mars using orbiting spacecraft will begin in 1971. The Mars 1971 spacecraft, which will use many of the proven subsystems of the Mariner IV and Mariner 1969 exploratory 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. Some of the scientific instruments for the Mariner-Mars 1971 missions will be improved versions of those carried on the Mariner-Mars 1961 flyby. However, the scientific data return will be increased significantly. This increase in data return results from the spacecraft being in orbit about the planet allowing multiple measurements and observations over a period of several months. From orbit, it will observe approximately 70% of the planet's surface including the wave of darkening, cloud movements and any other dynamic and seasonal changes in the planet's atmosphere or on the planet's surface.

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

The funds requested for FY 1970 will support post-launch operations for Mariner-Mars 1969 through encounter, and initial analysis of scientific and engineering data. FY 1970 funds requested for Mariner-Mars 1971 will be used to procure flight hardware, and provide for tests of prototype subsystems, and environmental systems tests of the prototype spacecraft. Fiscal Year 1970 funds will also be used to prepare functional specifications for Mariner-Mercury 1973 spacecraft and to permit initial flight hardware procurement activities.

Viking

The exploration of Mars initiated in 1965 by the Mariner series of spacecraft will be continued in 1973. While these prior missions were to study the planet from orbital or flyby distances, the 1973 mission will be the first opportunity to obtain data from direct measurements in the Mars atmosphere and on its surface.

The objectives established for the Viking project are to obtain, through the use of two lander/orbiter missions to Mars in 1973, scientific data which will significantly increase our knowledge of the Mars atmosphere and surface with particular emphasis on providing information relevant to life on the planet. Entry objectives include measurements of atmospheric composition and structure. Post-landing objectives are to visually characterize the landing sites, search for organic compounds, and investigate the ability of the environment to support life. Orbiter objectives are to study the dynamic characteristics of the planet and its atmosphere from orbit, to provide pictures of the landing area, and to relay data from the lander on the Mars surface to earth. This teamwork between the orbiter and lander should yield scientific results which would not be attainable for independent lander and orbiter missions.

The lander to be used for this mission will be a soft lander similar to those used in the Surveyor project. Technology developed for Surveyor and the Apollo Lunar Module will be directly applicable to the Viking lander. 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 surface dispersions for the lander, lower entry velocities, and better control of entry angles.

FY 1970 funds will provide for the completion of functional specifications, selection of prime contractor for the lander system, initiation of detailed system design for the lander and orbiter, and will provide for continued development work on long lead items. During FY 1970, the specific scientific instruments to be flown will be selected after the results of the Mariner 1969 mission are known and development work on these instruments will begin.

Planetary Explorers

The Planetary Explorers are relatively small, low-cost, spin-stabilized spacecraft designed for a Thor/Delta launch and to orbit the near planets. The five-shot program includes launches to Venus in 1972, 1973, and 1975 and to Mars in 1973 and 1975.

The Planetary Explorers will team with the larger Mariner spacecraft to produce a highly efficient program to explore the near planets, just as the most efficient program to explore the earth and its environment proved to be a mix of small Explorer orbiters with larger satellites such as Nimbus and OGO. As part of its role on the team, the magnetically clean Planetary Explorers

will make those sensitive readings of the particle and field environments around Venus and Mars which are difficult to make aboard the higher-powered Mariners with their strong internal magnetic fields. The Planetary Explorers will thus free the Mariners to concentrate on conducting those high priority experiments which require stable and precise pointing, high power, and high data rate. Effort during Fiscal Year 1970 will include completion of the detailed design, fabrication, and test of a structural test model and a thermal control model.

Schedule of Launches

Project	Mission	Calendar Year
Pioneer	Pioneer E	1969
	Pioneer F	1972
	Pioneer G	1973
	Helios A	1974
	Helios B	1975
Mariner	Mars 1969 (2)	1969
	Mars 1971 (2)	1971
	Mercury 1973 (1)	1973
Viking	Mars 1973 (2)	1973
Planetary Explorers	Planetary Explorer A	1972
	Planetary Explorer B	1973
	Planetary Explorer C	1973
	Planetary Explorer D	1975
	Planetary Explorer E	1975

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1970 ESTIMATES

SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS — BIOSCIENCE PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Bioscience program has three principal objectives: (1) the attainment of a thorough understanding of the effects of the space flight environment on terrestrial organisms; (2) the search for extraterrestrial life, with the primary emphasis directed initially to the moon and nearest planets; and (3) prevention of the transfer of terrestrial organisms to the planets, so that their scientific value for studying hypotheses on existence of extraterrestrial life will not be destroyed.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1968	1969	1970
Supporting research and technology/advanced studies.....	$10,122	$9,900	$11,400
Planetary quarantine.....	1,678	1,300	3,000
Biosatellite.....	30,000	21,500	18,000
Total.....	$41,800	$32,700	$32,400

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology/Advanced Studies

Research in environmental biology deals with the response and interaction of living earth systems with the variables of the space and planetary environments. Critical space environmental factors, e.g., altered gravity, are being studied to determine the manner in which each of these individually or in combination with others, influence normal function in biologic systems removed from their normal earth habitat. Knowledge of this nature is required to establish expeditious and efficient means for using a variety of living organisms to assist in the biologic exploration of the unique space environment. The ground based research carried out under Supporting Research and Technology (SR&T) supports flight research on the Biosatellite and other flight projects.

Behavioral biology seeks fundamental knowledge concerning the behavior of organisms, their behavioral mechanisms of adaptation to artificial and extraterrestrial environments, and determining the biologic bases of such behavior, thus providing a broader understanding of the function of the total organism

and its environmental interactions. Both ground based and in-flight studies are designed to investigate the effects of weightlessness and other conditions peculiar to the space environment.

Emphasis is placed on intensive studies in four areas, which appear to hold promise of the greatest return in terms of basic scientific information and future applicability to space research. These include: (1) effects of the space environment on behavior; (2) experimental analysis of behavior; (3) neurological and biochemical bases of behavior; and (4) biological information, control, and communication systems.

The Physical Biology program involves ground based basic research in bioinstrumentation, comparative physiology and biophysics. In comparative physiology, studies are being carried out on the dynamics of physiological systems, special attention is being paid various oscillatory activities in the thermoregulatory, cardiovascular, behavioral, and hormonal systems. While the long-term goals of studying these phenomena have implications for understanding of the mechanism of life processes and the workings of entire physiological systems, a more direct goal for space biology and medicine is in monitoring and evaluating the physical condition and well being of astronauts during space flight missions.

The Exobiology research program has dual objectives of understanding the controlling factors in the origin of life, and determining the uniqueness of life on earth. The research ranges from the analysis of fossil remains and simulation of planetary atmospheres and other environmental extremes, to the development of automated life detection equipment intended to increase the reliability of the data by broadening the basis for analysis of individual samples. In addition to the biological interest in Mars, laboratory experiments now suggest that organic synthesis may be occurring on Jupiter which has a primitive reducing atmosphere. The development of prototype instrumentation for exobiologic studies on the Martian surface is needed as a precursor to flight instrument developed for an early Mars lander. The life detection and organic analytical techniques developed in various laboratories must now be converted into flight instruments which in turn must be tested and integrated into a suitable payload so as to achieve the scientific objectives of the exobiology program. Such work must be done in FY 1969 and 1970 in order to support Viking, a 1973 Mars lander, and later missions. The development of this instrumentation is considered to be the most important single item in the Bioscience Supporting Research and Technology (SR&T) project and is extremely critical to the Viking mission. The entire increase in the Bioscience SR&T project has been requested for this purpose.

The Bioscience Communications project was established to increase effective communication between NASA program scientists and administrators and scientists in universities, industry, and other government agencies. Through support of ad hoc and interdisciplinary conferences, symposia, scientific training programs, research literature and reports, and the Space Science Board of the National Academy of Sciences, the project works toward a more complete exchange of information and ideas within the scientific community.

Funding for advanced programs and technology is used to define the requirements for future Bioscience missions and to develop specific mission plans based upon those requirements. In cooperation with the other life science programs in OART and OMSF, experiment priorities are established and specific payloads recommended for the proposed missions.

Planetary Quarantine

Earlier Planetary Quarantine efforts were directed toward reducing and assaying the biologic contamination on spacecraft and toward defining decontamination and sterilization procedures needed to reduce that contamination to levels required to maintain the planets free of terrestrial life. Excellent results have been achieved in limiting contamination in spacecraft manufacture and assembly. More recently, studies have been continuing to critically examine various factors, including microbial resistance and survival characteristics, that suggest modification in sterilization methods and procedures, so that planetary quarantine requirements will be achieved at less cost along with greater ease and assurance. Of particular value have been the results of studies of the probability of release of organisms buried in the solids of the spacecraft and growth of terrestrial micro-organisms in severe environments as may be encountered on Mars and Venus.

The Planetary Quarantine activity is shown as a separate line item because of its direct relationship to the planetary flight program. Continuing efforts are being made, before initiation of space flights destined to land on the planets, to assure adequate technology development in the solution of the complex problems related to the planetary quarantine constraints. The funding increase requested is in direct support of the Viking mission.

Investigations in FY 1970 are directed towards further simplifying the sterilization requirements and in direct support of planetary missions.

Biosatellite

The biological effects of the space flight environment are being studied in the Biosatellite project. During flights of Biosatellite I and II the engineering design and integrated operation of the spacecraft systems were thoroughly checked out.

The Biosatellite II experiment results showed that there was an interaction between radiation and weightlessness and other factors encountered in space flight.

Biosatellite D, Primate Mission, is to be flown early in 1969 and will carry a primate and subject the animal to a long-duration period of weightlessness (up to 30 days) and, through extensive instrumentation, will determine the changes that occur to his central nervous system and physiology. The primate's brain waves will be recorded and analyzed as will its cardiovascular system performance (through electrocardiograms), its alertness,

memory, and coordination through the use of a behavioral task performance panel. Also, through the use of a unique automated and miniature wet-chemistry laboratory, measurements of calcium and other urine constituents will be made to determine the changes in body metabolism.

Funding for FY 1970 will provide for continued development of the primate experiment, the analyses of the Biosatellite D flight results, the acceptance of the spacecraft, and preparations for launch of Biosatellite F.

SCHEDULE OF LAUNCHES

Project	Mission	Calendar Year
Biosatellite	Biosatellite D	1969
	Biosatellite F	1970

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1970 ESTIMATES

SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS SPACE APPLICATIONS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATIONS:

The objectives of the Space Applications program are to: (1) conduct a broad program of research and technical development oriented toward the application of space techniques for the benefit of mankind; (2) expand the knowledge of atmospheric and space phenomena; (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 Environmental Science Services Administration (ESSA), Department of Commerce, the operational meteorological satellite system; and (6) cooperate with the user government agencies such as the Departments of Agriculture, Commerce, Interior, and Department of the Navy through the Earth Resources Survey Program Review Committee to achieve the practical benefits to mankind in earth resources.

Effort in the Space Applications program is directed toward research, development, and flight test of experiments, subsystems, and spacecraft in the areas of applications technology, communications, earth resources, geodesy, meteorology, and navigation and includes development of operational systems for user agencies.

Through these efforts the knowledge and technology of space are applied to the solution of the practical problems of mankind. Examples of these applications are: (1) improved weather forecasting through more knowledge and better understanding of the atmosphere and its content and energy; (2) improvement of communication techniques through understanding and expansion of the frequency spectrum, development of space antenna designs and pointing accuracies, and increasing multi-access capabilities; (3) increasing our knowledge of the size and shape of the earth through the acquisition of global datum; and (4) better understanding and assessment of the factors affecting the agriculture environment, water resources, and soil and terrain conditions.

The Space Applications flight programs include Tiros, Nimbus, Synchronous Meteorological, Applications Technology, Geodetic, and Earth Resources

Technology Satellites. Planned launches during the FY 1970 period include ATS-E, Nimbus D, a number of Meteorological Sounding Rockets, support to the Tiros Operational Satellite System funded by ESSA, and support of launches for the Intelsat III series for COMSAT. In FY 1970, effort will be initiated on hardware procurement for two Earth Resources Technology Satellites (ERTS) planned for launch in 1971 and 1972 and on two Synchronous Meteorological Satellites (SMS) planned for launch in 1971 and 1973.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1968	1969	1970
Supporting research and technology/ Advanced studies	$19,300	$19,600	$22,400
TIROS/TOS improvements	9,100	5,800	5,200
Nimbus	33,700	31,800	29,200
Synchronous meteorological satellite	---	---	3,600
Meteorological soundings	3,000	3,000	3,000
Cooperative applications satellite	100	100	100
Applications technology satellites	25,600	24,700	44,200
Geodetic satellites	3,400	2,400	3,000
Earth resources survey	5,300	11,200	25,100
Aircraft program	(5,300)	(9,200)	(11,000)
Earth resources technology satellite	(---)	(2,000)	(14,100)
Total	$99,500	$98,600	$135,800

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

The objectives of the supporting research and technology are to conduct programmatic and project oriented technological development, fundamental studies, component and subsystem design, materials improvement research, and advanced mission studies to determine feasibility and conceptual characteristics. The effort includes supporting activities in the applications disciplines (applications technology, communications, earth resources, geodesy, meteorology, and navigation) and a number of interdisciplinary activities. FY 1970 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 certain technology areas, particularly development of automatic data processing capabilities related to earth resources survey.

TIROS/TOS Improvements

The objectives of this project are: (1) to provide research and development toward advanced meteorological satellite systems, particularly in support of the TIROS Operational System (TOS) program; (2) to provide maximum interim operational data for use in weather analysis and forecasting; (3) to measure emitted infrared and reflected solar radiation in selected spectral regions; and (4) to observe cloud cover and patterns, and measure the earth atmosphere heat balance.

Nine TIROS research and development spacecraft funded by NASA and nine operational spacecraft funded by ESSA have been successfully launched. Current development effort by NASA is to complete the TIROS M spacecraft for launch in second quarter of calendar year 1969. Under TOS Improvements, effort will be continued in the development of advanced sensors and subsystems such as high resolution radiometers and attitude determination systems which will be incorporated into future operational spacecraft. FY 1970 funds are required for post launch support and data acquisition and handling for TIROS M, for continued sensor and subsystems development for TOS Improvements and for a systems definition study for a future spacecraft system (TIROS N).

Nimbus

The objectives of this project are to develop a significantly improved meteorological satellite to provide data for use by the scientific community; to carry out flight tests to prove the applicability of the instrumentation; to fulfill special data requirements of the atmospheric sciences research community which can be provided uniquely by this instrumentation functioning as a space meteorological observatory and to provide the basis for further significant technological advances in meteorological satellites for operational as well as scientific uses. These objectives will be extended in the Nimbus E and F missions to develop an applications observatory in polar orbit at low to medium altitude that will flight test technology and experiments for meteorology and other applications disciplines.

Seven spacecraft are in the series of which two have been successfully launched: Nimbus I, August 28, 1964, and Nimbus II, May 15, 1966. A third spacecraft launch, May 18, 1968, was lost due to launch vehicle failure. Immediately thereafter, action was initiated to provide a replacement for this launch. This mission, identical to the Nimbus B configuration, has been designated B2 and is scheduled to be launched in CY 1969, D in 1970, E in 1972, and F in 1973.

FY 1970 funds are required for continued data acquisition and analysis of spacecraft in orbit; to complete, test and launch Nimbus D; and to continue the development of Nimbus E and F spacecraft and selected experiments.

Synchronous Meteorological Satellite (SMS)

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 larger areas and in much less time than heretofore possible; and (4) provide capability for rapid dissemination of processed meteorological data to local meteorologists.

Feasibility and project definition studies were completed in FY 1968. FY 1970 funds are required to undertake the design and development of two SMS satellites capable of continuous weather observations, analysis of cloud motions through observations that will permit derivation of important wind fields, and for obtaining other significant meteorological data from synchronous altitude.

Meteorological Soundings

The objectives of this project are to investigate the structure and characteristics of the atmosphere through the use of sounding rockets and to develop a small inexpensive meteorological sounding rocket system. Three areas of effort are involved: (1) large research sounding rockets to explore the characteristics and pnenomena of the atmosphere between 30 and about 100 km which is otherwise inaccessible; (2) the development of an inexpensive operational meteorological sounding rocket system capable of reliable launches amenable to the requirements for range support, research, and network operations; (3) sounding rocket field experiment support, which, through cooperation with other countries, provides for the establishment of self-sustaining capabilities for coordinated meteorological sounding rocket launches from sites that will contribute mutually valuable data. Approximately 50 large research rockets and about 125 small development rockets are launched each year. FY 1970 funds are required to procure additional large research and small developmental rockets, flight test various payload experiments, improve rocket performance and to continue field experiment projects with other cooperating countries to obtain additional atmospheric research data.

Cooperative Applications Satellite

This cooperative project between the United States and France in space meteorology consists of developing instrumented balloon techniques to be utilized in conjunction with an earth orbiting satellite for the purpose of obtaining the characteristics of air masses, particularly in-situ measurements of speed and wind direction at various altitudes. The meteorological data obtained will be used by U. S. and French scientists to assist in understanding the structure of the atmosphere and extended weather forecasting capability. One spacecraft and one backup with instruments will be

provided by France. The spacecraft will be launched by NASA in 1970 to gather data from approximately 500 balloons, developed and launched by France in the Southern Hemisphere. Satellite tracking and data acquisition, reduction and analysis will be provided by France, after initial tracking by NASA. The U. S. will provide the Scout launch vehicle, and backup if required, launch services, initial satellite tracking, and analysis, along with France, of the reduced data.

FY 1970 funds are required to continue technical support, procure the Scout launch vehicles, and provide for launch and post launch support.

Applications Technology Satellites

The overall objectives of this project are to design, develop, flight test and evaluate a variety of scientific and technological experiments in the space applications disciplines by use of a series of spacecraft, most of which are launched into synchronous orbit. Seven spacecraft are in the series of which four have been launched to date, one planned for medium altitude and three for synchronous orbit. However, due to launch vehicle anomalies, two planned orbits, medium altitude of ATS II and synchronous orbit of ATS IV, were not achieved. Three additional spacecraft are being developed for launch: ATS-E for launch in CY 1969, F in 1972, and G in 1974. ATS-E will flight test an experimental three-axis gravity gradient stabilization system for spacecraft in geostationary orbit, test a millimeter wave experiment, an L-band communications experiment, and will measure the environment of the geostationary orbit. ATS F and G also will be launched in synchronous orbit to flight test a space erectable parabolic antenna, approximately 30 feet in diameter, and capable of accurate pointing to about .1 degree of arc. A number of additional scientific and technological experiments will also be flight tested on these missions. Effort will also continue in FY 1970 to develop promising advanced experiments which have been defined but have not been assigned to a specific flight mission.

FY 1970 funds are required to complete development of the ATS-E spacecraft and associated experiments in preparation for launch in the third quarter CY 1969, to complete the spacecraft design for ATS F&G, initiate development of these spacecraft and selected experiments, and continue development of advanced applications experiments.

Geodetic Satellites

The objectives of this project are to support the National Geodetic Satellite Program (a joint NASA/DOD/DOC program under NASA management) and to develop the application of geodetic satellite techniques to solid-earth geophysics and oceanography.

Three geodetic satellites have been launched, PAGEOS I, June 23, 1966; GEOS I, November 6, 1965; and GEOS II, January 11, 1968. Data obtained from

these launches are utilized in the establishment of a unified worldwide geodetic datum. Effort will be initiated in FY 1970 for an additional mission (GEOS-C) for launch in late CY 1970, to obtain the additional data required to meet the gravimetric objective of the National Geodetic Satellite Program, and to demonstrate the feasibility of employing a geodetic satellite radar altimeter to measure the mean sea level of the oceans. FY 1970 funds are required for continued data acquisition and analysis, and for preparations for the GEOS-C mission.

Earth Resources Survey

The objectives of this project are to: (1) assess the practical value of remote sensing of earth resources from space; (2) compare the capabilities in earth resources data acquisition of a space system versus aircraft; (3) determine whether, and in what configuration, an operational space-assisted user-oriented earth resources survey system should be pursued; (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 operational system requirements and costs.

This project includes two activities in the earth resources disciplines: (1) an aircraft flight program to develop and test remote sensing techniques, sensors, and data handling systems at altitudes of from 500 feet to above 50,000 feet altitude; and (2) to design, develop, launch, and evaluate two spacecraft carrying earth resources experiments.

The objectives of the aircraft program are to promote the development, modification, calibration, and test of remote sensors being planned for future space missions and to contribute to the development of data handling and analysis techniques needed before earth resources space hardware becomes available. Three aircraft are utilized in this activity, each equipped with a variety of sensors and data handling subsystems to obtain earth resources data. Aircraft flights are conducted over a number of domestic and foreign test sites.

The objectives of the Earth Resources Technology Satellite (ERTS) are to design, develop, launch and test a series of spacecraft conducting a variety of experiments in the earth resources disciplines.

Effort in the earth resources survey is coordinated with other user agencies through the Earth Resources Survey Program Review Committee which includes representatives from Departments of Agriculture, Commerce, Interior, and Navy, and is chaired by NASA.

FY 1970 funds are required to continue aircraft operations, sensor procurement, data processing, and to conduct about 50 flights over 60 test sites and to initiate spacecraft and sensor hardware development for two ERTS spacecraft.

SCHEDULE OF LAUNCHES

Schedule of Significant Research and Development Events

Project	Mission	Calendar Year
TIROS	Launch of TIROS M	1969
TOS and ITOS*	Launch of TOS G, H, and ITOS A-E	1969-1972 (about 2 per yr, subject to call-up by ESSA)
Nimbus	Launch of Nimbus B2	1969
	Launch of Nimbus D	1970
	Launch of Nimbus E	1972
	Launch of Nimbus F	1973
Synchronous Meteorological Satellite	Launch of SMS-A	1971
	Launch of SMS-B	1972
Cooperative Applications Satellite	Launch of CAS-A	1970
	Launch of Back-up (If Required)	1971
Applications Technology Satellites	Launch of ATS-E	1969
	Launch of ATS-F	1972
	Launch of ATS-G	1974
Geodetic Satellites	Launch of Geos C	1970
Earth Resources Technology Satellites	Launch of ERTS-A	1971
	Launch of ERTS-B	1972
INTELSAT**	Launch of INTELSAT III C-E	1969-1970 (subject to call-up by COMSAT)

* ESSA funded.
** COMSAT funded.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1970 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 launch vehicles and related services to support mission requirements and to improve existing vehicles to support future mission needs. Operational vehicles currently being procured are: Scout, Delta, Thor Agena, and Centaur. In addition to these vehicles, initial funding for the Titan III C is also included in FY 1970. Integration of the Centaur stage with the Titan booster is being initiated to support the Viking mission.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1968	1969	1970
Supporting research and technology/ advanced studies	$4,350	$4,000	$4,000
Scout	10,200	12,600	15,700
Delta	33,696	24,000	33,700
Agena	7,999	11,900	7,300
Centaur	68,305	47,700	57,600
Titan III C	---	---	5,900
Total	$124,550	$100,200	$124,200

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology/Advanced Studies

Under this project launch vehicle requirements to support future missions are defined and new technology required for advanced missions is developed in a timely and orderly manner. In FY 1968 and FY 1969 advanced studies efforts have been directed toward the Centaur/Burner II integration, Saturn S-IVB/Centaur integration, and solar-electric propulsion. In FY 1970 advanced studies are planned in the areas of chemical and electric high-energy upper stages. FY 1969 supporting research and technology efforts are being conducted in five disciplines of launch vehicle technology: Propulsion and energy conversion, guidance, control and navigation, instrumentation and electronics, structures and materials, and vehicle engineering. In FY 1970 efforts in these areas will be continued.

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Scout

Scout is the smallest launch vehicle in the NASA vehicle family. It is capable of lifting small payloads into earth orbit and performing small probe and reentry missions. FY 1970 funds for procurement of Scout vehicles will be utilized to purchase vehicle hardware, production systems engineering and management, vehicle checkout and launch services, maintenance and engineering services and vehicle improvements.

Delta

The Delta vehicle is capable of lifting a wide variety of medium-sized payloads into earth orbit or launching smaller payloads into deep space. It has launched more meteorological, communications, and scientific spacecraft than any other NASA vehicle. Its configuration consists of a Thor booster, Delta second stage, and a third stage as necessary to support given missions. FY 1970 funds will be utilized to procure first and second stage vehicles, launch services, and other supporting services. In addition, funding will be necessary for vehicle related engineering support and maintenance of ground support equipment. Vehicle improvements will also be continued.

Agena

The Thor Agena launch vehicle is utilized for polar orbital missions which exceed the capability of the Delta vehicle. The Atlas Agena vehicle was phased out of NASA use during FY 1968. During FY 1970 funds will be required to purchase Agena upper stages and Thor boosters in addition to a variety of launch related activities.

Centaur

The Centaur is the largest vehicle system employed by NASA exclusively for automated space missions. It consists of the Atlas booster and the high energy Centaur upper stage. This vehicle is uniquely qualified to launch high velocity deep space and heavy earth orbital missions. During FY 1970 funds will be utilized for procurement of vehicle hardware for the Orbiting Astronomical Observatory, Mariner-Mars 1971, Pioneer, Planetary Explorer, and Mariner-Mercury 1973 missions. In addition, funds will be necessary for launch services and other supporting activities, for continuation of the Centaur improvement program, and for the Titan Centaur integration.

Titan III C

The Titan III C vehicle is capable of lifting heavy payloads into earth orbit. It consists of two five-segment solid stages and three liquid propellant stages. Titan III C will be procured through the U. S. Air Force which has primary management responsibility for this vehicle. During FY 1970 funds will be needed to initiate procurement of vehicles and services for the Applications Technology Satellite F and G missions.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1970 ESTIMATES

SUMMARY

OFFICE OF UNIVERSITY AFFAIRS — SUSTAINING UNIVERSITY PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The University program includes support from many elements of NASA. University investigators conceive and design the majority of NASA space science experiments, conduct extensive supporting research, advise the agency of policy and technical issues, and, in the process, train thousands of engineers, scientists, and managers for the national aerospace program. Through their participation, universities gain new knowledge and experience necessary to their own advancement and for the development of responsive educational programs.

The Sustaining University program supports university training and research essential to the NASA effort which is outside the responsibility of other NASA organizations. These grants complement project research and field center activities but are generally broader and longer range than project research. Multidisciplinary research and training activities are supported which include the consideration of social and economic implications of scientific and technical advancement as well as those which promote closer working relationships among universities, industry, and NASA Centers. Graduate training, summer fellowships, and research in areas where NASA has identified special needs, such as management of technology and engineering systems design, are supported under the Sustaining University program.

The program is designed to bring the universities into closer partnership with NASA. It helps increase the nation's technological resources by sharing with the universities the responsibility of determining, directing, and assessing research and training pursuits. This support is largely managed by the universities, and thereby provides the distinct benefit of contributing to greater fiscal and academic strength in each university. The program also has the effect of providing greater geographic distribution of research support.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1968	1969	1970
Research	$6,000	$5,000	$5,000
Administration and Management	1,500	1,500	1,500
Engineering Systems Design	1,000	1,000	1,000
Special Training	1,500	1,500	1,500
Total	$10,000	$9,000	$9,000

BASIS OF FUND REQUIREMENTS:

Research

The research element of the Sustaining University program supports activities that are broader in scope and longer range in nature than mission oriented project research. Multidisciplinary approaches to research are stressed and participating universities are given extensive local control and flexibility to assess and respond to broad Agency needs. The emphasis is on multidisciplinary studies that include the social, economic, and public policy aspects of scientific and technical developments. This program also complements NASA's project research and supports activities that encourage the application of aerospace research to the understanding and solution of contemporary human problems.

With a budget of $5 million in FY 1970, the research element of the Sustaining University program will support multidisciplinary programs at 25 universities. A limited number of research projects will be supported at developing institutions in cooperation with NASA Centers.

Administration and Management

The success of future complex technological efforts is becoming increasingly dependent on the education and training of individuals with a much broader understanding of the management process, as well as science and technology. This portion of the program is aimed at supporting those few universities that have a responsibility for education in the fields of administration and management. Students and faculty associated with these programs are encouraged to use the facilities and managerial staff of NASA and similar organizations as a research laboratory to enable them to gain insight into the realistic problems of public management. They are given access to data, systems, and management experiences not usually available.

The $1.5 million in FY 1970 will be allocated to continue support for research and training programs at 10 universities.

Engineering Systems Design

The engineering systems design element brings together the relevant engineering specialists at the doctorate level to create a research team to undertake a major systems design problem, such as a satellite communications system. The design approach uses and promotes the most recent advances in both the engineering and physical sciences and incorporates advanced information and systems theories as part of graduate training programs.

In FY 1970 a budget of $1 million will allow NASA to continue the support of graduate students and supporting research in engineering systems design at five institutions.

Special Training

As aerospace manpower deficiencies are identified, the Sustaining University program responds with special training activities to meet the new conditions and demands. A Summer Faculty Fellowship Program is designed to help young faculty members become familiar with the newest aerospace developments in engineering and science. A faculty fellowship program in systems engineering design brings young faculty members from different engineering and scientific disciplines together to work on space related problems requiring a team approach. Other activities of a specialized nature include summer institutes for upper division undergraduates to acquaint them with some of the substantive problems of space science and engineering; and post-M.D. training in aerospace medicine for a few selected medical doctors.

In FY 1970, $1.5 million is requested for continuation of these specialized training activities.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1970 ESTIMATES

SUMMARY

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY — BASIC RESEARCH PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Basic Research program supports fundamental research in the physical and mathematical sciences. It is aimed at providing an understanding of the physical phenomena pertinent to other NASA programs concerned with current and future aircraft and space activities. This basic research is carried out principally in NASA's Research and Space Flight Centers supplemented by investigations at universities, industrial research laboratories, and other Government research centers. Fundamental understanding of physical phenomena in many fields of science is required to develop the technology for NASA's programs. Basic research in NASA, therefore, must encompass a wide spectrum of disciplines. It ranges from very fundamental studies into the nature and properties of atoms and molecules to the more applied research areas such as determining the best materials for the supersonic transport airplane.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1968	1969	1970
Supporting research and technology.....	$21,465	$21,000	$21,400
Total.....	$21,465	$21,000	$21,400

BASIS OF FUND REQUIREMENTS:

The Basic Research program is divided into four broad disciplines: Fluid Physics, Electrophysics, Materials, and Applied Mathematics.

The Fluid Physics subprogram promotes basic research on aerodynamic and gas dynamic problems relevant to NASA objectives in both aeronautics and space. During the past year the program has been reoriented to emphasize aeronautics problems. In aeronautics, for example, preliminary results show promise for understanding and reducing sonic boom and noise. A program of research on air pollution from aeronautics sources is beginning. Entry research continues with studies primarily concerned with experimental simulation and verification of theories regarding high speed entry.

The objective of the electrophysics subprogram is to obtain a better understanding of fundamental electron-atom-molecule behavior in an environment of acoustic, nuclear, electric, and magnetic forces. The research

results are directly relevant to advancing communications technology, plasma propulsion technology, and the technology associated with several advanced space power supply systems.

The materials subprogram covers a broad spectrum of activities ranging from explorations of the behavior of materials in unusual environments to very fundamental studies to define the relationship between atomic and electronic structure of solids and their physical and mechanical characteristics. Increased emphasis is being placed on those programs which are especially applicable to aeronautics. These include studies of ceramics and polymers for advanced composites for aircraft structures and propulsion systems. Long range studies to determine feasibility of processing materials in space are a recent addition to the program.

The applied mathematics subprogram is aimed at producing the new and improved mathematical techniques required to solve aeronautics and space problems. The areas of interest include the mathematics to optimize the control of spacecraft and the mathematics required for rendezvous and for precise re-entry.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1970 ESTIMATES

SUMMARY

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY — SPACE VEHICLE SYSTEMS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Space Vehicle Systems program is an applied research and technology program dealing with entry vehicle and launch vehicle aerothermodynamics, with launch vehicle and spacecraft structures, with spacecraft environmental protection and control, and with space vehicle design criteria. The objectives of the program are to conduct research in laboratory facilities and by selected flight experiments to: Provide baseline technological information required for decisions relative to new space vehicle mission undertakings; provide the advanced technology for the conception and design of future manned and unmanned spacecraft and for launch vehicles; and encourage and support technological innovations in the approach to space vehicle design to permit new and useful accomplishments.

Although the principal focus for the advanced research and technology efforts is NASA vehicles and missions, the program also recognizes and contributes to related DOD technology needs.

A new activity has been initiated, providing a data bank for the collection and dissemination of information on aerospace safety and providing for research programs in selected areas of aerospace safety.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1968	1969	1970
Research and Technology:			
Space vehicle aerothermodynamics.....	$11,815	$9,605	$8,545
Space vehicle structures.....	9,779	9,771	8,980
Space environmental protection and control.....	10,754	10,550	9,105
Space vehicle design criteria.....	1,752	1,774	1,570
Aerospace safety research.....	---	---	1,800
Total.....	$34,100	$31,700	$30,000

BASIS OF FUND REQUIREMENTS:

Research and Technology

A primary objective of this ongoing research during FY 1970 is development of technology for manned orbital logistics vehicles with the goals of improved economy through land recovery and reuse and improved operational flexibility through greater maneuverability during reentry.

Research will continue also on a number of techniques for terminal descent and landing of semiballistic types of spacecraft like Apollo. Of these, the gliding parawing offers promise for early application, and an ongoing large-scale flight program will continue during FY 1970.

Another major objective is to develop technology for planetary atmospheric probes and hard landers. Also, Parachute/decelerator flight experiments will investigate deployment, performance and reliability of planetary decelerator systems under conditions representative of deployment in the atmosphere of Mars.

Scout-launched reentry technology experiments, which deal with aerothermodynamic aspects of atmosphere entry flight, will continue. A planetary atmosphere experiment will investigate a technique to use special measurements of vehicle motions and heating to determine the properties and composition of an unknown planetary atmosphere. A heat transfer and boundary layer transition experiment will measure heat transfer, map the transition region, and measure the acoustic environment.

The cooperative NASA and USAF Lifting-Body Flight Research program will continue to investigate piloting problems and flying and handling qualities of configurations representing advanced concepts of manned reentry vehicles. During FY 1970, the HL-10 tests will move into the supersonic phase. The X-24A will begin flight tests, and the M-2 will be modified and used as a research tool for investigating advanced lateral control techniques.

Major objectives of the space vehicle structure subprogram relate to establishing new and improved concepts and developing advanced analysis and test techniques to permit future vehicles to achieve appropriate balance between performance, efficiency and cost.

Emphasis will be given to structural concepts for manned lunar exploration involving expandable shelters and airlocks for near-term applications. Critical problems associated with orbital space station structures will be studied also.

Emphasis will be given to improving the effectiveness of structural test programs of launch vehicles to reduce costs without increasing the risk of failure.

Unique structures are being studied to develop feasible concepts for orbiting radio telescopes 1,000 meters in diameter to operate at frequencies lower than 10 megahertz (MHz).

The importance of meteoroid protection increases as space vehicles become larger and mission durations become longer. A flight experiment to investigate the effectiveness of meteoroid bumpers will be undertaken to provide correlation with laboratory investigations. Flight experiments to obtain additional data on both the near-earth and interplanetary meteoroid environments may be included on missions conducted for other purposes.

As more complex space missions are undertaken, the need for active thermal control systems increases also. Emphasis will be placed on development of techniques for more advanced and reliable temperature control of spacecraft.

Two "piggyback" experiments will be carried on the NASA Orbiting Frog Otolith Experiment; one is to verify a new radiation dosimetry technique, the other is to qualify in flight a thin-film meteoroid velocity sensor.

The space vehicle design criteria subprogram develops, documents, and publishes criteria, including models of the environments, that are applicable to the design of space vehicle structures, propulsion systems, and guidance and control systems. The FY 1970 funds will be used to contract for the services of technical experts outside of the Federal Government who have knowledge and experience in fields of current interest.

Aerospace Safety Research

The objective of this new activity is to insure that NASA maintains and pursues an adequate research program to provide information needed for safety. An Aerospace Safety Research and Data Institute has been established at the Lewis Research Center which functions as a central point within NASA for the gathering of technical data and coordination and stimulation of an active research program for increased safety of aerospace activities. Preliminary activities relating to the establishment of the Technical Data Bank and the survey and analysis of ongoing safety-related research and development activities are underway.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1970 ESTIMATES

SUMMARY

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY — ELECTRONICS SYSTEMS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objective of the Electronics Systems program is to identify and support endeavors fundamental to new and continued progress in electronic technology. Component and system progress in terms of performance, reliability, and cost provide the means for timely and efficient attainment of future national goals in aeronautics and space. Research activities are performed both in-house and under contract. In building a base of technology in electronics, NASA has struck a balance between system oriented efforts and efforts to develop new technology applicable to aeronautics and space operations. In addition to the accumulation of fundamental knowledge which can be drawn from over the years, this program includes critically needed techniques and components, particularly those which will be pacing items in future aeronautical and space developments; exploration of more than one possible path to a desired goal; and configuration of selected techniques and components into systems in order to demonstrate their technical feasibility, and collect data on their operational potential and cost effective application.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1968	1969	1970
Supporting research and technology	$37,557	$34,271	$35,000
Flight projects	500	500	---
Total	$38,057	$34,771	$35,000

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

The requested FY 1970 funds are needed to support basic and applied research and advanced technical development efforts in the disciplines related to electronics and control. Avionic components are an integral part of all automatic and semiautomatic systems used in aircraft and manned and unmanned space vehicles. Key systems and components such as communications, flight control, navigation and guidance, computation and data processing, a myriad of sensors, reference and control systems, approach and landing, surveillance and identification, and hazard avoidance depend on electronic equipment. Specific objectives of the guidance program are advanced precision inertial and electromagnetic sensors

and simplified techniques for navigation and guidance applicable to supersonic aircraft and future space vehicles. Increased emphasis on V/STOL aircraft guidance, control and display systems will help realize the promise which V/STOL vehicles have in relieving overloaded transportation systems in major population centers. Advanced research in avionics offers substantial support to various aspects of air traffic control such as communications, navigation, surveillance, and hazard avoidance. Research in communication at higher frequencies (centimeter to millimeter wave lengths) is expected to result in higher information transfer rates, smaller and lighter weight antennas, simpler power generation equipment. Continued advancements in the technology of computing and data processing are required to keep pace with the growing complexity, variety and volume of data attendant to the experimental development and operation of advanced aeronautical and space vehicles; the end objective is to facilitate the acquisition and extraction of useful information for human users. Instrumentation research will be continued to advance measurement capabilities in the far ultraviolet and soft X-ray regions. Development of instrumentation systems will be carried on using laser technology for accurate measurement of gas parameters and flow field characteristics of test models at hypersonic speeds. Research in solid state technology with emphasis on integrated circuits in which many components are combined into one functional assembly of minute weight and size for aerospace application will be continued; integral to the program is the search for materials and techniques to provide longer useful lifetimes of components and a consequent reduction in cost of both system and component testing.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1970 ESTIMATES

SUMMARY

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY HUMAN FACTOR SYSTEMS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objective of the Human Factor Systems program is to provide the essential research data and the technology necessary to ensure the safe and proper participation of man in advanced aeronautical and space missions and to further the development of the systems necessary to sustain him. The program elements include: (1) Human Research and Performance, (2) Life Support and Protective Systems, (3) Man-Systems Integration, and (4) Advanced Concepts. The program efforts are concentrated on the measurement of stress in man and animals under the unique environmental factors of aeronautical and space missions, particularly the relationships of stress to the operators' safety, performance, and proper utilization. These measurements are made in controlled simulation studies and validated by essential flight experiments. The life support technology effort is concentrating on providing advanced technology for efficient, reliable, and maintainable long duration subsystems. These are assembled into complete environmental control systems and tested in long duration manned space cabin simulator tests.

The work is accomplished through a multidisciplinary approach which includes research in physiology, psychology, medicine, biology, engineering, physics, chemistry, and electronics at NASA Centers, Department of Defense aerospace medical laboratories, other Government facilities, universities, and industry.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1968	1969	1970
Supporting research and technology.....	$18,228	$17,910	$21,600
Biotechnology flight projects.....	1,600	1,790	2,000
Total.....	$19,828	$19,700	$23,600

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

This is an integrated program effort directed toward fulfillment of the Human Factor Systems program objectives. In FY 1970, emphasis will be given to investigations to define and understand such phenomena as changes in man's

cardiovascular function due to prolonged exposure to zero gravity and other space flight stressors, behavioral changes in small groups of men isolated and confined for extended periods, the unique design features necessary to ensure the highest reliability of life support and protective systems, and the psychological and physiological effects of aircraft noise. These and other problem areas require research in cardiovascular, respiratory, and vestibular physiology; in bioinstrumentation, to measure the effects of stresses on man and animals; in radiobiology, stress endocrinology, and microbiology; in water and waste management; in oxygen regeneration and air pollution control; in space suits; in extravehicular activities; in man-machine interactions, and in many more areas. The work is directed toward defining and solving known and anticipated problems in future aeronautical and space operations.

Biotechnology Flight Projects

The small flight experiments are designed to provide information necessary to qualify man and his support equipment for extended space flight. In FY 1970, work will continue on experiments which will examine the total physiological effects of prolonged weightlessness (90 days or more) on a small primate; ascertain the need of induced or artificial gravitational force in space vehicles; and test life support and protective equipment designed to function in zero gravity. The study to determine the characteristics of an earth orbiting biotechnology laboratory will be continued and expanded. Further work will be done on preparing experiments on vision in the lunar environment; these will include investigations in color perception, contrast, and distance judgments under conditions of no atmospheric scattering of light. A Scout launch is scheduled for a vestibular experiment to study the action in weightlessness of the basic cells in the frog's balance mechanisms which is similar to that in man's inner ear.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1970 ESTIMATES

SUMMARY

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY

SPACE POWER AND ELECTRIC PROPULSION SYSTEMS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The primary objectives of the Space Power and Electric Propulsion program are to: (1) establish or advance the state-of-the-art of a limited number of systems and components having the greatest potential of satisfying estimated future mission requirements to the point where there is a high degree of confidence in their ultimate successful development, and (2) effect a timely and orderly introduction of the new or advanced technology emanating from the program.

Current estimates of potential future mission power system requirements encompass a wide range of power, life and mission environments. No one power system can meet these varied requirements. The space power program is aimed at providing the research and technology necessary for the improvement and/or development of a limited number of solar, chemical and nuclear systems for anticipated auxiliary power and electric propulsion mission requirements ranging from watts to kilowatts in the 1970's to megawatts in the 1980's.

The early application of solar powered electric thrusters for spacecraft position control and for small, automated, interplanetary spacecraft continues to be a major goal of the electric propulsion program. The experience to date from the ATS (Applications Technology Satellite) flight program, coupled with the design and ground evaluation of typical thruster systems, confirms their potential advantages of spacecraft operational flexibility and simplicity, increased payload or decreased trip time, or reduced spacecraft weight. The proposed SERT II (Space Electric Rocket Test) flight, the continuing ATS program, and the ground technology program are essential steps toward the goal of early application.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1968	1969	1970
Supporting research and technology	$42,385	$40,700	$39,400
SNAP-8 technology	(7,500)*	(5,000)*	(5,000)*
Space electric rocket test (SERT)	1,350	1,500	500
Total	$43,735	$42,200	$39,900

*Included in the Supporting Research and Technology.

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BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

The nuclear power system technology program is focused on a limited number of energy conversion concepts to meet a broad range of potential space power requirements that may grow from watts to kilowatts in the 1970's, to megawatts in the 1980's and beyond. This broad power range is being met by technical emphasis on both static and dynamic conversion systems including thermoelectric, Brayton, SNAP-8, advanced Rankine, and thermionic conversion systems. The technology underlying these systems is difficult and long range requiring sustained effort to establish engineering data on new materials, components, subsystems and systems under conditions of temperatures, life and reliability never before achieved in power systems.

Emphasis in the FY 1970 solar power generation program will be placed on obtaining improved understanding of the structural dynamic characteristics of large area solar cell arrays. In addition, technological advances in the electromechanical drive systems needed to turn the large solar cell arrays to track the sun will be pushed. Methods for compact stowage during launch, and reliable, automatic deployment once in space, will be pursued for these high power solar cell arrays. Major advances in the resistance of solar cells to degradation in the space environment will be sought in FY 1970.

An urgent need exists in FY 1970 to advance the technology required for distribution, regulation, and control of space vehicle electrical power. The electrical components and circuits needed to perform these critical functions continue to be inadequate. Deficiencies in these power processing equipments have been the cause of spacecraft failures in recent years. Efforts to advance this technology must be increased in FY 1970 if reliable, long life power systems are to be possible in the future.

A major goal of the chemical power program in FY 1970 continues to be the development of nondestructive test methods that would permit a determination of rechargeable battery life expectancy from tests performed for less than 1% of battery life. The development of such a test program would contribute substantially to increased battery life and reliability. A second major goal in FY 1970 is the work to achieve impact resistant, heat sterilizeable batteries for use on planetary landing capsules. Emphasis will turn toward larger batteries for higher power and toward remote activation to avoid deterioration during the extended travel time required to reach the planets.

The electric thruster technology program continues to make progress toward the goal of early mission application. During FY 1969, such systems have seen their first NASA operational flight in the Applications Technology Satellite (ATS) program where accurate production of very low thrust for accomplishing east-west station keeping was the principal advantage sought and realized. During FY 1970 the electric propulsion program will focus on the high, specific impulse ion thruster system with electric thrust vectoring capability which shows to advantage in long duration missions for both auxiliary and prime propulsion applications. Work on the high temperature resistojet and the use

of biowastes as propellants from the life support system for manned space stations will also continue.

The flight safety program provides coordination and direction for the NASA portion of the joint AEC/DoD/NASA reviews and analyses of proposed missions utilizing nuclear space power systems, provides guidelines for future mission applications, develops specific design information in areas where NASA has special competence, and the recovery of NASA launched spacecraft carrying nuclear materials, when feasible.

Space Electric Rocket Test (SERT)

The SERT flight program's overall objective is to provide information on the operation of electric thruster systems in the space environment. The SERT II orbital flight has as its primary objective the verification of long term electron bombardment ion engine performance in space. The spacecraft will also carry experiments aimed at assessing possible electric propulsion spacecraft interactions. SERT II is considered to be the next major step in the development of electric propulsion for prime propulsion of interplanetary spacecraft. The launch is scheduled for CY 1969 using the Thorad Agena launch vehicle from the Western Test Range. The FY 1970 funds are required for launch support and data reduction.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1970 ESTIMATES

SUMMARY

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY — NUCLEAR ROCKETS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objective of the Nuclear Rockets program is to provide rocket propulsion systems for application to advanced orbital, lunar and planetary missions. In carrying out this objective, the AEC-NASA Space Nuclear Propulsion Office is conducting a detailed program of system analysis, design, development and testing to provide a 75,000 pound thrust NERVA engine capable of performing advanced space missions. Engine development is proceeding using the base of technology established through the Phoebus and NERVA technology programs.

The Nuclear Rockets program activities to be conducted in FY 1970 include, for NERVA development, the establishment of the final engine design; the procurement, fabrication and testing of component development hardware; and the initiation of procurement of nozzle forgings and other long leadtime hardware for the first development reactor and engine. In addition, the design of Engine Test Stand No. 1 (ETS-1) modifications will be established and a contract will be initiated for the fabrication of the new exhaust duct for NERVA engine testing.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1968	1969	1970
Supporting research and technology...	$12,500	$6,000	$8,000
NERVA.....	37,500	22,200	27,500
NRDS operations	4,000	3,800	1,000
Total.....	$54,000	$32,000	$36,500

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

The supporting research and technology effort (SR&T) covers a very broad spectrum of programs, most of which are of relatively small dollar value. The general aims are: (1) to provide support to the NERVA engine design and development program; (2) to extend the technology for solid-core, nuclear rocket systems beyond current performance levels; (3) to establish the technology base required for nuclear stage development; and (4) to investigate the feasibility of advanced propulsion concepts.

NERVA

The prime output of the Nuclear Rockets program will be a nuclear engine, developed through Pre-Flight Rating Tests (PFRT), having a specific impulse of approximately 825 seconds, and a thrust of about 75,000 pounds (approximately 1500 megawatts of reactor power). This engine will provide a major advance in propulsion capability. A nuclear stage would be capable of performing a wide variety of advanced space missions, beyond the performance potential of chemical rocketry. It can greatly extend the usefulness of the Saturn V launch vehicle, can be used effectively in Space Propulsion of rendezvoused payloads and as an upper stage for low cost boosters.

NRDS Operations

The Nuclear Rocket Development Station is the national site for the ground, static-testing of nuclear rocket reactors and engines. Eventually, it will be used to test the propulsion modules or rocket stages associated with flight development. The funding in this area provides for NASA's share of the general site operations, the major portion of which is supported by the AEC.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1970 ESTIMATES

SUMMARY

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY CHEMICAL PROPULSION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Chemical Propulsion program has the objective of providing required technology to permit the straightforward development of advanced chemical rocket systems necessary for the nation's future space mission. Elements of this program are: (1) identification of future mission propulsion requirements; (2) research into fundamental propulsion concepts to meet these requirements; (3) study of principal design parameters; (4) investigation of sound technical solutions to key design problems; (5) development of experimental design, fabrication, and test techniques; (6) demonstration of experimental engines and motors and, (7) evaluation of concepts and verification of technical capability to meet the mission requirements.

The development of advanced propulsion systems to meet future space program needs for launch vehicles and spacecraft requires a carefully planned technology base which should precede the actual system development phase by many years.

Applied research and experimental work is directed toward two primary types of propulsion: systems using liquid propellants and motors which use solid propellants. Hybrid chemical propellant systems which use both liquid and solid propellants are also included. Thrust levels range from millipounds to several million pounds and applications range from small attitude stabilization thrusters for spacecraft to very large motors for first stages of future launch vehicles. This program is directed to find solutions to these requirements which are reliable, economical, and expeditious.

Propulsion processes, performance improvement, combustion problems, engine design, engine materials, and fabrication techniques are major categories of active research. In addition, propellant physical properties, and chemical reaction phenomena, as they relate to advanced propulsion systems, are explored and reported. The basic technological investigations are supported by complementary system demonstration programs, which have the purpose of establishing the validity of the advanced propulsion systems concepts generated by the program.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1968	1969	1970
Supporting research and technology.....	$33,537	$28,900	$25,100
Large solid motor project.....	3,500	---	---
Total.....	$37,037	$28,900	$25,100

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

High performance liquid, solid, and hybrid propellants are being examined for use in launching payloads at low cost and for use in orbital, lunar, solar, and planetary space systems. High performance propellants can be translated into greater payload capability or into carrying the necessary payload with a smaller launch and space vehicle system. The work extends the use of hydrogen fuel as a rocket propellant for space missions and is examining the use of high density mild cryogenic oxidizers and fuels for certain long duration in space missions. A strong effort in simplified, relatively low-cost engine systems for launch vehicle systems will be continued. New propulsion concepts and advanced engine designs to improve the capabilities for transporting and maneuvering payloads in the solar space environment are being explored.

Research on solid propellant motor systems includes nondestructive testing techniques for inspection and qualification of loaded motors, ignition, methods of combustion termination and restart, and improved predictability of propellant burning rate.

Experimental engineering programs in liquid and solid propellant motors verify research design and data extrapolations by demonstration tests of breadboard systems. Very often such tests disclose new problems that require continued research effort. The experience helps greatly in defining the appropriate design criteria, cycle selection, and operating conditions for such new equipment. The work involves the design, fabrication and test of experimental components and systems to determine their practicality, providing a sound basis for selection of advanced propulsion equipment. It furthermore provides a clear indication of design and test methods that will reduce the cost of development and production of these equipments. Fabrication process specifications, development procedures, costs, schedules, facility and special equipment requirements, can be assessed as a result of such work.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1970 ESTIMATES

SUMMARY

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY — AERONAUTICAL VEHICLES PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The role of the Aeronautical Vehicles program is to provide continued improvements in the safety, efficiency and utility of all classes of military and commercial aircraft. Advanced data for the design of new aircraft, technological advances needed to develop safer and superior commercial aircraft, and leadership in the generation of advanced aircraft concepts are integral parts of the program. Effort in the advanced research and technology disciplinary areas of aerodynamics, loads and structures, propulsion, operating environment and flight dynamics; plus proof-of-concept effort in the general aviation, V/STOL, subsonic, supersonic and hypersonic aircraft areas, is conducted in furtherance of the above objectives. Proof-of-concept activity is system integration technology whereby full scale operating systems are used to extend laboratory technology in system elements. The programs in these areas encompass work in materials, noise and sonic boom, operational aspects, propulsion system and airframe integration, and the relationships which exist between the pilot and the total aircraft system.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1968	1969	1970
Advanced research.....	$12,800	$16,891	$21,785
General aviation aircraft technology.....	450	535	500
V/STOL aircraft technology.....	7,057	8,740	11,250
Subsonic aircraft technology.....	7,905	17,046	16,190
Supersonic aircraft technology....	24,050	21,893	20,900
Hypersonic aircraft technology....	14,538	9,795	8,275
Total.....	$66,800	$74,900	$78,900

Advanced Research

Advanced research in aircraft aerodynamics is a continuing investigation of airflows determining flight performance, stability, and control. The program in this area embraces the subsonic, transonic, supersonic, and hypersonic flight regimes involved in advanced aeronautical vehicles. Funds are required for extensions of basic studies on the supercritical wing and its adaption to transonic aircraft, development of theory and computer programs for analyzing supersonic aircraft configurations with respect to performance optimization and sonic boom minimization, and application of fluid physics to the critical aerodynamic problems of hypersonic cruise flight. Provision has been made for upgrading of critical wind tunnel facilities as well as for the operational support required to increase their effectiveness.

The underlying goal of the loads and structures program is the achievement of lighter weight airframes which exhibit superior reliability and safety. The program involves analytical and experimental studies of the structural environment and the structural behavior and response to this environment, including the evaluation of new concepts. Included are basic studies of the structural response to gust loads, evaluation of gust alleviation systems, buffeting and flutter, structural fatigue, the use of composite materials to achieve lighter weight airframes, and the development of improved stress analysis procedures.

The primary goals of the Advanced Research air breathing propulsion program are to provide advanced technology through analytical and experimental investigations of engine components and propulsion concepts which either are not readily identified with a specific flight spectrum or else identified over a broad flight spectrum. Included are research studies of: basic mechanism of fan and compressor noise generation and suppression, jet exhaust noise suppression, development of engine noise prediction techniques, technological assessment of nuclear power for aircraft use, and smoke suppression of jet engines. Basic studies will be continued on advanced bearing and lubrication systems, and on aircraft-propulsion system integration problems.

The research effort in the aircraft operating environment program is aimed at solving general problems associated with the runway and flight environments, flight safety, noise, flight instrumentation and sonic boom. It involves theoretical analyses and laboratory and flight test experiments to validate current engineering procedures and develop solutions to aircraft operational problems. The results provide the research for safer and quieter aircraft operations and the basic environmental design data for application to specific classes of aircraft.

The flight dynamics research program is aimed at the determination of the dynamic interaction and the fundamental relationships between the pilot and the cockpit displays, aircraft control system characteristics, aircraft flight response behavior and the required flight path performance. It involves theoretical analyses, ground based simulator studies and measurements in the real flight environment to investigate basic handling qualities factors. The

program also includes studies of improved methods for aircraft control and of improved test techniques, and research to establish more realistic piloted flight simulators.

General Aviation Aircraft Technology

The general aviation industry continues to exhibit rapid growth, especially in the area of the scheduled air taxi operation (so-called third level carrier, mini-airlines, etc.) where the small airplane is providing air transportation links between small communities and major air terminals. In order to assure a continuing increase in the level of operational safety and utility, the NASA is conducting research to provide the necessary technology base which the industry and FAA can use for constantly improving these aircraft. The program encompasses aerodynamics, structures, and flight dynamics technology which, coupled to the effort in the operating environment area, is already beginning to fill the technology gaps in the general aviation area.

V/STOL Aircraft Technology

Technology effort will be increased both in the disciplinary and proof-of-concept areas. Particular emphasis will be given in continuing wind tunnel and analytical studies to providing basic information to support the design of advanced lift-fan and rotor V/STOL concepts. General flight research will utilize, for example, the newly-acquired XC-142 tilt-wing and XV-5B lift-fan vehicles. These studies will add to the limited information now available, enabling the establishment of more reliable criteria on which low speed control and handling qualities requirements for future V/STOL aircraft designs will be based.

More specific, proof-of-concept type programs will be initiated to evaluate in flight two concepts for providing significantly improved short-take-off and landing aircraft: one for prop-driven and one for jet-propelled transports. Similar programs will be started leading to verification of two promising rotor concepts aimed at improving the cruise performance and reducing the vibration of conventional helicopters.

Another program will be initiated to provide the XV-5B research airplane with higher-performance lift-fans and an improved control system enabling handling quality research over a broader envelope of take-off and descent conditions more representative of future production V/STOL aircraft.

Subsonic Aircraft Technology

Technology work on subsonic aircraft is oriented toward safety of flight, improvement of flight efficiency and the reduction of noise. In the disciplinary areas, aerodynamic technology will be conducted on advanced aircraft configurations with particular emphasis on seeking favorable flow interactions between airframes and high by-pass ratio turbofan engines. Structures research applicable to subsonic commerical aircraft will include studies of structural loads and environment, fatigue and the development of improved crack detection

techniques. Propulsion technology will seek to improve the efficiency, utility and safety of present and advanced subsonic aircraft propulsion system concepts and to provide supporting in-house technology for the Quiet Engine Project. Included are analytical and experimental research studies of high performance, low noise fans, compressors, combustors and turbines and studies of problems related to the integration of the Quiet Engine with subsonic aircraft. Flight dynamics research will be concentrated on investigation of handling qualities and operational techniques of subsonic jet transports to provide a more rational foundation for certification criteria, studies of pilot-managed automatic flight control in terminal area operations, and tests of improved vertical situation displays for noise abatement steep approaches.

In FY 1969 a program was initiated to study supercritical airfoils in flight through the modification of an F-8 aircraft on loan from the Navy. In FY 1970 the modified aircraft will be instrumented and flight tested.

In continuing to provide the full research and technology support required by the Interagency Aircraft Noise Abatement Program, the NASA will conclude the nacelle fan noise minimization program by conducting flight tests of choked inlet nacelles (final configurations of acoustically treated nacelles will have been completed in FY 1969) and fabricating and testing components for the Quiet Engine project.

Supersonic Aircraft Technology

The supersonic aircraft technology effort is directed toward advancing the state-of-the-art in the technical disciplines specifically related to both civil and military supersonic aircraft. Broad based technology programs have been generated aimed at classes of problems whose results are applicable to these airplane requirements. Such a program is pointed necessarily at new and advanced configurational development through removal of state-of-the-art gaps that may restrict utilization of the supersonic flight regime.

By interagency agreement, NASA will continue to provide technical support and assistance to the FAA in the evolution of the U. S. prototype supersonic transport. Design problems arising during the current development have indicated several areas wherein improvements can be achieved through the planned research program. In addition, technology directed at advanced supersonic transport configurations is a major element of the program.

NASA will continue to provide technical assistance to the Navy and Air Force in the evolution of the proposed VFX, FX and AMSA airplanes. Based upon presentations made by potential airframe and engine contractors, a NASA research program was formulated to generate solutions to potential technical problems. This program involving a number of technical disciplines is being actively pursued.

Utilizing an F-111A aircraft, measurements of high-frequency inlet airflow oscillations are continuing. In addition, flight tests of a boron composite

horizontal tail and an investigation of aerodynamic buffet will be made.

Performance and aerodynamic data obtained during flight from a YF-12A airplane will be compared with information from ground based facilities, in order to assess the validity of current analytical and experimental procedures.

Hypersonic Aircraft Technology

At the present early stage in the development of hydrogen fueled air-breathing hypersonic airplanes, optimum configuration concepts are not clearly defined. Parametric studies of complete configuration designs are being performed in sufficient depth to resolve this problem and evaluate realistic potentials for these aircraft. In these studies, tradeoffs among the aerodynamic, structural and propulsion disciplines will be evaluated from flight-profile analyses.

As vehicle concepts are developed, experimental model studies will continue to be made over the required operating speed range. The general performance level of hypersonic propulsion systems, utilizing subsonic and/or supersonic combustion, and their effect on the performance of hypersonic aircraft, is to be determined. To obtain satisfactory aerodynamic characteristics, tests of configuration modifications will be conducted. Various structural concepts that offer the least weight and thermal protection systems will be investigated.

The hypersonic research engine proof-of-concept program, initiated in FY 1965, continues to furnish design information for hypersonic propulsion systems. A boilerplate engine, which will incorporate the most advanced aerothermodynamic technology developed during the program, will be tested at the Lewis Research Center's Plum Brook Facility.

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. In addition, 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, for insuring the safety of the astronauts.

Tracking and data acquisition support is provided by a worldwide network of NASA ground stations supplemented by appropriate instrumentation ships, 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 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)		
	1968	1969	1970
Operations.....	$211,483	$226,950	$239,400
Equipment.....	51,567	41,222	46,100
Supporting research and technology.....	12,800	11,500	12,500
Total.....	$275,850	$279,672	$298,000

BASIS OF FUND REQUIREMENTS:

Operations

Funds are required for the operation and maintenance of the worldwide tracking and data acquisition facilities. A significant portion of the increase from FY 1969 to FY 1970 is attributable to the operation of the Manned Space Flight Network in support of the Apollo program. Reimbursement for an increase in services provided by DOD, and provision of funds to cover a full year's cost of a limited second shift of personnel, contribute to the increase in FY 1970 for the operation of this network.

In the Deep Space Network, additional engineering effort is necessary as the network capability evolves from one of basically lunar support to one of planetary support involving multiple spacecraft. A small increase in Satellite Network operations is required in FY 1970 to provide for the operation of selected control centers at Goddard Space Flight Center and for cost-of-living additions.

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 for approved and planned programs. Funds for equipment are required to replace obsolete and wornout items, to modify existing systems to maintain compatibility with changes in 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 and planned programs. In FY 1970, emphasis will continue on sustaining the existing capability of the networks with only minor augmentations of equipment to meet the requirements of new programs such as the Earth Resources Technology Satellite (ERTS).

Supporting Research and Technology

Supporting Research and Technology is the activity whereby concepts, techniques, and hardware are developed, tested, and evaluated for use in the networks to meet support requirements of new flight projects. In FY 1970, emphasis will continue on assessing network responsiveness and operating techniques which show promise of improving network effectiveness in terms of cost and performance.

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RESEARCH AND DEVELOPMENT

FISCAL YEAR 1970 ESTIMATES

SUMMARY

OFFICE OF TECHNOLOGY UTILIZATION — TECHNOLOGY UTILIZATION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

This program provides a necessary follow-on to all government supported programs in line with the principle that techniques and methods discovered and/or developed with public support should be made available to the public expeditiously for their benefit. Those techniques and methods which are of direct benefit to the aeronautical and space communities almost automatically are put to use throughout that community. However, there are inevitably discoveries and developments in any line of research which are of potential benefit to users outside of the developing community. It is the purpose of the program to uncover such useful discoveries and provide a mechanism for making them known and available to the general public. In addition, this program provides a similar service in connection with management techniques for large, complex research and development activities by giving wide dissemination to new systems and concepts in this area.

The primary objectives of the 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; (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)		
	1968	1969	1970
Identification and publication.....	$1,500	$1,600	$1,700
Evaluation.....	700	800	950
Dissemination.....	1,600	1,400	2,350
Analysis.....	200	---	---
Total.....	$4,000	$3,800	$5,000

BASIS OF FUND REQUIREMENTS:

Identification and Publication

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. Continued increased emphasis is placed on the identification and reporting of new technology by NASA contractors.

Evaluation

Personnel at NASA installations and research institutes evaluate the new technology so identified, determine its novelty, significance and potential nonaerospace industrial application and utility and prepare reports which are published and made available to the scientific, industrial and academic communities. In addition, NASA personnel and research institute personnel are continually evaluating technology transfer mechanisms and feeding the new knowledge back into the Technology Utilization program.

Dissemination

This program element is accomplished by the employment of regional dissemination centers that store, retrieve and interpret, the new technology developed by NASA for local industry. Biomedical application teams are also employed to assist researchers in defining and solving medical problems by adaptation of NASA technology. In addition, Government developed computer software is evaluated and disseminated to industry. Cooperative programs are underway with several other agencies such as the Bureau of Reclamation, Law Enforcement Assistance Administration, Social Rehabilitation Service of HEW, Small Business Administration, Atomic Energy Commission and others to disseminate applicable new technology developed by NASA.

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, [$21,800,000] *$58,200,000*, 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, 1969; 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 0107-0-1-251	Budget plan (amounts for construction of facilities actions programed)			Costs and obligations		
	1968 actual	1969 estimate	1970 estimate	1968 actual	1969 estimate	1970 estimate
Program by activities:						
Direct program:						
1. Manned space flight	21,340	10,414	14,250	54,403	22,000	17,000
2. Scientific investigations in space	3,595	1,925	1,595	7,416	6,000	4,000
3. Space applications	----------	----------	----------	10	----------	----------
4. Space technology	2,115	386	8,088	14,824	15,000	11,000
5. Aircraft technology	3,170	----------	4,767	4,910	10,000	6,000
6. Supporting activities	3,285	22,975	29,500	12,408	15,000	22,000
Total direct program costs, funded	33,505	35,700	58,200	93,971	68,000	60,000
Reimbursable program:						
3. Space applications	----------	----------	----------	111	35	----------
Total program costs, funded	----------	----------	----------	94,081	68,035	60,000
Change in selected resources [1]	----------	----------	----------	−29,563	36,934	−1,800
10 Total	33,505	35,700	58,200	64,518	104,969	58,200
Financing:						
21 Unobligated balance available, start of year, for completion of prior year budget plans	----------	----------	----------	−95,386	−69,269	----------
22 Unobligated balance transferred from other accounts	----------	----------	----------	−600	----------	----------
Reprograming to prior year budget plans	4,295	----------	----------	----------	----------	----------
24 Unobligated balance available, end of year, for completion of prior year budget plans	----------	----------	----------	69,269	----------	----------
Budget authority	37,800	35,700	58,200	37,800	35,700	58,200

CONSTRUCTION OF FACILITIES—Continued

Program and Financing (in thousands of dollars)—**Continued**

Identification code 27-00-0107-0-1-251	Budget plan (amounts for construction of facilities actions programed)			Costs and obligations		
	1968 actual	1969 estimate	1970 estimate	1968 actual	1969 estimate	1970 estimate
Budget authority:						
40 Appropriation	35,900	21,800	58,200	35,900	21,800	58,200
42 Transferred from other accounts	1,900	13,900	----------	1,900	13,900	----------
43 **Appropriation (adjusted)**	**37,800**	**35,700**	**58,200**	**37,800**	**35,700**	**58,200**
Relation of obligations to outlays:						
71 Obligations incurred, net				64,518	104,969	58,200
72 Obligated balance, start of year				145,043	83,464	118,433
74 Obligated balance, end of year				−83,464	−118,433	−116,633
90 Outlays				126,097	70,000	60,000

Note.—Reconciliation of budget plan to obligations:	*1968 actual*	*1969 estimate*	*1970 estimate*
Total budget plan	33,505	35,700	58,200
Deduct portion of budget plan to be obligated in subsequent years	20,498	-------	------
Add obligations of prior year budget plans	51,511	69,269	------
Total obligations	64,518	104,969	58,200

[1] Selected resources as of June 30 are as follows:	*1967*	*1968*	*1969*	*1970*
Unpaid undelivered orders	82,061	52,498	89,432	87,632
Advances	1	------	------	------
Total selected resources	82,062	52,498	89,432	87,632

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1970 ESTIMATES

SUMMARY OF CONSTRUCTION OF FACILITIES BUDGET PLAN BY LOCATION

Location	Fiscal Year 1968	Fiscal Year 1969	Fiscal Year 1970
	(Thousands of dollars)		
Ames Research Center.....	$ 3,170	$ 386	$ ---
Electronics Research Center.....	---	---	8,088
Goddard Space Flight Center.....	565	---	670
Jet Propulsion Laboratory.....	1,930	---	---
John F. Kennedy Space Center, NASA.....	21,632	9,014	12,500
Langley Research Center.....	---	---	4,767
Lewis Research Center.....	2,115	---	---
Manned Spacecraft Center.....	750	1,333	1,750
Marshall Space Flight Center....	823	---	---
Michoud Assembly Facility.....	425	400	---
Wallops Station.....	740	275	500
Various Locations.....	---	23,292	26,425
Facility Planning and Design....	1,355	1,000	3,500
Total.....	$33,505	$35,700	$58,200

The geographic location of NASA installations is shown on the map under the Summary Information tab. Installations for which construction projects are requested in the fiscal year 1970 budget are identified thereon.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

INSTALLATION SUMMARY

CONSTRUCTION OF FACILITIES

FISCAL YEAR 19 70 BUDGET ESTIMATES

(Dollars in thousands)

NASA INSTALLATION		COGNIZANT PROGRAM OFFICE FOR INSTALLATION
Electronics Research Center		Advanced Research and Technology
LOCATION OF INSTALLATION	COUNTY	NEAREST CITY
Cambridge, Massachusetts	Middlesex	Cambridge, Massachusetts

INSTALLATION MISSION

The mission of the Electronics Research Center is to increase the nation's capability in space by providing the knowledge and advanced technology needed to improve performance and reliability of space and aeronautical electronic systems and components. The Center organizes, manages, and conducts a comprehensive program of basic and applied aerospace electronics research. It also provides a focal point for national aerospace electronics research, coordinating nation-wide research efforts and sponsoring electronics research conducted by industry, universities, and private institutions.

PROJECT LINE ITEM	COGNIZANT OFFICE	FY 1959 THRU CURRENT YR	FY 1970 (Estimated)	FUTURE YEARS (Estimated)	TOTAL ALL YEARS (Estimated)
Computer/Instrumentation Research Laboratory	ART	255	6,962		7,217
Center Support Facilities III	ART	66	1,126		1,192
TOTAL			8,088		

CF 7 NASA-HQ

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

INSTALLATION SUMMARY

CONSTRUCTION OF FACILITIES

FISCAL YEAR 19 70 BUDGET ESTIMATES

(Dollars in thousands)

NASA INSTALLATION		COGNIZANT PROGRAM OFFICE FOR INSTALLATION
Goddard Space Flight Center		Space Science and Applications
LOCATION OF INSTALLATION	COUNTY	NEAREST CITY
Greenbelt, Maryland	Prince George's	Greenbelt, Maryland

INSTALLATION MISSION

This Center is responsible for complete development of unmanned sounding rockets and orbiting spacecraft experiments in basic and applied science. The work covers scientific satellites, and communications and weather satellites which orbit in cislunar space (region between the earth and moon). In addition, the Center manages NASA's Delta rocket and two world-wide tracking, data acquisition and data reduction networks.

PROJECT LINE ITEM	COGNIZANT OFFICE	FY 1959 THRU CURRENT YR	FY 1970 (Estimated)	FUTURE YEARS (Estimated)	TOTAL ALL YEARS (Estimated)
Fire Protection and Prevention Modifications	SSA	57	670		727
TOTAL			670		

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

INSTALLATION SUMMARY

CONSTRUCTION OF FACILITIES

FISCAL YEAR 19 70 BUDGET ESTIMATES

(Dollars in thousands)

NASA INSTALLATION	COGNIZANT PROGRAM OFFICE FOR INSTALLATION
John F. Kennedy Space Center, NASA	Manned Space Flight

LOCATION OF INSTALLATION	COUNTY	NEAREST CITY
Merritt Island, Florida	Brevard	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 19 59 THRU CURRENT YR	FY 19 70 (Estimated)	FUTURE YEARS (Estimated)	TOTAL ALL YEARS (Estimated)
Launch Complexes 34 and 37	MSF	104,168	8,000		112,168
Manned Spacecraft Facilities Modifications	MSF	46,205	1,000		47,205
Utility Installations	MSF	66,313	3,300		69,613
High Pressure Gas Maintenance Facility	MSF	12	200		212
TOTAL			12,500		

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

INSTALLATION SUMMARY

CONSTRUCTION OF FACILITIES

FISCAL YEAR 19 70 BUDGET ESTIMATES

(Dollars in thousands)

NASA INSTALLATION		COGNIZANT PROGRAM OFFICE FOR INSTALLATION
Langley Research Center		Advanced Research and Technology
LOCATION OF INSTALLATION	**COUNTY**	**NEAREST CITY**
Langley Station Hampton, Virginia	---	Hampton, Virginia

INSTALLATION MISSION

The Center undertakes research to provide a technical base for such missions as: (1) Manned and unmanned exploration of space; (2) Improvement of performance and utility of airborne flight. The Center plans, develops, and operates necessary facilities; generates new and advanced concepts; provides research advice and assistance to other branches of the government; disseminates scientific and technical information; searches for and identifies potential industrial applications involved in the course of research.

PROJECT LINE ITEM	COGNIZANT OFFICE	FY 19 59 THRU CURRENT YR	FY 19 70 *(Estimated)*	FUTURE YEARS *(Estimated)*	TOTAL ALL YEARS *(Estimated)*
Aircraft Noise Reduction Laboratory	ART	332	4,767		5,099
TOTAL			4,767		

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

INSTALLATION SUMMARY

CONSTRUCTION OF FACILITIES

FISCAL YEAR 19 70 BUDGET ESTIMATES

(Dollars in thousands)

NASA INSTALLATION		COGNIZANT PROGRAM OFFICE FOR INSTALLATION
Manned Spacecraft Center		Manned Space Flight
LOCATION OF INSTALLATION	COUNTY	NEAREST CITY
Houston, Texas	Harris	Houston, Texas

INSTALLATION MISSION

The Manned Spacecraft Center has as its primary mission the development of spacecraft for manned space flight programs. The Center is also responsible for manned space flight operations, conduct of astronaut training, and earth resources programs.

PROJECT LINE ITEM	COGNIZANT OFFICE	FY 19 59 THRU CURRENT YR	FY 19 70 (Estimated)	FUTURE YEARS (Estimated)	TOTAL ALL YEARS (Estimated)
Mission Control Center Power Generation Facility	MSF	2,198	1,750		3,948
TOTAL			1,750		

CF 11 NASA-HQ

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

INSTALLATION SUMMARY

CONSTRUCTION OF FACILITIES

FISCAL YEAR 19 70 BUDGET ESTIMATES

(Dollars in thousands)

NASA INSTALLATION		COGNIZANT PROGRAM OFFICE FOR INSTALLATION
Wallops Station		Space Science and Applications
LOCATION OF INSTALLATION	COUNTY	NEAREST CITY
Eastern Shore of Virginia	Accomack	Temperanceville, Virginia

INSTALLATION MISSION

The basic mission of the Station is to prepare, assemble, and launch scientific experiments; achieve the desired position and velocity in space; and track, acquire and record the data sought. These data are processed and reduced to meaningful form and analyzed.

PROJECT LINE ITEM	COGNIZANT OFFICE	FY 19 59 THRU CURRENT YR	FY 19 70 (Estimated)	FUTURE YEARS (Estimated)	TOTAL ALL YEARS (Estimated)
Flight Information Control and Analysis Laboratory	SSA	30	500		530
TOTAL			500		

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

INSTALLATION SUMMARY

CONSTRUCTION OF FACILITIES

FISCAL YEAR 19 70 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 19 59 THRU CURRENT YR	FY 19 70 (Estimated)	FUTURE YEARS (Estimated)	TOTAL ALL YEARS (Estimated)
Modifications and Rehabilitations at All Locations	O&M	540	9,000		9,540
Space Launch Complex 2, Modifications	SSA	1,029	425		1,454
Deep Space Antenna (210 Foot) Facilities	TDA	17,540	17,000		34,540
TOTAL			26,425		

CF 13 NASA-HQ

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

INSTALLATION SUMMARY

CONSTRUCTION OF FACILITIES

FISCAL YEAR 19 70 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 19 59 THRU CURRENT YR	FY 19 70 (Estimated)	FUTURE YEARS (Estimated)	TOTAL ALL YEARS (Estimated)
Facility Planning and Design	O&M	53,865	3,500		Not Applicable
TOTAL			3,500		

NASA-HQ

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

[ADMINISTRATIVE OPERATIONS] *RESEARCH AND PROGRAM MANAGEMENT*

For necessary expenses of [operation] *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; [supplies, materials, services, and equipment] awards; hire, maintenance and operation of administrative aircraft; purchase (not to exceed [ten] *thirty-five* for replacement only) and hire of passenger motor vehicles; and maintenance, repair, and alteration of real and personal property; [$603,173,000] *$650,900,000: 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, 1969; 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 ["Administrative Operations"] *"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.

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

| *Research and Program Management*

Program and Financing (in thousands of dollars)

Identification code 27-00-0103-0-1-251	Budget plan			Costs and obligations		
	1968 actual	1969 estimate	1970 estimate	1968 actual	1969 estimate	1970 estimate
Program by activities:						
Direct program:						
1. Manned space flight	324,352	322,261	317,300	318,690	322,800	318,000
2. Scientific investigations in space	68,855	74,300	77,900	77,139	73,600	78,000
3. Space applications	20,203	19,900	21,000	23,094	19,700	21,000
4. Space technology	139,998	142,500	141,800	143,026	142,700	142,000
5. Aircraft technology	51,714	55,300	56,000	52,840	55,400	56,000
6. Supporting activities	34,171	34,000	36,900	39,898	33,500	37,000
Total direct program costs, funded	639,293	648,261	650,900	654,687	647,700	652,000
Reimbursable program:						
1. Manned space flight	1,241	1,400	1,616	1,211	1,400	1,616
3. Space applications	939	1,330	1,284	1,131	1,330	1,284
4. Space technology	522	570	600	487	570	600
Total reimbursable program costs	2,702	3,300	3,500	2,829	3,300	3,500
Total program costs, funded	641,995	651,561	654,400	657,517	651,000	655,500
Change in selected resources [1]				−15,522	561	−1,100
10 Total	641,995	651,561	654,400	641,995	651,561	654,400

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

	1967	*1968 adjustments*	*1968*	*1969*	*1970*
Unpaid undelivered orders	54,265	−2,751	35,806	36,367	35,267
Advances	157	------	342	342	342
Total selected resources	54,421	−2,751	36,148	36,709	35,609

Program and Financing (in thousands of dollars)—**Continued**

Identification code 27-00-0103-0-1-251	Budget plan			Costs and obligations		
	1968 actual	1969 estimate	1970 estimate	1968 actual	1969 estimate	1970 estimate
Financing:						
Receipts and reimbursements from:						
11 Federal funds				−2,494	−3,000	−3,200
14 Non-Federal sources [2]				−208	−300	−300
25 Unobligated balance lapsing				130	----------	----------
Budget authority				**639,423**	**648,261**	**650,900**
Budget authority:						
40 Appropriation				628,000	603,173	650,900
41 Transferred to other accounts				−127	−280	----------
42 Transferred from other accounts				11,550	45,368	----------
43 **Appropriation (adjusted)**				**639,423**	**648,261**	**650,900**
Relation of obligations to outlays:						
71 Obligations incurred, net				639,293	648,261	650,900
72 Obligated balance, start of year				101,291	86,373	74,934
74 Obligated balance, end of year				−86,373	−74,934	−70,834
77 Adjustments in expired accounts				−2,685	----------	----------
90 Outlays				651,527	659,700	655,000

[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 1970 ESTIMATES

RESEARCH AND PROGRAM MANAGEMENT

SUMMARY OF OBLIGATIONS BY INSTALLATION
(In thousands of dollars)

	Fiscal Year 1968	Fiscal Year 1969	Fiscal Year 1970
MANNED SPACE FLIGHT.....	$315,098	$312,028	$307,450
John F. Kennedy Space Center, NASA.....	93,131	97,669	97,501
Manned Spacecraft Center.....	95,737	97,998	97,748
Marshall Space Flight Center....	126,230	116,361	112,201
SPACE SCIENCE AND APPLICATIONS....	$77,073	$82,510	$88,053
Goddard Space Flight Center.....	68,305	73,490	79,024
Wallops Station.....	8,768	9,020	9,029
ADVANCED RESEARCH AND TECHNOLOGY..	$189,059	$193,924	$195,600
Ames Research Center.....	33,781	34,036	34,050
Electronics Research Center.....	15,352	17,237	18,566
Flight Research Center.....	9,469	9,680	9,615
Langley Research Center.....	62,213	62,947	63,308
Lewis Research Center.....	66,222	67,845	68,061
Space Nuclear Propulsion Office.	2,022	2,179	2,000
SUPPORTING OPERATIONS			
NASA Headquarters.....	$58,063	$59,799	$59,797
TOTAL.....	$639,293	$648,261	$650,900

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1970 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 Propulsion Office	Headquarters
Personnel																
1968	$432,294	$191,209	$37,248	$63,669	$90,292	$55,328	$50,160	$5,168	$149,608	$26,872	$10,118	$7,228	$48,694	$54,851	$1,845	$36,149
1969	463,722	202,840	43,297	68,938	90,605	62,664	57,043	5,621	160,040	28,426	11,944	7,589	51,613	58,579	1,889	38,178
1970	469,550	201,806	44,296	70,025	87,485	68,163	62,513	5,650	161,557	28,358	12,843	7,583	51,974	58,984	1,815	38,024
Travel																
1968	15,095	7,340	661	3,929	2,750	2,045	1,919	126	3,474	731	308	184	1,130	954	167	2,236
1969	14,625	6,869	771	3,923	2,175	1,771	1,639	132	3,360	630	318	189	1,132	896	195	2,625
1970	14,600	6,530	679	3,773	2,078	2,054	1,918	136	3,391	630	351	197	1,132	896	185	2,625
Automatic Data Processing																
1968	32,045	17,506	1,214	6,243	10,049	6,011	5,951	60	7,177	1,634	1,382	92	3,541	528	---	1,351
1969	24,636	14,151	1,045	6,059	7,047	5,490	5,426	64	3,693	994	1,329	85	950	335	---	1,302
1970	23,829	13,685	914	5,975	6,796	5,452	5,385	67	3,315	583	1,225	85	1,145	277	---	1,377
Facilities Services																
1968	94,297	64,989	42,291	11,609	11,089	8,106	5,707	2,399	20,415	3,425	1,668	1,109	6,373	7,840	---	787
1969	85,896	58,989	41,376	9,307	8,306	7,493	5,193	2,300	18,756	2,997	1,786	1,099	6,749	6,125	---	658
1970	84,954	57,368	40,722	8,693	7,953	7,422	5,141	2,281	19,496	3,458	2,375	1,056	6,554	6,053	---	668
Technical Services																
1968	20,505	5,216	---	2,090	3,126	872	826	46	2,028	109	1,038	29	145	697	10	12,389
1969	17,398	3,057	---	1,850	1,207	823	753	70	1,937	84	933	42	138	645	95	11,581
1970	16,860	2,828	---	1,668	1,160	737	675	62	1,752	84	823	42	138	665	---	11,543
Administrative Support																
1968	45,057	28,838	11,717	8,197	8,924	4,711	3,742	969	6,357	1,010	838	827	2,330	1,352	---	5,151
1969	41,984	26,122	11,180	7,921	7,021	4,269	3,436	833	6,138	905	927	676	2,365	1,265	---	5,455
1970	41,107	25,233	10,890	7,614	6,729	4,225	3,392	833	6,089	937	949	652	2,365	1,186	---	5,560
Total																
1968	639,293	315,098	93,131	95,737	126,230	77,073	68,305	8,768	189,059	33,781	15,352	9,469	62,213	66,222	2,022	58,063
1969	648,261	312,028	97,669	97,998	116,361	82,510	73,490	9,020	193,924	34,036	17,237	9,680	62,947	67,845	2,179	59,799
1970	650,900	307,450	97,501	97,748	112,201	88,053	79,024	9,029	195,600	34,050	18,566	9,615	63,308	68,061	2,000	59,797

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1970 ESTIMATES

RESEARCH AND PROGRAM MANAGEMENT

DISTRIBUTION OF OBLIGATIONS BY OBJECT CLASSIFICATION BY FUNCTION

(Thousands of Dollars)

Object Classification	Total NASA	Personnel	Travel	Automatic Data Processing	Facilities Services	Technical Services	Administrative Support
Fiscal Year 1968							
Personnel compensation	$398,536	$398,536	---	---	---	---	---
Personnel benefits	30,382	30,382	---	---	---	---	---
Benefits for former personnel	336	336	---	---	---	---	---
Travel & transp. of persons	16,803	202	$15,095	---	---	---	$1,506
Transportation of things	4,090	635	---	---	---	$123	3,332
Rents, communications, and utilities	48,683	---	---	$17,138	$18,270	---	13,275
Printing and reproduction	7,286	---	---	---	---	728	6,558
Other services	107,204	2,203	---	12,196	63,513	18,396	10,896
Supplies and materials	17,214	---	---	---	8,402	530	8,282
Equipment	6,825	---	---	2,711	2,283	728	1,103
Lands and structures	1,829	---	---	---	1,829	---	---
Grants, subsidies & contributions	82	---	---	---	---	---	82
Insurance claims and indemnities	23	---	---	---	---	---	23
Totals	$639,293	$432,294	$15,095	$32,045	$94,297	$20,505	$45,057
Fiscal Year 1969							
Personnel compensation	$428,060	$428,060	---	---	---	---	---
Personnel benefits	32,477	32,477	---	---	---	---	---
Benefits for former personnel	283	283	---	---	---	---	---
Travel & transp. of persons	16,356	241	$14,625	---	---	---	$1,490
Transportation of things	4,023	505	---	---	---	$143	3,375
Rents, communications, and utilities	47,324	---	---	$14,109	$18,174	---	15,041
Printing and reproduction	6,342	---	---	---	---	769	5,573
Other services	92,812	2,156	---	10,466	56,383	15,507	8,300
Supplies and materials	15,960	---	---	---	8,290	406	7,264
Equipment	3,380	---	---	61	1,925	573	821
Lands and structures	1,124	---	---	---	1,124	---	---
Grants, subsidies & contributions	83	---	---	---	---	---	83
Insurance claims and indemnities	37	---	---	---	---	---	37
Totals	$648,261	$463,722	$14,625	$24,636	$85,896	$17,398	$4[illegible],984
Fiscal Year 1970							
Personnel compensation	$433,723	$433,723	---	---	---	---	---
Personnel benefits	32,951	32,951	---	---	---	---	---
Benefits for former personnel	---	---	---	---	---	---	---
Travel & transp. of persons	16,339	232	$14,600	---	---	---	$1,507
Transportation of things	3,987	504	---	---	---	$143	3,340
Rents, communications, and utilities	46,963	---	---	$13,536	$18,293	---	15,134
Printing and reproduction	6,342	---	---	---	---	773	5,569
Other services	90,697	2,140	---	10,278	55,604	14,975	7,700
Supplies and materials	15,768	---	---	---	8,321	422	7,025
Equipment	2,849	---	---	15	1,583	547	704
Lands and structures	1,153	---	---	---	1,153	---	---
Grants, subsidies, & contributions	92	---	---	---	---	---	92
Insurance claims and indemnities	36	---	---	---	---	---	36
Totals	$650,990	$469,550	$14,600	$23,829	$84,954	$16,860	$4[illegible],107

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1970 ESTIMATES

JOHN F. KENNEDY SPACE CENTER

MISSION:

The Kennedy Space Center, formerly the Launch Operations Directorate of the Marshall Space Flight 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 Kennedy Space Center, Florida, and unmanned vehicles at the Air Force Western Test Range. The Center is now concentrating on the Apollo Saturn V manned launches, as well as scientific unmanned launches. 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.

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 approximately 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 of Kennedy Space Center including work in progress, contractor-held facilities at various locations, and the Western Test Range, as of June 30, 1968, was $1,050,510,000.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Dollars in Thousands)		
	1968	1969	1970
Authorized permanent positions, end of year.....	2,917	2,921	2,881
Research and Program Management.	$93,131	$97,669	$97,501

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1970 ESTIMATES

MANNED SPACECRAFT CENTER

MISSION:

The Manned Spacecraft Center was established in November 1961 at 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. Manned Spacecraft Center and its predecessor organization, the NASA Space Task Group, have completed two major programs: (1) the Mercury program, which was the United States' pioneering venture into manned space flight; and (2) the Gemini program, which extended manned flight capability in space in many significant ways. Manned Spacecraft Center is now heavily engaged in the Apollo program and is also proceeding with necessary spacecraft modifications for the Apollo Applications project as well as program planning and technical analysis of other post-Apollo activities.

The Apollo program utilizes the capabilities of the Manned Spacecraft Center in several ways. This Center is responsible for:

1. The design, development, and fabrication of the Apollo 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 experiments to be flown on Apollo flights.

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

The longer duration flights planned for the post-Apollo missions will make it necessary to use the experienced personnel of this Center to upgrade spacecraft and lunar module subsystems. This Center is also responsible for the

development of earth sensor experiment modules and biomedical, bioscience, and behavioral experiment modules to be flown on Apollo Applications missions.

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 55,861 acres at the White Sands Test Facility. The total capital investment of the Manned Spacecraft Center, including fixed assets in progress, contractor-held facilities at various locations, and the White Sands Test Facility, as of June 30, 1968, is $420,878,000.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Dollars in Thousands)		
	1968	1969	1970
Authorized permanent positions, end of year.....	4,604	4,383	4,303
Research and Program Management.	$95,737	$97,998	$97,748

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1970 ESTIMATES

GEORGE C. MARSHALL SPACE FLIGHT CENTER

MISSION:

The Marshall Space Flight Center (MSFC) at Huntsville, Alabama, became a part of NASA in July 1960, and serves as NASA's primary center for the design, development, and testing of large launch vehicles and space transportation systems. MSFC is also engaged in payload development and payload integration for post-Apollo flights. MSFC includes the component field activities at Michoud Assembly Facility (MAF) at New Orleans, Louisiana; the Slidell Central Computer Facility nearby; and the Mississippi Test Facility (MTF) in southwest Mississippi. The Center is now proceeding with the direction and management of the following:

1. The Saturn IB, which provides a launch vehicle for Apollo spacecraft development and serves as the carrier for all Apollo Applications missions.

2. The Saturn V, which provides the launch vehicle for manned lunar landing missions, planetary missions, and future very large scientific satellite payloads.

3. Selected payloads for Apollo Applications missions, such as the Saturn I Workshop, and the Apollo Telescope Mount.

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

1. Design and develop large launch 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 on-going and future space exploration.

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

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

5. Technical and business management of industrial programs involving space vehicles, payloads and systems.

In support of its assigned programs, Marshall also maintains the research and development capability to conduct advanced studies on launch vehicle and space systems, space navigation techniques, astronautics, and space science investigations. Its capability for research and for management of large industrial programs gives the Marshall Space Flight Center a highly flexible base for space programs.

DESCRIPTION:

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

The first location, 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, and 64 leased acres. The capital investment as of June 30, 1968 was $512,117,000. Certain facilities such as the Redstone Arsenal Air Field and some utilities are used jointly by NASA and the Army. The Huntsville location has deep-water access via the Tennessee, Ohio and Mississippi Rivers.

The second location, the Michoud Assembly Facility, is located 15 miles east of New Orleans, Louisiana. The main facility occupies approximately 897 acres and the Slidell Central Computer Facility, a satellite facility 20 miles to the northeast, occupies 14 additional acres. The capital investment as of June 30, 1968, was $147,004,000. Michoud facility space totals 3,559,016 square feet, including the main assembly plant, covering an area of 43 acres under one roof. MSFC exercises overall management of the facility, while a support contractor provides administrative and technical services, and the vehicle prime contractors produce the Saturn I and Saturn V booster stages at this location. The Michoud Assembly Facility is on the Gulf Intra-Coastal Waterway, and has deep-water access via the Mississippi River.

The third location, the Mississippi Test Facility, is in southwest Mississippi, approximately 50 miles northeast of New Orleans, Louisiana. Total land area is 138,870 acres of which 13,428 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, 7,558 acres are owned by NASA, and 117,884 acres are under restrictive easement. Capital investment for the Mississippi Test Facility as of June 30, 1968, was $286,452,000. 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). MSFC exercises overall management of the facility, while a support contractor provides administrative and technical services, and the vehicle prime contractors are responsible for conducting tests on the stands. The site has deep-water access for transporting large boosters via the Pearl River and the Intra-Coastal Waterway.

The total capital investment of the Marshall Space Flight Center, including fixed assets in process and contractor-held facilities at various locations, as of June 30, 1968, was $945,573,000.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Dollars in Thousands)		
	1968	1969	1970
Authorized permanent positions, end of year.....	6,440	5,981	5,851
Research and Program Management.	$126,230	$116,361	$112,201

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1970 ESTIMATES

GODDARD SPACE FLIGHT CENTER

MISSION:

The Goddard Space Flight Center, established in 1959 as the first major United States laboratory devoted to the investigation and exploration of space, conducts a wide-ranging program of experimentation in the space sciences and space applications. As a result, Goddard Space Flight 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.

Although the majority of Goddard Space Flight Center's personnel are at the Greenbelt site, 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 Space Flight Center is responsible for the management of communications and meteorological satellite programs, such as the Applications Technology and Nimbus Satellites; the management of scientific satellite projects to include the Orbiting Geophysical (OGO), 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.

Significant achievements of the Goddard Space Flight Center in 1968 included:

Scientific Satellites - Major scientific satellites successfully orbited in 1968 included: OAO A2, for ultraviolet (UV) sky survey and photometry of brighter objects; OGO-V for interdisciplinary studies in particles and fields; Explorer 38 (RAE-A) for radio astronomy; and Explorer 36 (GEOS-II) for geodesy in support of the National Geodetic Satellite Program. The Center also participated in technical management and launch of HEOS-I for ESRO, the first spacecraft for this organization for investigation of the solar wind and cosmic rays.

Meteorological and Communications Satellites - During 1968, Goddard Space Flight Center, on behalf of the Environmental Science Services Administration, launched two operational weather satellites, ESSA VII and VIII. One Intelsat,

operational communications satellite of the Communications Satellite Corporation, was also launched by this Center during 1968.

Sounding Rockets - The sounding rocket program consisted of 175 scientific rocket launchings in 1968, including 17 launches in conjunction with foreign scientists.

Tracking and Data Acquisition - The Goddard-managed Space Tracking and Data Acquisition Network provided communications and tracking coverage for unmanned scientific and applications satellites in 1968. The Manned Space Flight Network provided global tracking support for the first manned Apollo flight (Apollo 7), and support for the circumlunar manned Apollo flight (Apollo 8).

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 plots of 639 acres comprise the remote site area and contain 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. Total capital investment as of June 30, 1968, under the cognizance of Goddard Space Flight Center, including the Manned Space Flight Network, the Space Tracking and Data Acquisition Network, Apollo ships, and the Goddard Space Flight Center main site at Greenbelt, Maryland, is $614,860,000.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Dollars in Thousands)		
	1968	1969	1970
Authorized permanent positions, end of year.....	3,822	4,243	4,412
Research and Program Management.	$68,305	$73,490	$79,024

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1970 ESTIMATES

WALLOPS STATION

MISSION:

Wallops Station is primarily a launch and aeronautical test facility completely owned and operated by NASA for the purpose of conducting scientific experiments. Research at Wallops is devoted to gathering information about the earth's atmosphere and its near-space environment, and to the field of aeronautics.

The rocket-borne experiments flown from the Wallops Island Range are conceived, and for the most part designed and built, by scientists and engineers in the laboratories and research centers of NASA, other Government agencies, colleges and universities, and the worldwide scientific community.

In addition to supporting the rocket-propelled experiments, Wallops uses its facilities for many other research projects, such as space component tests utilizing helicopter or aircraft drops; slow speed landing techniques for jet aircraft; anti-skid tests on grooved runways; noise abatement; and laser and radar tracking of aircraft and satellites. A sizeable portion of Wallops effort is devoted to NASA's program of international cooperation in space research. More than 50 countries have sent representatives to observe operations and procedures. Wallops has assisted 17 of these countries with training of personnel, activation of their launch sites, or launching their experiments. Another important element of the Wallops research program is the four-stage Scout vehicle, capable of performing a variety of missions, including the launching of small satellites, high altitude probes, and atmospheric reentry tests. Wallops' mission also includes management of several NASA sponsored projects, such as the Orbiting Frog Otolith (OFO) project; the Experimental Inter-American Meteorological Rocket Network (EXAMETNET); a Bio-Space Technology Training Program for bioscientists; and implementation of remote site launching and tracking facilities, including a mobile range facility transportable anywhere, and an Arctic launch site at Point Barrow, Alaska.

Wallops personnel participate in these tasks and perform those engineering functions necessary to design and establish ground facilities and instrumentation systems compatible with test requirements. However, the primary mission of Wallops Station is to prepare, assemble, and launch experimental payloads, position them correctly in space at the right velocity; track them; and acquire meaningful data.

In the early years, research at Wallops was concentrated on obtaining aerodynamic data at transonic and low supersonic speeds, as part of the

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effort to penetrate the sound barrier of flight. Today, the facility is obtaining scientific data about the atmosphere and the space environment utilizing launch vehicles ranging in size from the small Arcas and Hasp meteorological rockets to the 72-foot Scout with orbital capability. Twelve satellites have been launched to date. Since its origin in 1945, Wallops has launched more that 7,000 research vehicles consisting of from one to seven stages in the quest for scientific knowledge.

Wallops Station's achievements during 1968 include: the launching of 451 sounding rockets, 1 satellite, 2 reentry measurements, and 165 test rockets; conducting the fourth annual Bio-Space Technology Training Program; and launching the second and third in a series of four Gravity Preference experiments. Scout vehicle launches included the Explorer XXXVII satellite, Reentry F and RAM C-B. Seventy foreign nationals representing 15 countries visited the installation to observe its operations or seek assistance in establishing a sounding rocket facility of their own. The preliminary design phase of the OFO project has been completed. This project will provide data on frog's balance mechanism under weightlessness and repeated acceleration while in orbit. Several aeronautical projects were either initiated or continued, such as the anti-skid tests on grooved runways, noise abatement, the Gemini V/STOL tests, and the paraglider tests. A new Federal Job Information Center was opened to provide service for residents of Virginia's Eastern Shore who are rather isolated from areas where jobs are more plentiful.

DESCRIPTION:

Wallops Station includes three separate areas on the Atlantic coast of Virginia's eastern shore: the main base (formerly Chincoteaque Naval Air Station), the Wallops Island launching site and the Wallops mainland. The administrative offices, the range control center, support shops and the 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 its widest point is only one-half mile. Located on the island are rocket storage buildings, blockhouses, assembly shops and the launch sites. The Wallops mainland is a one-half mile strip west of the island and houses the radar and optical tracking sites. An additional Wallops holding is the Eastville tracking site located about 50 miles south of 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 unusuable marsh land. The Eastville tracking site consists of an additional 53 acres of government-owned property. The total capital investment as of June 30, 1968, including off-site holdings was $103,388,000.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Dollars in Thousands)		
	1968	1969	1970
Authorized permanent positions, end of year.....	494	488	488
Research and Program Management.	$8,768	$9,020	$9,029

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1970 ESTIMATES

AMES RESEARCH CENTER

MISSION:

The programs at the Ames Research Center are directed at research and development in the areas of aircraft and spacecraft technology as well as application to national needs of the new science and technology growing out of the aerospace program. In carrying out this mission, the Center works closely with the aerospace and educational communities in an effort to take full advantage of the nation's manpower capabilities. More specifically, Ames Research Center has, in addition to the traditional research mission in the physical sciences, a major research responsibility in the life and space sciences, flight project management responsibility, and the operational responsibility for the NASA Convair 990 aircraft to conduct airborne scientific experiments.

In the current and budget years, this installation has flight project management responsibility for the Pioneer and Biosatellite projects. Pioneer provides scientific observations of phenomena in interplanetary space from an unmanned spacecraft, and the Biosatellite project explores the biological effects of the space environment on primates and other earth organisms.

Research in the physical sciences includes studies in atmosphere entry and environmental physics, guidance and control systems, and aeronautics. The work in entry and environmental physics includes basic studies of the physics of high-temperature gases, the stability, control, and performance of a wide range of spacecraft configurations, and of materials and structures for spacecraft. In the area of gas physics, particular emphasis is placed on problems associated with flight into earth and other planetary atmospheres. Through this effort, significant contributions have been made to the design of the Mercury, Gemini, and Apollo spacecraft, the design of Mars and Venus entry vehicles, and the design of ballistic missiles.

The work in guidance and control systems is broad in nature and is applicable to manned and unmanned spacecraft, as well as aircraft. Current emphasis in guidance systems is directed mainly at current and follow-on manned missions. This includes an intensive theoretical and experimental effort in the areas of midcourse navigation and terminal guidance with a smaller effort directed at studies involving lunar approach, lunar landing, and rendezvous. The research in control systems is directed at examining various techniques applicable to unmanned satellites and probes and techniques applicable to vertical and short take-off (V/STOL) aircraft, the supersonic transport, and manned spacecraft.

The research program in aeronautics is directed at fundamental studies in aerodynamics, propulsion and operating problems associated with supersonic aircraft with particular emphasis on the supersonic transport, a wide variety of V/STOL vehicles, and hypersonic research aircraft. This includes studies of piloting problems with numerous fixed-base, moving-base, and flight simulators.

Research in the space sciences includes studies in the field of solar physics, planetary environments, and geophysics. This includes ground based and sounding rocket experiments as well as experiments requiring specialized instruments aboard satellites and space probes. The work covers studies pertaining to magnetic fields and plasmas in space, studies to determine the composition and structure of planets and of planetary and stellar atmospheres, and studies of cratering mechanics in natural materials to aid in understanding the structure of lunar surfaces.

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

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 traditional physical sciences as well as the space sciences and life sciences, all of which are included in the mission of the Center. These include conventional 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 Navy. The total capital investment of the Ames Research Center, including work in progress and contractor-held facilities, as of June 30, 1968, was $226,711,000.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Dollars in Thousands)		
	1968	1969	1970
Authorized permanent positions, end of year.....	2,083	1,974	1,956
Research and Program Management.....	$33,781	$34,036	$34,050

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1970 ESTIMATES

ELECTRONICS RESEARCH CENTER

MISSION:

The mission of the Electronics Research Center is to increase the nation's capability in space by providing the knowledge and advanced technology needed to improve performance and reliability of space and aeronautical electronic systems and components. The Center meets this responsibility in two principal ways:

First, the Center organizes, manages, and conducts a comprehensive program of basic and applied aerospace electronics research to: (a) investigate concepts and techniques that will provide the technological foundation for the development of electronic equipment of reduced weight, size, power drain, and complexity, able to operate for long periods of time in the temperatures, radiation, vacuum, and other conditions of aerospace flight environment; (b) investigate concepts and techniques, establish performance characteristics, test procedures, and specifications for aerospace electronic components and techniques that will make aerospace electronics equipment inherently more reliable; and (c) devise new electronic concepts and techniques and prove their feasibility both analytically and experimentally, leading to aerospace electronic equipment with performance characteristics far beyond those of today.

Second, the Center provides a focal point for national aerospace electronics research, coordinating nationwide research efforts and sponsoring electronics research conducted by industry, universities, and private institutions. In this capacity, the Center: (a) responds to the needs of specific aerospace programs and projects for new electronic techniques, concepts, and devices, and helps shape future electronics research to resolve anticipated problems in these programs; (b) distributes knowledge about basic and applied research on aerospace electronics within NASA and also to industry, universities, and other members of the scientific and engineering community; and (c) provides to NASA programs and projects aerospace electronic scientists and engineers who are fully knowledgeable in the electronics state-of-the-art.

Electronics research being managed and conducted by the Center during FY 1969 and FY 1970 is largely contracted with industry and universities and is focused in the following areas:

1. Aerospace electronics materials and components.

2. Guidance and navigation of space vehicles, aircraft, and the supporting ground based equipment.

3. Space vehicle and aircraft control, stabilization and information systems.

4. Electronics system simulation, analysis, evaluation, and integration in the fields of guidance, control, navigation, tracking, communication and instrumentation.

5. Electrical and electronic power conditioning and distribution.

6. Bioelectronics.

7. Space and ground based computers, computing systems, and instrumentation technology.

8. Solid state physics, microwave propagation, microwave communications, and transmitting and receiving phenomena.

9. Optical communications.

10. Astrophysical measurements.

An in-house research effort is being conducted by the Center staff on those tasks offering great promise for aerospace electronics technology and on those problems requiring first-hand experience on the part of the Center personnel in order to contract, monitor, and evaluate related research with industry and universities.

DESCRIPTION:

The Electronics Research Center is being constructed on a tract in the Kendall Square area of Cambridge, Mass. The site, one and a half miles west of the center of Boston, Massachusetts, is immediately north of the Massachusetts Institute of Technology and one and a half miles from Harvard University. The tract is bounded on the north by Binney Street, on the south by Broadway, on the east by Third Street, and on the west by the Penn-Central Railroad. The total area to be occupied at the Kendall Square site in Cambridge is 24.3 acres, of which 8.8 acres have been acquired. The total capital investment as of June 30, 1968, was $20,157,000.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Dollars in Thousands)		
	1968	1969	1970
Authorized permanent positions, end of year.....	794	844	900
Research and Program Management.	$15,352	$17,237	$18,566

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1970 ESTIMATES

FLIGHT RESEARCH CENTER

MISSION:

The Flight Research Center, established in 1947, conducts aeronautical and space research within and outside the atmosphere. The work includes effort on problems of take-off, landing, low-speed flights, 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 and 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 heavy weight 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 used for various research investigations having application to both civil and military aviation. Special purpose vehicles such as lifting bodies, 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 used under a permit from the Department of 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 and a calibration hangar, and a high temperature loads calibrations facility. Auxiliary buildings include warehouses, an auxiliary power systems building, and a communications building. 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 work in progress and contractor-held facilities, as of June 30, 1968, is $42,819,000.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Dollars in Thousands)		
	1968	1969	1970
Authorized permanent positions, end of year.....	566	539	534
Research and Program Management.	$9,469	$9,680	$9,615

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1970 ESTIMATES

LANGLEY RESEARCH CENTER

MISSION:

The mission of the Langley Research Center is to provide the advanced technology necessary for the development of civil and military aircraft having improved performance, utility and safety, and for the furtherance of space flight programs.

The Center's aeronautical research program is directed toward general aviation, V/STOL, subsonic jet transports, supersonic and hypersonic aircraft and uses both ground based and flight techniques. In high speed aerodynamics research major emphasis is given to generating, developing and refining aircraft configurations which maximize flight efficiency at all operating speeds. The supercritical wing for subsonic aircraft, and the fixed and variable planform wings for supersonic flight represent major efforts in this area. In the field of hypersonic research, work on vehicle configurations, efficient integration of advanced propulsion systems and demonstration of the technology for practical hypersonic ramjet aircraft propulsion systems is progressing. Current research on aircraft noise alleviation includes studying in detail the basic nature of propulsion system sound generation and propagation, operating procedures, and the effects of noise on man; and developing aircraft configuration features to minimize sonic boom effects.

A substantial portion of the Center's skills and resources is devoted to advancing national space flight programs. Vigorous research is under way to expose new opportunities for important progress in understanding and using the space environment; to evolve systems and operating concepts for achieving advanced space mission capabilities; and to assess the effectiveness, technical feasibility, and resource requirements of alternate approaches. Research is also under way to develop advanced design, construction, and operations technology for the optimum definition and successful achievement of national space flight goals. Langley manages and supports a number of these space flight projects.

The responsibility for managing the 1973 Mars mission (Viking), a major national space effort, has been assigned to the Center. The objectives are to obtain scientific data increasing our knowledge of both the Mars atmosphere and surface by means of an orbiter and surface lander. Particular emphasis will be placed on obtaining information relevant to life on the planet and the capability of the environment to support life.

The Langley Research Center has developed research teams in the technical areas of: aerodynamics, stability and control, airworthiness, fluid physics, flight environments, vehicle loading, structures and structural dynamics,

materials, energy conversion, navigation and control, communications, data sensing and handling, operational problems, crew performance and vehicular accommodations, life support, systems integration, flight operations, and air-breathing propulsion.

To support an effective attack on crucial flight problems, the Center's staff has developed and utilizes a unique complex of powerful research tools and techniques. These include a wide array of wind tunnel (continuous and intermittent) facilities for investigations of fluid flow phenomena and configuration characteristics; environmental test facilities for preflight determination of the reaction of flight systems and materials; flight simulators for the optimization of vehicle design requirements, and of operational techniques for complex manned missions involving navigation, rendezvous and dual vehicle maneuvering, extraterrestrial landings and surface operations; specialized laboratories for the development and evaluation of advanced life support systems, guidance and control components, propulsion and energy conversion devices, structures and materials, data sensors and processing equipment, and communications elements for future flight applications; and powerful analytical computing capabilities. For exploration and definition of an actual flight environment, Langley has pioneered in flight research using drop-test and free-flight models, rocket-propelled flight systems, satellites, and other space vehicles.

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 other Government agencies, and 9 acres under lease. The total acreage presently owned, under permit or leased, is 4,169. The total capital investment including fixed assets in progress, and contractor-held facilities at various locations, as of June 30, 1968, was $358,608,000.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Dollars in Thousands)		
	1968	1969	1970
Authorized permanent positions, end of year.....	4,037	3,885	3,849
Research and Program Management.	$62,213	$62,947	$63,308

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1970 ESTIMATES

LEWIS RESEARCH CENTER

MISSION:

The Lewis Research Center's principal mission is research and development in the areas of aircraft and spacecraft propulsion, and power generation systems for spacecraft.

The Center's emphasis is predominantly research; however, the entire spectrum of activities is undertaken going from basic research to applied research to development. The scope of research 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.

Several large launch vehicle and power generation development programs are assigned here. The Centaur, Atlas, and Agena launch vehicle programs are under this Center's supervision and tentative plans are underway for handling the Titan vehicle. The SNAP-8 nuclear powered electric generating system and SERT (Space Electric Rocket Test) contracts are directed, and there is also considerable supporting in-house research effort on these projects. New projects in their early phases include the development of a Quiet Engine (turbo-fan jet) and improved hydrogen-oxygen burning rocket engines.

Our research and development activities cover many technical fields. Some examples of major activity are discussed in the following paragraphs:

It is expected that engines for future supersonic planes will be of a turbo-fan design incorporating high bypass ratios, high compressor pressure ratios and high turbine inlet temperatures. A large part of the research effort at Lewis is aimed directly at solving the problems that limit the development of engines for supersonic flight. Among these research efforts are: slotted compressor blades to increase pressure ratio per stage, cooled turbine blades, high speed bearings, air inlets, exhaust nozzles, combustor configurations, higher energy fuels, and fuel tank fire hazard evaluations. A large addition to the Propulsion Systems Laboratory is being built to test full scale engines for supersonic airplanes.

The problems of the Supersonic Combustion Ramjet engine for hypersonic flight speeds up to Mach 7 are being studied in existing facilities, and construction of a new facility is underway at Plum Brook to extend the effort to engines of practical size.

At the lower end of the speed scale, the effects of cross flow on high pressure ratio lift fans for V/STOL aircraft are being investigated in the return passage of the 8-by-6-Foot Supersonic Wind Tunnel.

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, and nozzle insulating coatings.

Propellant management systems for Centaur, Saturn S-IV and the Apollo Service Module vehicles were studied and their designs were based on data obtained in the Lewis Zero Gravity facilities. Current research includes studies of in-orbit propellant transfer, propellant re-orientation and slosh dynamics.

A full-scale Centaur vehicle will be installed in the Spacecraft Propulsion Research Facility early in 1969. This vehicle will be equipped with a prototype tank pressurizing system replacing the current pump system for feeding the propellants to the engine.

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 environment essential to electric propulsion research is 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 means many years of 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 will reduce weight, but call for new designs of compressors, turbines, bearings and electric generators. The heat source may be either a nuclear reactor, or the sun's rays concentrated by a large concave mirror. A 20-foot flight weight mirror has been assembled at the Lewis Research Center.

Various problems in connection with the development of nuclear power systems and nuclear rockets are conducted at Plum Brook. 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 will be placed in operation at Plum Brook where nuclear powered electric generating systems will be operated under simulated space environment conditions for long periods of time.

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 140,000 gauss over a six-inch bore.

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. Our activity covers the entire temperature range of materials usage going from the cryogenic temperature of liquefied gases to the high temperatures encountered in the rocket nozzles of aircraft engine combustors and turbine wheels.

The material 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 products investigated.

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 Municipal Airport. The original area has been expanded to 364 acres, of which 15 are leased from Cleveland for use as a parking lot. Funds for the purchase of these 15 acres have been appropriated. 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, three 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 50 miles west of Cleveland on land formerly occupied by the Plum Brook Ordnance Works. Known as the Plum Brook Station, it occupies 5,981 acres owned by the Government. Funds for the purchase of additional land to serve as a buffer zone around the present site have been appropriated. There are over 200 buildings on this 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, a 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, a Fluorine Pump Laboratory and a temporary site for testing rockets at sea-level conditions. A Spacecraft Propulsion Research Facility is nearing completion to test the ignition and operation of spacecraft propulsion systems after a period of soaking in a space environment. Also nearing completion is the Space Power Facility for testing full-scale nuclear powered electric generating systems. 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, 1968 was $385,733,000, of which $107,901,000 represents facilities located at the Plum Brook Station.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Dollars in Thousands)		
	1968	1969	1970
Authorized permanent positions, end of year	4,452	4,235	4,195
Research and Program Management	$66,222	$67,845	$68,061

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1970 ESTIMATES

SPACE NUCLEAR PROPULSION OFFICE

MISSION:

The mission of the Space Nuclear Propulsion Office is to provide rocket propulsion systems for application to advanced orbital, lunar and planetary missions. In the conduct of this role, the primary objective is the development of a nuclear engine (NERVA) through Pre-Flight-Rating-Tests (PFRT) having a specific impulse of approximately 825 seconds and a thrust of approximately 75,000 pounds (equivalent to a reactor power of about 1,500 megawatts).

In addition to NERVA development, work includes effort to advance the technology of nuclear rocketry, and in particular specific impulse, duration and reactor recycling capability. Effort is also directed toward the development of vehicle technology, radiation effects studies, and studies to enhance the reliability of nuclear rocket components.

DESCRIPTION:

The Nuclear Rocket program is a joint AEC-NASA undertaking. To ensure an integrated program, the Space Nuclear Propulsion Office, established by an interagency agreement between NASA and the Atomic Energy Commission, manages all aspects of the program.

The Space Nuclear Propulsion Office consists of a Headquarters office located at Germantown, Maryland, and three field extensions located in Ohio, New Mexico, and Nevada. At the Nevada location, the Nuclear Rocket Development Station (NRDS) was established to provide a site for ground static testing of the reactors, engines, and eventually, vehicles associated with nuclear rocket development.

The Nuclear Rocket Development Station consists of an approximately 78,000-acre site owned by the Atomic Energy Commission, approximately 90 miles northwest of Las Vegas, Nevada. The total capital investment of NASA-funded facilities, including fixed assets in progress and contractor-held facilities, as of June 30, 1968, is $49,852,000.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Dollars in Thousands)		
	1968	1969	1970
Authorized permanent positions, end of year	108	100	99
Research and Program Management	$2,022	$2,179	$2,000

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RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1970 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 - To provide a broad national capability for manned space exploration, including earth orbital, lunar orbital, and lunar surface operations, and to achieve the specific objective of manned lunar landing and return within this decade;

Space Flight Operations - To expand the participation and capabilities of men in scientific, technological and applied observations in space through earth orbital flights of increasing duration and complexity, initially using Saturn IB launch vehicles, modified Apollo spacecraft, the Saturn I Workshop, and the Apollo Telescope Mount and progressing to an orbital space station.

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

The Office of Manned Space Flight has launch responsibility for all major manned and unmanned missions utilizing the three installations primarily concerned with the manned space flight programs. These installations 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 earth, moon, sun, planets, and interplanetary space utilizing ground based, airborne, and space techniques such as sounding rockets, earth satellites, and deep space probes; for scientific experiments to be conducted by man in space and for assisting in the selection and training of astronaut-scientists; 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, such as Centaur.

The Office of Space Science and Applications has an overall institutional responsibility for those 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 which are conducted primarily to demonstrate the feasibility of a concept, structure, component, or system 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 the 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 Electronics Research Center, the Flight Research Center, the Langley Research Center, the Lewis Research Center, and the Space Nuclear Propulsion Office.

Office of Tracking and Data Acquisition - Responsible for the development, implementation, and operation of tracking, data acquisition, 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, public affairs, communications, financial management, 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)		
	1968	1969	1970
Authorized Permanent Positions, end of year.....	2,154	2,152	2,132
Research and Program Management.	$58,063	$59,799	$59,797

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1970 ESTIMATES

SUMMARY OF APPROPRIATION BUDGET PLANS BY INSTALLATION

(In millions of dollars)

Installation	Research and Development			Construction of Facilities			Research and Program Management			Total		
	1968	1969	1970	1968	1969	1970	1968	1969	1970	1968	1969	1970
John F. Kennedy Space Center, NASA.....	374.1	388.2	344.9	21.6	9.0	12.5	93.1	97.7	97.5	488.8	494.9	454.9
Manned Spacecraft Center.....	1,231.1	1,088.5	942.6	.8	1.3	1.7	95.7	98.0	97.7	1,327.6	1,187.8	1,042.0
Marshall Space Flight Center.....	1,169.8	682.2	706.1	.8	-	-	126.2	116.4	112.2	1,296.8	798.6	818.3
Michoud Assembly Facility.....	-	-	-	.4	.4	-	-	-	-	.4	.4	-
Goddard Space Flight Center.....	435.0	416.4	462.4	.6	-	.7	68.3	73.5	79.0	503.9	489.9	542.1
Wallops Station.....	7.4	8.3	7.4	.7	.3	.5	8.8	9.0	9.0	16.9	17.6	16.9
Jet Propulsion Laboratory.....	196.0	133.9	157.4	1.9	-	-	-	-	-	197.9	133.9	157.4
Ames Research Center.....	66.0	53.6	67.8	3.2	.4	-	33.8	34.0	34.1	103.0	88.0	101.9
Electronics Research Center.....	26.8	24.1	25.5	-	-	8.1	15.4	17.2	18.6	42.2	41.3	52.2
Flight Research Center.....	23.5	18.9	13.3	-	-	-	9.5	9.7	9.6	33.0	28.6	22.9
Langley Research Center.....	84.0	74.6	103.6	-	-	4.8	62.2	63.0	63.3	146.2	137.6	171.7
Lewis Research Center.....	134.9	119.0	137.4	2.1	-	-	66.2	67.8	68.1	203.2	186.8	205.5
Space Nuclear Propulsion Office.....	50.4	30.1	32.8	-	-	-	2.0	2.2	2.0	52.4	32.3	34.8
NASA Headquarters:												
Headquarters.....	160.9	152.1	164.1	-	-	-	58.1	59.8	59.8	219.0	211.9	223.9
NASA Pasadena Office.....	7.1	3.6	3.6	-	-	-	-	-	-	7.1	3.6	3.6
Various Locations.....	-	-	-	-	23.3	26.4	-	-	-	-	23.3	26.4
Facility Planning and Design.....	-	-	-	1.4	1.0	3.5	-	-	-	1.4	1.0	3.5
Total Budget Plan.....	3,967.0	3,193.5	3,168.9	33.5	35.7	58.2	639.3	648.3	650.9	4,639.8	3,877.5	3,878.0

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1970 ESTIMATES

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

(Thousands of dollars)

PROGRAM OFFICE	TOTAL	J. F. Kennedy Space Center NASA	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 Propulsion Office	NASA Headquarters	NASA Pasadena Office
Office of Manned Space Flight															
1968	2,809,230	369,428	1,220,304	1,151,560	587	1,108	191	867	1,986	---	2,095	---	---	61,104	---
1969	2,177,500	383,645	1,071,624	668,550	---	100	---	605	---	---	450	---	---	52,526	---
1970	2,007,700	340,400	920,800	690,700	---	---	---	800	---	---	200	---	---	54,800	---
Office of Space Science and Applications															
1968	552,850	4,566	6,550	1,022	223,365	118,069	1,538	40,127	3,483	---	24,584	74,767	---	53,113	1,666
1969	438,416	4,519	11,464	1,803	197,003	59,880	1,522	28,442	3,217	---	15,485	58,125	---	56,956	---
1970	558,800	4,500	14,719	1,343	231,383	80,087	1,110	38,347	3,185	---	47,091	69,200	---	67,835	---
Office of University Affairs															
1968	10,000	---	---	---	---	---	---	---	---	---	---	---	---	10,000	---
1969	9,000	---	---	---	---	---	---	---	---	---	---	---	---	9,000	---
1970	9,000	---	---	---	---	---	---	---	---	---	---	---	---	9,000	---
Office of Advanced Research and Technology															
1968	315,022	75	4,220	16,797	9,779	24,410	712	24,960	21,348	21,543	55,654	60,150	50,400	19,575	5,399
1969	285,171	---	5,411	11,622	9,866	23,538	790	24,569	20,850	16,965	57,299	60,864	30,080	19,718	3,599
1970	290,400	---	7,080	13,620	10,910	23,085	300	28,705	22,150	11,330	54,975	68,220	32,800	13,675	3,550
Office of Tracking and Data Acquisition															
1968	275,850	---	---	400	201,302	52,368	5,000	---	---	2,000	1,625	---	---	13,155	---
1969	279,672	---	---	300	209,522	50,400	6,000	---	---	2,000	1,350	---	---	10,100	---
1970	298,000	---	---	400	220,100	54,200	6,000	---	200	2,000	1,300	---	---	13,800	---
Office of Technology Utilization															
1968	4,000	---	---	---	---	---	---	---	---	---	---	---	---	4,000	---
1969	3,800	---	---	---	---	---	---	---	---	---	---	---	---	3,800	---
1970	5,000	---	---	---	---	---	---	---	---	---	---	---	---	5,000	---
Total Budget Plan															
1968	3,966,952	374,069	1,231,074	1,169,779	435,033	195,955	7,441	65,954	26,817	23,543	83,958	134,917	50,400	160,947	7,065
1969	3,193,559	388,164	1,088,499	682,275	416,391	133,918	8,312	53,616	24,067	18,965	74,584	118,989	30,080	152,100	3,599
1970	3,168,900	344,900	942,599	706,063	462,393	157,372	7,410	67,852	25,535	13,330	103,566	137,420	32,800	164,110	3,550

CAPITALIZED VALUE OF NASA'S FACILITIES
AS OF JUNE 30, 1968
(IN-HOUSE AND CONTRACTOR-HELD FACILITIES)
($ in thousands)

Date : January 13, 1969

Reporting Installation	Land	Buildings	Other Structures and Facilities	Leasehold Improvements	Plant Equipment	Fixed Assets in Progress	Total
OFFICE OF MANNED SPACE FLIGHT							
Kennedy Space Center	$ 60,516	$ 242,915	$ 378,948	$ -	$ 44,805	$240,231	$ 967,415
Western Test Range Operation Div	-	-	-	-	2,841	-	2,841
Various Locations (Contractor-Held)	-	-	-	-	80,254	-	80,254
Manned Spacecraft Center	5,443	125,701	26,769	-	106,758	47,477	312,148
White Sands Test Facility	-	8,651	17,272	-	4,487	1,193	31,603
Various Locations (Contractor-Held)	3,572	24,436	5,383	8	43,728	-	77,127
Marshall Space Flight Center	95	102,632	39,418	161	147,243	42,352	331,901
Michoud Assembly Facility	7,502	63,212	24,251	-	41,338	5,097	141,400
Mississippi Test Facility	15,224	61,394	152,625	-	24,846	32,363	286,452
Slidell Computer Facility	63	4,406	824	-	311	-	5,604
Various Locations (Contractor-Held)	3,707	20,457	42,552	23	88,837	24,640	180,216
Total	$ 96,122	$ 653,804	$ 688,042	$ 192	$ 585,448	$393,353	$2,416,961
OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY							
Ames Research Center	$ 2,372	$ 161,816	$ 2,383	$ -	$ 52,421	$ 6,470	$ 225,462
Various Locations (Contractor-Held)	-	-	-	-	1,249	-	1,249
Electronics Research Center	1,099	1,671	9	-	13,224	4,151	20,154
Various Locations (Contractor-Held)	-	-	-	-	3	-	3
Flight Research Center	-	7,627	1,900	-	32,313	960	42,800
Various Locations (Contractor-Held)	-	-	-	-	19	-	19
Langley Research Center	110	103,393	130,877	-	88,583	17,780	340,743
Various Locations (Contractor-Held)	6	15,177	25	-	2,657	-	17,865
Lewis Research Center	310	106,752	38,632	147	53,149	24,632	223,622
Plum Brook Station	1,287	68,854	17,238	-	8,152	12,370	107,901
Various Locations (Contractor-Held)	99	4,228	4,019	8	35,583	10,273	54,210
Space Nuclear Propulsion Office	-	19,680	5,110	-	3,770	502	29,062
Various Locations (Contractor-Held)	-	-	125	-	20,638	27	20,790
Total	$ 5,283	$ 489,198	$ 200,318	$ 155	$ 311,761	$ 77,165	$1,083,880
OFFICE OF SPACE SCIENCE AND APPLICATIONS							
Goddard Space Flight Center	$ 1,200	$ 64,415	$ 11,142	$ 276	$ 147,888	$110,817	$ 335,738
* Tracking Stations	335	16,561	38,254	-	194,123	-	249,273
Various Locations (Contractor-Held)	-	88	45	31	29,685	-	29,849
Jet Propulsion Laboratory	799	42,509	6,450	408	77,745	-	127,911
Tracking Stations(Deep Space Networks)	-	7,947	21,066	-	26,051	-	55,064
Wallops Station	611	21,107	39,381	-	31,054	4,220	96,373
Various Locations (Contractor-Held)	-	2,558	270	-	4,187	-	7,015
Total	$ 2,945	$ 155,185	$ 116,608	$ 715	$ 510,733	$115,037	$ 901,223
OTHER							
Headquarters	$ -	$ -	$ -	$ -	$ 5,132	$ -	$ 5,132
Various Locations (Contractor-Held)	-	-	-	-	5,078	-	5,078
Total	$ -	$ -	$ -	$ -	$ 10,210	$ -	$ 10,210
Grand Total	$104,350	$1,298,187	$1,004,968	$1,062	$1,418,152	$585,555	$4,412,274

* Includes capital type facilities of the MSF and STADA networks and other supporting activities including equipment aboard ships and aircraft

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1970 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 of administrative aircraft and the purchase of passenger motor vehicles. These costs 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 information 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 lunar and planetary exploration.

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

3. A continuing program of supporting research and technology.

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 175.9 acres of land of which 145.9 acres are owned by NASA and 30 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. The 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 and contractor-held facilities, as of June 30, 1968, was $182,975,000.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Dollars in Thousands) 1968	1969	1970
Authorized permanent positions, end of year	4,150	3,990	4,370
Research and Program Management type costs	$76,265	$73,317	$80,081

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1970 ESTIMATES

CONSOLIDATED SUMMARY

FOR AIRCRAFT TECHNOLOGY

	(Dollars in Millions)		
	1968	1969	1970
OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY			
Research and Development:			
Aeronautical Vehicles	$66.8	$74.9	$78.9
Electronics Systems	7.8	11.1	12.3
Human Factor Systems	2.5	3.0	3.0
Basic Research	4.3	5.9	6.5
Subtotal	81.4	94.9	100.7
Research and Program Management: Support of Aeronautical Vehicles Program	51.7	55.3	56.0
Construction of Facilities	3.2	---	4.8
Subtotal	$136.3	$150.2	$161.5
Research and Program Management: Supporting Electronics, Human Factors and Basic Research Aircraft Technology Effort	21.0	22.7	25.7
Total	$157.3	$172.9	$187.2
Number of direct positions associated with Aeronautical Vehicles Program	2,278	2,302	2,307
Number of direct positions related to Electronics, Human Factors and Basic Research Programs supporting Aircraft Technology effort	948	908	1,026
Total Direct Positions	3,226	3,210	3,333

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1970 ESTIMATES

SUPPORTING RESEARCH AND TECHNOLOGY
(In thousands of dollars)

	1968	1969	1970
OFFICE OF SPACE SCIENCE AND APPLICATIONS	$76,476	$74,000	$82,000
Physics and astronomy	22,904	19,900	19,600
Lunar and planetary exploration	19,800	20,600	24,600
Bioscience	10,122	9,900	11,400
Space applications	19,300	19,600	22,400
Launch vehicle procurement	4,350	4,000	4,000
OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY	$235,016	$223,924	$234,350
Basic research	21,465	21,000	21,400
Space vehicle systems	29,358	27,703	26,650
Electronics systems	37,557	34,271	35,000
Human factor systems	18,228	17,910	21,600
Space power and electric propulsion systems	42,385*	40,700*	39,400*
Nuclear rockets	12,500	6,000	8,000
Chemical propulsion	33,537	28,900	25,100
Aeronautical vehicles	39,986	47,440	57,200
OFFICE OF TRACKING AND DATA ACQUISITION	$12,800	$11,500	$12,500
GRAND TOTAL	$324,292	$309,424	$328,850

* Includes SNAP-8 technology.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1970 ESTIMATES

Automatic Data Processing Equipment

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Automatic Data Processing Equipment

As in other Federal agencies and throughout American industry, the utilization of computers within NASA continues to increase; but in NASA the rate of increase is substantially less than in the preceding years of rapid buildup. NASA is now moving heavily into active mission phases involving flights of manned spacecraft and the more sophisticated unmanned spacecraft. The achievement of success in these missions requires the extensive use of digital computers which can accomplish the mandatory requirements of high reliability, extreme precision, and rapid decisions. In addition to the use of the computers while a flight is in progress, computation requirements are further increased by the varied in-depth testing, planning, and controlling that must take place before and after launch. The data generated from experiments of earlier flights, coupled with the sophisticated experiments of recent and near-future missions, will continue to place heavy requirements on the computers.

The uses of computers are divided into two categories. The Category A, general purpose use, includes all the equipments that can service multiple users. The increasing requirements for general purpose facilities have been met through the higher speed of third generation computers and continued improvements in management and programming efforts. Figure 1 shows the continuing growth in NASA's Category A computing requirements through FY 1970. The actual recorded computer workload for FY 1968, based on computer operations per second, is used as the base reference point of 100 percent. Also shown in Figure 1 is available computing capacity through FY 1970. The level of utilization of these computers will reach 95 percent of capacity by FY 1970. Figure 2 provides the breakdown of total requirements by the five elements comprising the Category A applications. These areas of use are:

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

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

(c) <u>Mission control</u>, which includes not only the active mission control computations but also the mission analysis and simulation necessary for effective control.

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

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(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.

Although Category A equipments are general purpose in nature, approximately one-half of our capacity in this category is used primarily in direct support of flight missions.

The Category B, special purpose applications, are primarily small computers integrated into overall operational systems in such a way as to make it impracticable to use them for other functions. Many special instrumentation facilities require the utilization of a small computer within the total system as a control or data acquisition device, but these normally small computers represent only a minor part of the instrumentation facilities supported. Figure 3 shows total Category B equipment growth. The scale for this chart shows value of equipment in millions of dollars. It has been found impossible to use capacity as a measure of Category B utilization, since these computers are totally embedded in the overall systems. Figure 4 breaks down the Category B equipment growth by application area.

Figure 5 reflects the relationship between the number of large, medium, and small computers and their respective capital values for FY 1968. As shown, large computers account for 9 percent of the inventory and 50 percent of the capital value; medium size 15 and 24 percent; and small comprise 76 percent of the inventory and only 26 percent of the capital value. Many small computers cost as little as $20 thousand, while large computers cost as much as $4 million; but in the inventory each computer is treated as one item regardless of its value.

Figure 6 reflects the capital value of the ADP equipment which was installed as of June 30, 1968. The figures show the capital value of NASA-owned and leased equipment. Figure 7 reflects the average employment of ADP personnel, both Civil Service and contractor, at each installation. The major ADP contractors at each installation are listed in Figure 8.

The inventory of computers by installation is shown in Figure 9. The tables at the bottom of Figure 9 reflect the breakdown of equipment between general purpose and special purpose, and by size of equipment.

The financing of ADP equipment by installation is shown in Figure 10, with the overall amounts reflecting a decline from 1968 to 1970. Fluctuations in lease and purchase dollars are primarily caused by minor reconfiguring of systems in the conversion to third generation equipment. Maintenance costs will continue to increase due to our growing capital investment in computers.

NASA has met its increasing requirements for ADP while still reducing the overall funding. This has been achieved by a combination of techniques: conversion to the more efficient third generation computers with lower cost per computation, closer management control of ADP at the installations,

and re-utilization of computers for new requirements. All new ADP requirements are carefully screened for the possibility of: (1) satisfying requirements through the use of existing equipment, either by consolidation of workloads into a central facility or by expanding present facilities, (2) the use of other than NASA facilities where excess time is available, and (3) the re-use of excess equipment obtained within NASA or from other Government agencies through GSA. A number of new requirements have been met by this last method at considerable economies to NASA.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

TOTAL CATEGORY A COMPUTER CAPACITY AND REQUIREMENTS BY FISCAL YEAR

(FY 1968 REQUIREMENTS EQUAL 100 PERCENT)

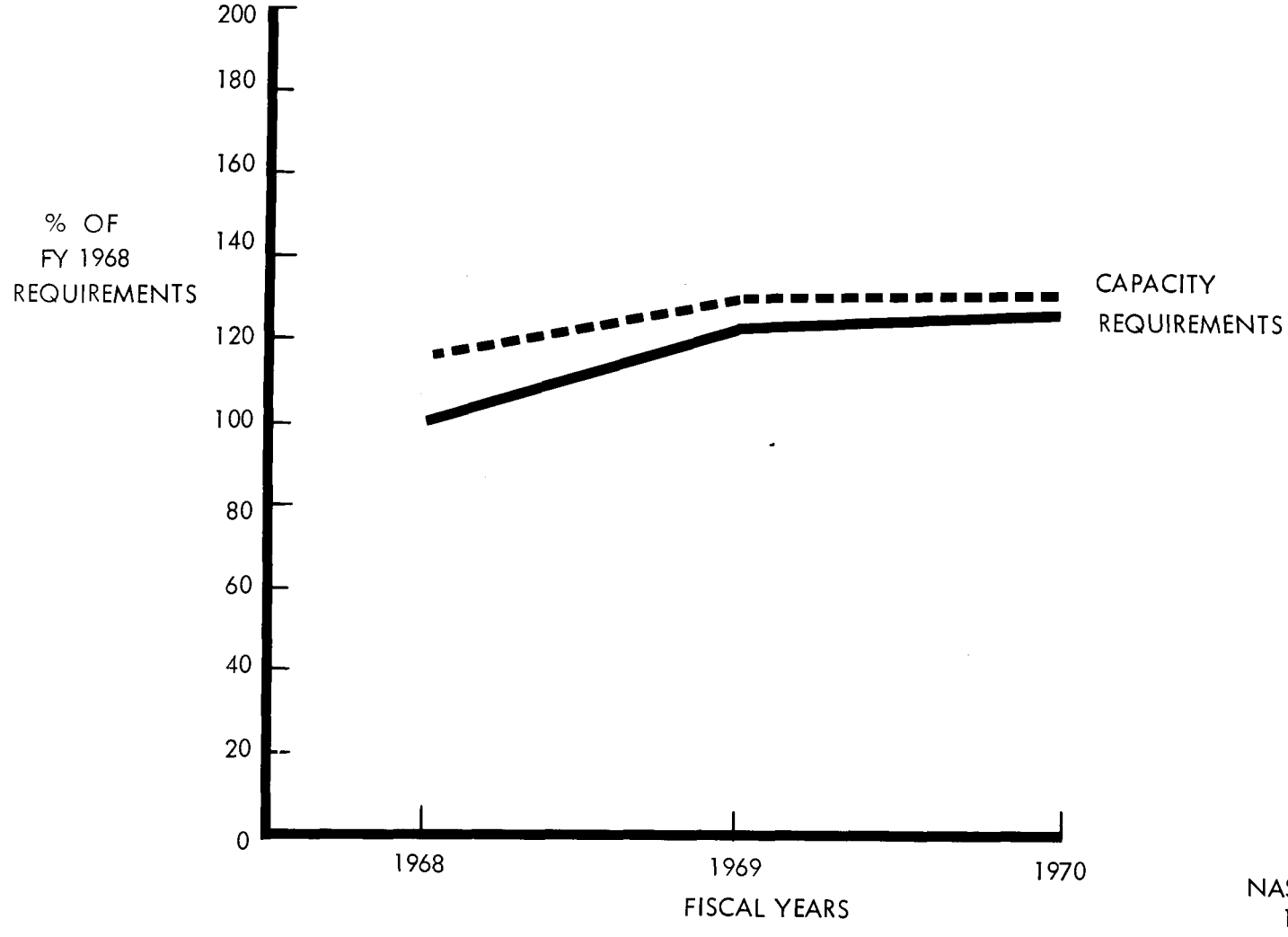

Figure 1

NASA BT69-131
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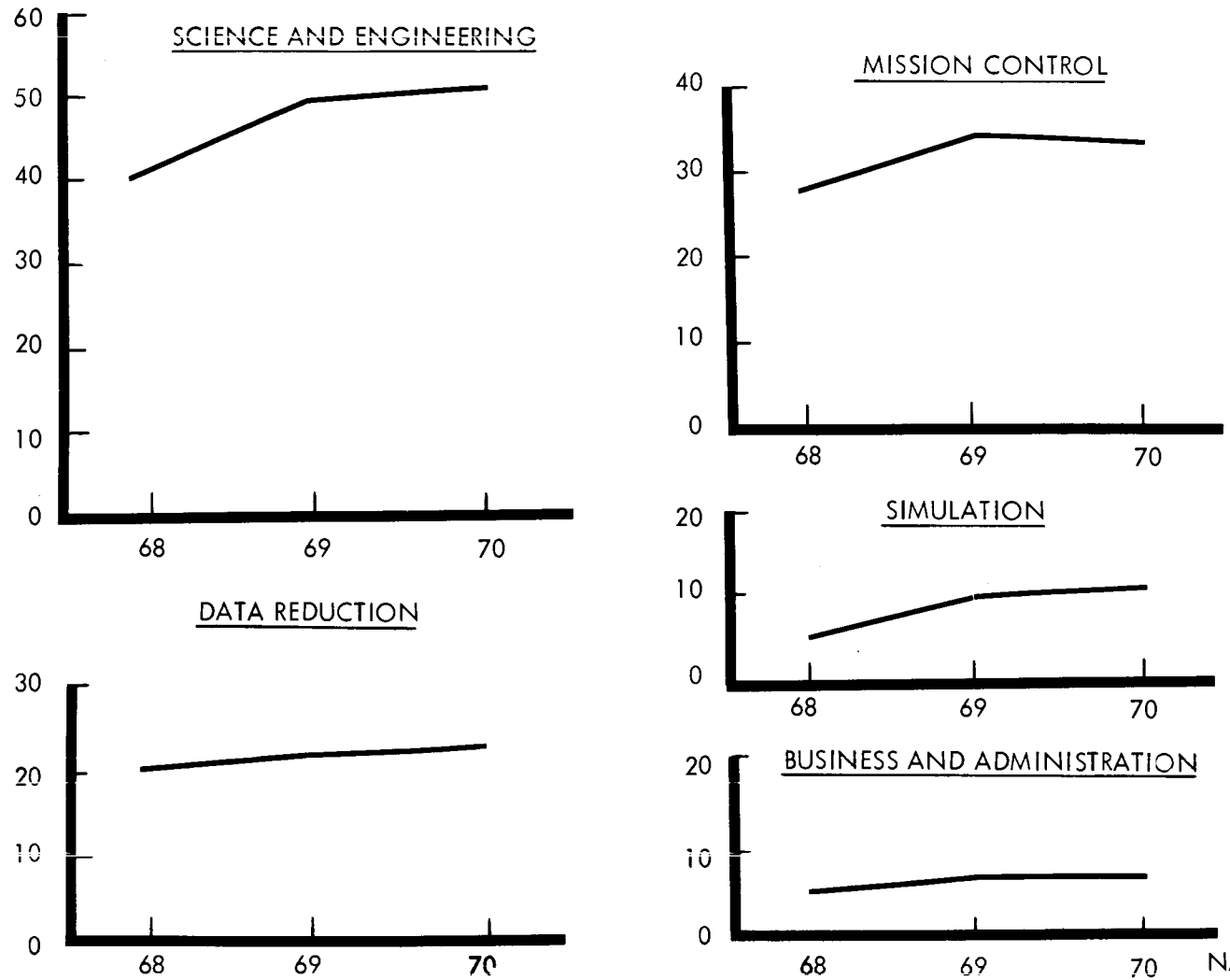
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CATEGORY A COMPUTER REQUIREMENTS BY TYPE OF USE

FY 1968 TOTAL REQUIREMENTS EQUAL 100 %

(ALL SCALES IN PERCENT)



NASA BT69-132
1-31-69

Figure 2

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

TOTAL CATEGORY B GROWTH

CAPITAL VALUE OF INSTALLED EQUIPMENT BY FISCAL YEAR

(FIGURES IN PARENTHESES REPRESENT END OF YEAR INVENTORY)

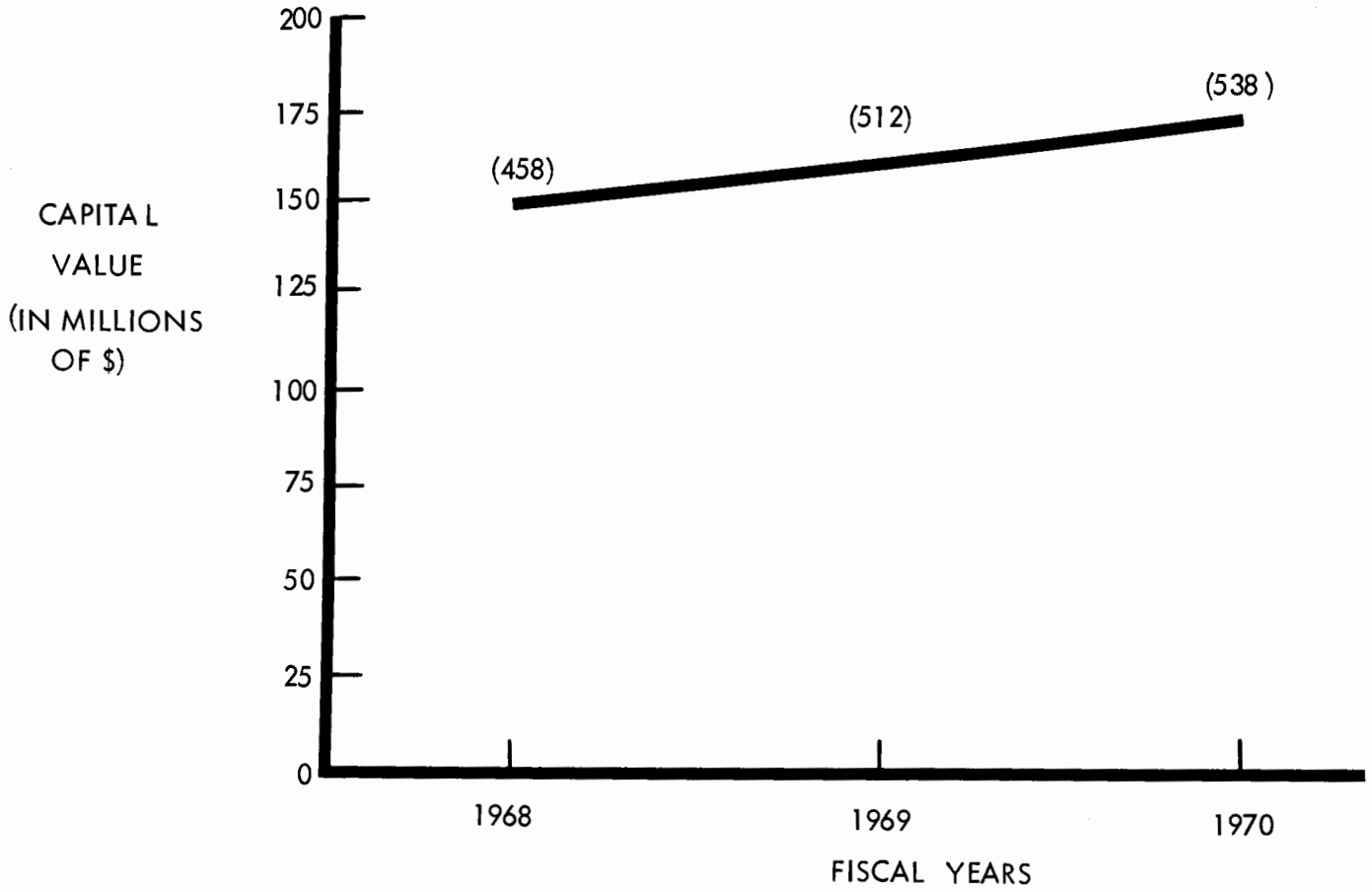


Figure 3

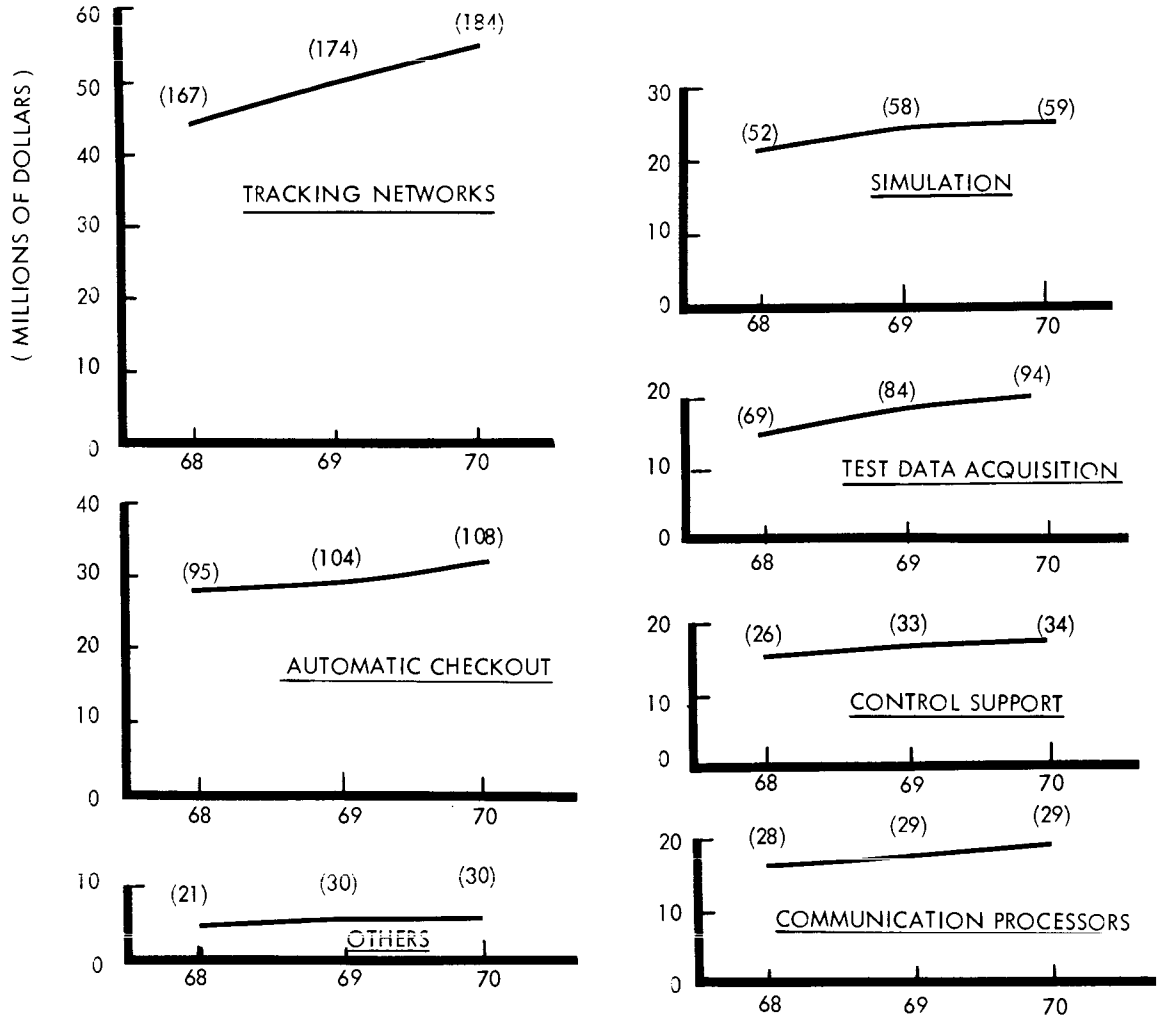
NASA BT69-133
1-31-69

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CATEGORY B GROWTH BY APPLICATION AREAS

CAPITAL VALUE OF INSTALLED COMPUTERS

(FIGURES IN PARENTHESES REPRESENT END OF FISCAL YEAR INVENTORY)



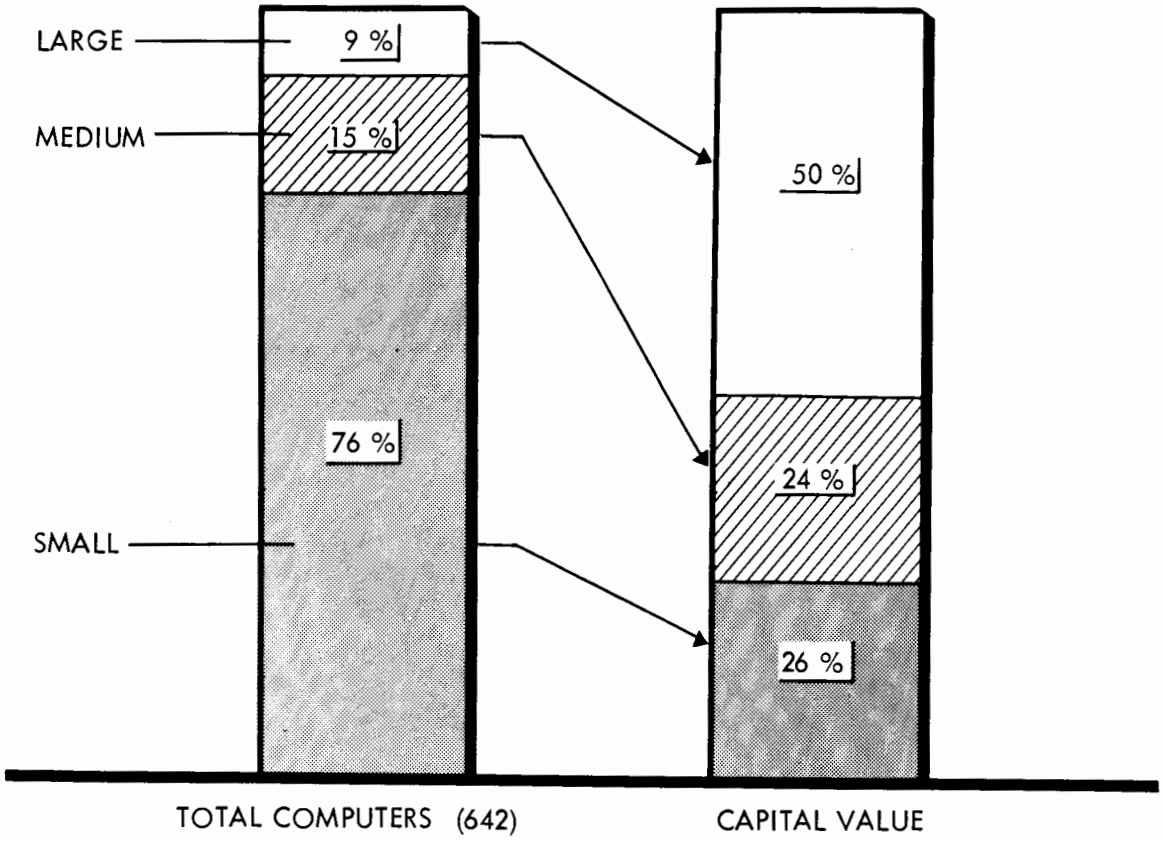
NASA BT69-135
1-31-69

Figure 4

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PERCENTAGE DISTRIBUTION OF COMPUTERS AND CAPITAL VALUES BY SIZE

AS OF JUNE 30, 1968



NASA BT69-134
1-31-69

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Figure 5

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Capital Value of Owned and Leased ADP Equipment
on Hand June 30, 1968

(In thousands of dollars)

	NASA-Owned Equipment	Leased Equipment	Total Capital Value
Office of Manned Space Flight....	$98,696	$58,074	$156,770
Kennedy Space Center.....	13,132	3,963	17,095
Manned Spacecraft Center.....	65,153	41,551	106,704
Marshall Space Flight Center...	20,411	12,560	32,971
Office of Space Science and Applications.....	$128,570	$23,008	$151,578
Goddard Space Flight Center....	94,973	13,934	108,907
Jet Propulsion Laboratory.....	31,226	8,954	40,180
Wallops Station.....	2,371	120	2,491
Office of Advanced Research and Technology.....	$30,539	$10,254	$40,793
Ames Research Center.....	4,587	3,281	7,868
Electronics Research Center....	3,300	736	4,036
Flight Research Center.....	2,060	380	2,440
Langley Research Center.....	9,335	4,344	13,679
Lewis Research Center.....	11,257	415	11,672
Space Nuclear Propulsion Office.....	---	1,098	1,098
Headquarters.....	$748	$2,375	$3,123
TOTAL.....	$258,553	$93,711	$352,264

Figure 6

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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

	FY 1968		FY 1969		FY 1970	
	Civil Service	Contractor	Civil Service	Contractor	Civil Service	Contractor
Office of Manned Space Flight.....	430	2,568	443	2,618	442	2,531
Kennedy Space Center.....	58	420	67	535	67	485
Manned Spacecraft Center.....	205	1,390	208	1,458	207	1,466
Marshall Space Flight Center....	167	758	168	625	168	580
Office of Space Science and Applications.....	669	1,327	728	1,326	740	1,255
Goddard Space Flight Center.....	419	1,056	486	1,064	493	1,001
Jet Propulsion Laboratory.....	226 a/	243	218 a/	234	223 a/	219
Wallops Station.....	24	28	24	28	24	35
Office of Advanced Research and Technology.....	392	216	403	296	413	332
Ames Research Center.....	60	62	60	77	60	90
Electronics Research Center.....	21	46	28	91	31	116
Flight Research Center.....	19	25	19	24	19	17
Langley Research Center.....	140	72	144	93	151	98
Lewis Research Center.....	152	---	152	---	152	---
Space Nuclear Propulsion Office.	---	11	---	11	---	11
Headquarters.....	17	114	17	114	19	116
Total.....	1,508	4,225	1,591	4,354	1,614	4,234

a/ Employees of JPL.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ADP Contractor Identification

Installation	Name of Firm	ADP Service Performed
Kennedy Space Center	Federal Electric Company	Programming, Analysis and Operations
Manned Spacecraft Center	Lockheed Electronics Co.	Programming, Analysis and Operations
	IBM	Mission Operations System Design, Programming, Operations and Maintenance
	Link Group, GP I	Apollo Simulator Program Maintenance and Modification
	TRW Systems	Apollo Mission Analysis
	Univac	Apollo Communications Control
	Philco-Ford	Apollo Procedures Control Unit Operation
	MIT	Apollo Guidance and Control Programming
	McDonnell-Douglas	Command Module Simulator Operations and Programming
Marshall Space Flight Center	Computer Sciences Corp.	Programming, Analysis and Operations
	Service Technology Corp. (LTV)	Keypunching, Programming and Operations
	General Electric	Data Reduction Programming and Operations

Figure 8

Installation	Name of Firm	ADP Service Performed
Goddard Space Flight Center	CEIR	Programming and Analysis
	Computer Applications, Inc.	Programming, Analysis, Operations and Maintenance
	Computing and Software, Inc.	Programming, Operations and Maintenance
	Computer Sciences Corp.	Programming, Analysis and Operations
	General Electric	Programming
	IBM	Programming, Analysis, Mission Support and Maintenance
	Univac	Programming, Analysis and Maintenance
	Westinghouse	Programming and Analysis
	Wolf Research and Development Corp.	Programming and Analysis
Jet Propulsion Laboratory	Computer Usage Development Corp.	Programming
	Computer Communications, Inc.	Software Maintenance and Operations Support
	Heliodyne Corporation	Programming and Analysis
	IBM	Programming and Analysis
	Informatics	Programming and Analysis
	Planning Research Corp.	Operations and Maintenance
	RCA	Operations and Maintenance
	Univac	Software Maintenance and Operations Support

Installation	Name of Firm	ADP Service Performed
Wallops Station	Philco-Ford	Programming and Computational Services
	Technitrol Engineering Corp.	Operations and Keypunching
Ames Research Center	Computer Sciences Corp.	Scientific Programming and Analysis, Administrative Applications, Keypunching
	IBM, Federal Systems Div.	Scientific Programming
	Informatics, Inc.	Scientific Programming
	Computer Usage Corp.	Operations
	System Development Corp.	Programming
Electronics Research Center	Service Technology Corp.	Programming, Analysis, Operations, Keypunching
Flight Research Center	General Electric	Operations, Data Preparation, Keypunching
	Computing and Software, Inc.	Biomedical Programming and Analysis
	North American	B-70 Data Reduction
Langley Research Center	Hampton Institute	Readout and Data Preparation
	Hayes International Corp.	Keypunching and Programming
	Computing and Software, Inc.	Scientific Computer Operations, Keypunching, Programming
	Control Data Corp.	Maintenance
	IBM	Maintenance
Lewis Research Center	IBM	Maintenance

Installation	Name of Firm	ADP Service Performed
Space Nuclear Pro-propulsion Office	Pan American World Airways, Inc.	Programming, Analysis, and Operations
Headquarters	Leasco	Programming and Operations
	Informatics (TISCO)	Programming, Analysis and Operations, Key-punching

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

End of Fiscal Year Inventory of Computers

	FY 1968	FY 1969	FY 1970
Office of Manned Space Flight.....	285	266	276
Kennedy Space Center.....	22	21	21
Manned Spacecraft Center.....	132	141	153
Marshall Space Flight Center.....	131	104	102
Office of Space Science and Applications	293	312	323
Goddard Space Flight Center.....	193	212	220
Jet Propulsion Laboratory.....	97	96	98
Wallops Station.....	3	4	5
Office of Advanced Research and Technology.....	60	77	82
Ames Research Center.....	26	27	30
Electronics Research Center.....	6	15	17
Flight Research Center.....	6	6	6
Langley Research Center.....	9	14	14
Lewis Research Center.....	12	14	14
Space Nuclear Propulsion Office.....	1	1	1
Headquarters.....	4	4	3
Total.....	642	659	684
Breakdown by Category of Equipment:			
Category A (General Purpose).....	184	147	146
Category B (Special Purpose).....	458	512	538
Breakdown by Size of Equipment:			
Large.....	58	58	58
Medium.....	97	96	94
Small.....	487	505	532

Figure 9

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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

	FY 1968				FY 1969				FY 1970			
	Lease	Maint.	Purch.	Total	Lease	Maint.	Purch.	Total	Lease	Maint.	Purch.	Total
Office of Manned Space Flight	$24,968	$2,158	$3,749	$30,875	$23,602	$2,472	$545	$26,619	$26,527	$2,302	$703	$29,532
Kennedy Space Center	1,496	361	1,933	3,790	1,363	505	---	1,868	1,040	525	---	1,565
Manned Spacecraft Center	15,107	1,215	1,157	17,479	17,483	1,295	430	19,208	17,654	1,313	700	19,667
Marshall Space Flight Center	8,365	582	659	9,606	4,756	672	115	5,543	7,833	464	3	8,300
Office of Space Science and Applications	$10,881	$3,459	$15,638	$29,978	$9,914	$4,619	$10,340	$24,873	$9,951	$4,718	$11,054	$25,723
Goddard Space Flight Center	5,822	2,206	13,276	21,304	5,912	3,527	8,847	18,286	5,819	3,607	9,137	18,563
Jet Propulsion Laboratory	5,012	1,202	2,310	8,524	3,951	1,030	1,222	6,203	4,081	1,019	1,617	6,717
Wallops Station	47	51	52	150	51	62	271	384	51	92	300	443
Office of Advanced Research and Technology	$3,964	$675	$8,400	$13,039	$4,431	$1,454	$7,811	$13,696	$3,579	$1,720	$5,077	$10,376
Ames Research Center	1,472	244	849	2,565	1,489	306	1,070	2,865	1,934	342	742	3,018
Electronics Research Center	138	31	1,455	1,624	346	156	611	1,113	396	176	335	907
Flight Research Center	20	41	461	522	2	50	250	302	118	50	---	168
Langley Research Center	1,902	224	5,341	7,467	2,215	767	5,806	8,788	765	976	4,000	5,741
Lewis Research Center	119	135	294	548	109	175	74	358	96	176	---	272
Space Nuclear Propulsion Office	313	---	---	313	270	---	---	270	270	---	---	270
Headquarters	$219	$32	$14	$265	$245	$65	---	$310	$320	$60	---	$380
Total	$40,032	$6,324	$27,801	$74,157	$38,192	$8,610	$18,696	$65,498	$40,377	$8,800	$16,834	$66,011
Breakdown by Appropriation:												
R&D	22,895	4,475	25,090	52,460	24,083	6,237	18,635	48,955	26,841	6,392	16,819	50,052
R&PM	17,137	1,849	2,711	21,697	14,109	2,373	61	16,543	13,536	2,408	15	15,959
Breakdown by Category of Equipment:												
Cat. A	37,680	3,580	18,427	59,687	34,625	5,258	6,579	46,462	37,106	5,352	7,221	49,679
Cat. B	2,352	2,744	9,374	14,470	3,567	3,352	12,117	19,036	3,271	3,448	9,613	16,332

Figure 10

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Summary of Requirements by NASA Installation

Kennedy Space Center

At the Kennedy Space Center the Central Instrumentation Facility (CIF) provides "quick-look" data reduction, real-time meteorological analysis, automatic checkout and general scientific computations in support of all space vehicle tests and launches. General data processing services at KSC are provided primarily by two GE 635's, two IBM 7010's and supporting equipment. Much of this equipment is operated "on-line" as part of the countdown and launch control system for a significant portion of the total operating time. In addition to supporting all major space vehicle projects, substantial computational services are provided to the aerospace contractors in the Cape Kennedy area.

Growth in requirements to support the operational checkout procedures for spacecraft and launch vehicles resulted in a plan to replace two IBM 7010's and an IBM 1440 with an IBM 360/50 - 360/40 combination. The new equipment was installed in the second quarter of FY 1969, with the conversion scheduled to be complete by February 1969. Also in FY 1969 a small processor will be purchased for use as a data evaluator in pre-processing real-time telemetry.

Additional computer resources do not appear necessary in the near term. Changes in future launch schedules will have a sharp impact on the ADP workload at KSC but the only changes which can now be anticipated in FY 1970 or beyond are those reconfigurations which may be necessary to adapt the computation complex to the data reduction requirements of experimenters.

Manned Spacecraft Center

At MSC the Computation and Analysis Division (CAD) is responsible for all general purpose computation and data processing. Flight Operations Directorate manages the ADP equipment supporting manned spacecraft missions, while the Information Systems Division monitors ADP requirements of a special purpose nature.

The largest increase in MSC computation requirements has occurred in the area of Apollo mission analysis. In addition to utilizing the full production of two IBM 7094's this function utilizes more than the total three-shift operation of a Univac 1108 computer.

In the Real-Time Control Center, Apollo mission control is supported by six IBM 360/75 computers. Little change is expected in this area during the Apollo program. Two IBM 360/50 computers used for program development in mission control are expected to become excess this year. One is planned for retention within the Flight Support Division to handle Apollo Lunar

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Surface Experiment Package (ALSEP) data processing. The other is being considered for transfer to NASA Headquarters.

The anticipated increase in administrative applications is expected to exceed the capacity of the Univac 1107's supporting the function by 1970. Augmentation of these systems may be necessary at that time.

Six CDC 160G computers were approved for installation during FY 1969 to support two automatic checkout (ACE) stations and a checkout systems development laboratory. Several other small Category B computers were installed during FY 1969 to support specific research projects and several more are anticipated during FY 1970 primarily for Apollo and lunar research projects.

Marshall Space Flight Center

Most MSFC computation requirements are served by two large central computer complexes located at Huntsville, Alabama, and Slidell, Louisiana. In addition, there are a variety of smaller computers dispersed throughout the research laboratories.

Conversion to Univac 1108's dominated ADP activity during FY 1968 and will continue to do so during FY 1969. Approximately 20 second generation computers are scheduled to be (or have already been) replaced at Huntsville by the third generation equipment. Most of the computers to be replaced were leased machines. Due to slippage in software delivery much of the third generation equipment has not yet been accepted and, as a result, the release dates of second generation computers have had to be extended. In several cases, leased second generation computers were purchased where the slippage would have exceeded the breakeven date. Government-owned computers will be re-utilized in other applications at MSFC and elsewhere. The primary equipment serving scientific computations (two IBM 7094's) will be transferred to a GSA service center to be established at Huntsville. A Burroughs B5500 utilized for data reduction and telemetry calculations was purchased by GSA in early FY 1968 and will be re-utilized by the Department of Interior in February or March 1969. Several small leased IBM 1130 computers were released for re-utilization by the Defense Supply Agency early in FY 1969.

At the Slidell facility, leased IBM 7040, 1440, and GE 235 computers were released in the first quarter of FY 1969. A general re-evaluation of equipment requirements is underway at Slidell as a result of the expected decline starting next year in workload at the Michoud Assembly Facility and the Mississippi Test Facility. In FY 1970 there is a good possibility of releasing or re-utilizing additional small and medium scale computers depending on the success of conversion to third generation systems. In addition, it is possible that some of the present Category B requirements for small special purpose equipment can be more efficiently handled by remote terminals linked to the central facilities.

No major computer acquisitions at either Huntsville or Slidell are anticipated in the next few years beyond completion of the present

conversion effort. Development of the full potential of the Univac third generation computer systems continues to constitute the primary ADP activity at the MSFC facilities.

Goddard Space Flight Center

Although no new Category A computers will be added to the Goddard Space Flight Center inventory during FY 1969 or FY 1970, some funds will be used for purchase of leased components of the existing computers. In FY 1970, it is planned to procure additional storage and supporting control circuitry for presently installed IBM 360/75's.

During FY 1969 some Category B computers will be acquired. These will support tracking and telemetry processing, primarily Apollo; automatic checkout systems associated with satellites under development; tracking functions associated with biosatellites; and certain other satellite projects as display generators. Although a large number of the computers will be added during this fiscal year, many represent systems procured during FY 1968, with final installation and acceptance occurring during FY 1969.

During FY 1970 nine computers will be added to the Category B inventory. Seven of these will be used for the tracking function, with three additional Univac 1218 computers needed to support future Apollo missions and four being obtained for the Goddard Optical Tracking Facilities. An additional mission support computer is necessary for the Goddard Multi-Satellite Operations Control Center (MSOCC) and one computer is required to provide test data acquisition and processing for the nuclear physics project.

The largest single cost relating to Category B computers does not increase the total number of computers in the inventory. This funding is needed for the conversion of the Communications Processing Computers (principally the Univac 494's) to the new American Standard Code for Information Interchange (ASCII). This code was recently adopted as a Federal standard and is expected to be applicable to new computers acquired after July 1, 1969.

Jet Propulsion Laboratory

The Jet Propulsion Laboratory has requirements for computers to aid in the development of spacecraft for the planetary programs and for the deep space network. The computers are used for trajectory and celestial mechanics, structural analysis, circuit design, propulsion research, and communications analysis. A Univac 1108 is currently being installed in the laboratory's Scientific Computing Facility (SCF). Another computer is being acquired for a centralized data acquisition system to interface between the SCF computer and the researcher's experiments.

No changes in the FY 1970 inventory of Category A computers is envisioned at this time. There will, however, be some peripheral additions to the existing computers during both FY 1969 and FY 1970.

Five computers will be added to the Category B inventory in FY 1969. Three of these computers will be added to the Deep Space Instrumentation Facility, one to serve in Deep Space Net Control Research and the other two to support Digital Tracking Station Development. The two additional computers scheduled for installation during FY 1969 are for research in Guidance and Control and for the Gamma Ray Spectrum Emission Research activity.

Three Category B computers will also be added during FY 1970, two for the Digital Tracking Station implementation and the other for the Roving Vehicle Motion Control Study.

Wallops Station

There are no planned additions to the Category A computer inventory during FY 1969 and FY 1970. Some minor funding is required during FY 1969 to update some of the peripherals on the GE 625, to provide greater flexibility in support of the launch and tracking functions assigned to the Wallops Station.

In the Category B area, it is planned that a computer will be acquired during the fourth quarter of FY 1969 to support the Mobile Range Systems. An excess computer at the Jet Propulsion Laboratory is expected to be available to meet this requirement. However, since this excess computer system does not contain all essential components, some funds will be required during FY 1969 to purchase the necessary peripherals. A second computer will be acquired during FY 1970 and installed as part of a telemetry system.

Ames Research Center

Ames Research Center utilizes ADP equipment for scientific and engineering computation, for reduction and analysis of data from experiments, for monitoring and controlling experiments in real-time, and for aircraft/spacecraft simulation studies. The IBM 360/50 computer system is used primarily for scientific and engineering computations, with a large part of the workload originating from remote access stations strategically located in the research laboratories and test facilities. Additional ADP workload demands result from increasing requirements for advanced theoretical studies in aerodynamics and propulsion, and for studies of operating problems associated with supersonic and hypersonic aircraft, and a wide variety of V/STOL vehicles.

Ames utilizes an IBM 7094/7040 system for general scientific and engineering computation, data reduction, simulation, and general business applications. A HON 800/200 system is used primarily for on-line wind tunnel test data reduction. Ames is planning to expand the system to provide on-line capability for two wind tunnels operating simultaneously. Additional system revisions will be required to provide on-line data processing for up to five wind tunnels.

As integral components of research and test facilities, Ames utilizes small special purpose computers for simulation, experiment control, and real-time data acquisition with "quick-look" display capability.

Ames is evaluating new techniques for consolidating ADP requirements into a more unified complex of equipment through development of an intracenter computer communications capability.

A real-time data acquisition computer will be put on-line to the 40 x 80' wind tunnel, and the IBM 360/50 central system will be expanded in FY 1970.

Electronics Research Center

General purpose ADP requirements at ERC are primarily for scientific and engineering computations, and are expected to more than double during the next two years. Data reduction requirements are expected to increase steadily along with simulation techniques. An IBM 7094 II computer system is used for general purpose scientific computation, data reduction, and business applications, along with a Univac 418 at the Manned Spacecraft Center. Data communications links provide for remote access to the computer complexes at the Langley Research Center and at MSC.

The present planning is for an expanded general purpose, large scale, unified central computation facility for completion during late FY 1971, or in FY 1972. ADP applications at ERC require equipment capability for processing a broad range of problems such as trajectory analysis, power spectral analysis, and large matrix inversion in support of V/STOL, SST, and other aeronautics and space projects.

Special purpose computers are used in conjunction with the research laboratory equipment for experiment sequence control, real-time data acquisition, and analysis for "quick-look" display. New applications include analog/digital simulation as part of the research work, and a combined hybrid-control configuration for a particularly complex requirement in guidance and control.

Flight Research Center

Flight Research Center plans to augment their IBM 360/40 computer system during FY 1969 by installing additional peripheral equipment to support the expected increased workload. The center is examining the feasibility of incorporating part of their special purpose computer requirements into the central, general purpose system. Studies currently in progress indicate a need for installation of new equipment during FY 1970.

General purpose computer requirements at FRC are primarily for data reduction, however, there is a rapidly increasing demand for scientific and engineering computation. While some major programs are being concluded, these are being replaced by a large number of small programs. Significant increases are a critical need for studies of F-111 handling qualities and trajectory optimization research. Additional new requirements include supporting studies for flight projects such as Supercritical Wing, Jet Transport, Airborne Simulator, and General Aviation.

In FY 1969, FRC is planning to install a SIGMA V computer as part of the radar range tracking facilities for real-time data acquisition purposes, and to upgrade their SEL 810-I computer with a more powerful SEL 810-B central processing unit.

Langley Research Center

Langley Research Center is consolidating a major part of their ADP workload onto one central computer system complex. The system was designed to provide a powerful, central computation capability with a flexible input/output interconnection for direct access from several of the research and testing facilities. A CDC 6400 and three CDC 6600 computers are installed and are directly interconnected with data cell drives to provide a large bulk data storage. Preliminary interconnections have been completed for interfacing the equipment for real-time digital simulation applications, for on-line data reduction applications, and for connection of the remote access terminals located in the research laboratories.

A large part of the general purpose digital computing requirement is for analytical research, and includes studies of structures, aerodynamics, thermal analysis, dynamic loads, and systems analysis. Also of major significance is real-time simulation in support of aerospace flight research, requiring the precision, flexibility and high speeds that can best be provided through digital simulation techniques. Applications include general research on aircraft operating problems, rendezvous, extra vehicular studies, and space vehicle control, as well as support to FAA for glide slope studies and air traffic control. During FY 1969, plans provide for the installation of a large capacity magnetic core memory to provide for incorporating the four CDC computers into a single integrated computer complex. It is expected also that additional peripheral equipment will be installed to meet new requirements resulting from changing program techniques, and new applications. During FY 1970, a CDC 7600 computer system is to be installed in the central computer complex and the interim leased CDC 6600 now installed will be released. Four special purpose computers will be installed during FY 1969 for on-line, real-time data acquisition, and for experiment control applications.

Lewis Research Center

Lewis Research Center's ADP requirements are about evenly divided between data reduction and scientific/engineering computations. The Center is implementing a centralized data collection system to provide for a more efficient data flow from the testing facilities to the central data processing facilities. The data reduction workload will increase slightly over the current requirement during the next year.

The Center has no plans for additional general purpose computer actions during FY 1969 or FY 1970. Presently installed equipment operates approximately three shifts per day and current planning indicates a continuing requirement at this level.

Computer applications include heat transfer calculations, trajectory calculations, and other elements related to engine systems and performance during all flight phases. In addition, mathematical models are employed for materials research that spans a wide temperature range from cryogenic temperatures of liquid gases to the high temperatures encountered in rocket nozzles.

Lewis is installing a centralized data collection network through interconnection of the research testing facilities with the central computer systems. The time sharing features of the IBM 360/67 can be utilized to efficiently service the many experimental and test facilities which otherwise would have to be supported by several small dedicated computers. However, three special purpose computers will be installed during FY 1969 with direct interconnection to the research and test facilities to complement the time sharing system.

Space Nuclear Propulsion Office

The Space Nuclear Propulsion Office is evaluating the feasibility of replacing or augmenting the present computer system during late FY 1969 or FY 1970. SNPO is using a CDC 3200 computer located at the Nuclear Rocket Development Station (NRDS) for nuclear engine systems test monitoring and display of test progress based on quick analysis, test data reduction, engineering studies, and business support operations. The central computer is also used to maintain a large inventory of data and to control channels from their testing facilities, and for scientific and engineering work including computations in fluid dynamics, reactor decay heat, fuel element weight loss, and radiation dose predictions.

Headquarters

General data processing requirements at Headquarters are provided by two IBM 1410 computers managed by the Management Systems Division, recently reorganized under the Office of Technology Utilization. Primary applications include Financial Accounting, Status of Contracts and Grants, Personnel and Payroll. The Scientific and Technical Information Facility (STIF), also operated by the Office of Technology Utilization, is supported by an IBM 360/40 and IBM 1401 located at College Park, Maryland. The application is primarily that of information retrieval of scientific reports and research programs. There has been a steady increase in both the general data processing and information retrieval areas in recent years which is expected to continue. An expansion of the STIF calls for direct CRT links with each NASA installation. When operational, this system will also be used by OART to retrieve data for management and evaluation of research and technical programs.

An excess IBM 360/50 computer at MSC is being considered for transfer to the Headquarters Scientific and Technical Information Facility to upgrade the IBM 360/40 system. The IBM 360/40 would then be used to accommodate the general business applications workload which now saturates the 1410's. The shift of equipment would require little software modification since 1410 programs can be processed by the 360 in emulation mode; and this augmentation would provide Headquarters with sufficient computer capacity through FY 1970.

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