National Aeronautics and Space Administration

BUDGET ESTIMATES

FISCAL YEAR 1971

Volume I

SUMMARY DATA

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1971 ESTIMATES

SUMMARY DATA

TABLE OF CONTENTS

VOLUME I

	Page No.
General statement	SUM 1
NASA organization chart	SUM 3
Geographic location of NASA installations	SUM 4
Summary Tables	
Summary of appropriations	SUM 5
Summary of budget plan by appropriation by budget activity	SUM 7
Summary of budget plan by appropriation by program office	
Office of Manned Space Flight programs	SUM 8
Office of Space Science and Applications programs and Office of University Affairs program	SUM 9
Office of Advanced Research and Technology programs, Office of Tracking and Data Acquisition program and Office of Technology Utilization program	SUM 10
Number of personnel positions	SUM 12
Program Highlights	
Research and Development	
Appropriation language (proposed)	RD 1
Program and financing schedule	RD 3

Page No.

Summary of research and development budget plan by program by cognizant office..... RD 5

Summary narrative program presentation

Office of Manned Space Flight..... RD 7

Apollo..... RD 9

Space Flight Operations..... RD 13

Advanced missions..... RD 19

Office of Space Science and Applications..... RD 21

Physics and astronomy..... RD 23

Lunar and planetary exploration..... RD 29

Bioscience..... RD 37

Space applications..... RD 41

Launch vehicle procurement..... RD 51

Office of University Affairs

Sustaining university program..... RD 53

Office of Advanced Research and Technology..... RD 55

Basic research..... RD 57

Space vehicle systems..... RD 61

Electronics systems..... RD 65

Human factor systems..... RD 69

Space power and electric propulsion systems..... RD 73

Nuclear rockets..... RD 77

Chemical propulsion..... RD 79

Page No.

Aeronautical vehicles..... RD 81

Office of Tracking and Data Acquisition

Tracking and data acquisition..... RD 87

Office of Technology Utilization

Technology utilization..... RD 91

Construction of Facilities

Appropriation language (proposed)..... CF 1

Program and financing schedule..... CF 2

Summary of construction of facilities budget plan by location..... CF 5

Summary installation presentation

Ames Research Center..... CF 7

Goddard Space Flight Center..... CF 8

Jet Propulsion Laboratory..... CF 9

John F. Kennedy Space Center, NASA..... CF 10

Manned Spacecraft Center..... CF 11

Marshall Space Flight Center..... CF 12

Nuclear Rocket Development Station..... CF 13

Various Locations..... CF 14

Facility Planning and Design..... CF 15

Research and Program Management

Appropriation language (proposed)..... RPM 1

Program and financing schedule..... RPM 3

	Page No.
Summary of obligations by installation	RPM 5
Distribution of obligations by function (by Installation)	RPM 6
Distribution of obligations by object classification by function	RPM 7
Distribution of obligations by object classification by installation	RPM 9
Summary narrative installation presentation	
Office of Manned Space Flight	
John F. Kennedy Space Center, NASA	RPM 11
Manned Spacecraft Center	RPM 13
Marshall Space Flight Center	RPM 15
Office of Space Science and Applications	
Goddard Space Flight Center	RPM 19
Wallops Station	RPM 23
Office of Advanced Research and Technology	
Ames Research Center	RPM 25
Electronics Research Center	RPM 29
Flight Research Center	RPM 31
Langley Research Center	RPM 33
Lewis Research Center	RPM 37
Space Nuclear Propulsion Office	RPM 41
Supporting Operations	
NASA Headquarters	RPM 43

Page No.

Special Analyses

Summary of appropriation budget plans by installation..... SA 1

Distribution of research and development budget plan by installation and fiscal year..... SA 2

Capitalized value of NASA's facilities..... SA 3

Jet Propulsion Laboratory (Summary)..... SA 5

Consolidated summary for aviation technology..... SA 7

Supporting research and technology..... SA 8

Automatic data processing equipment..... SA 9

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1971 ESTIMATES

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 of $3,333,000,000 is requested to support current and proposed programs.

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.

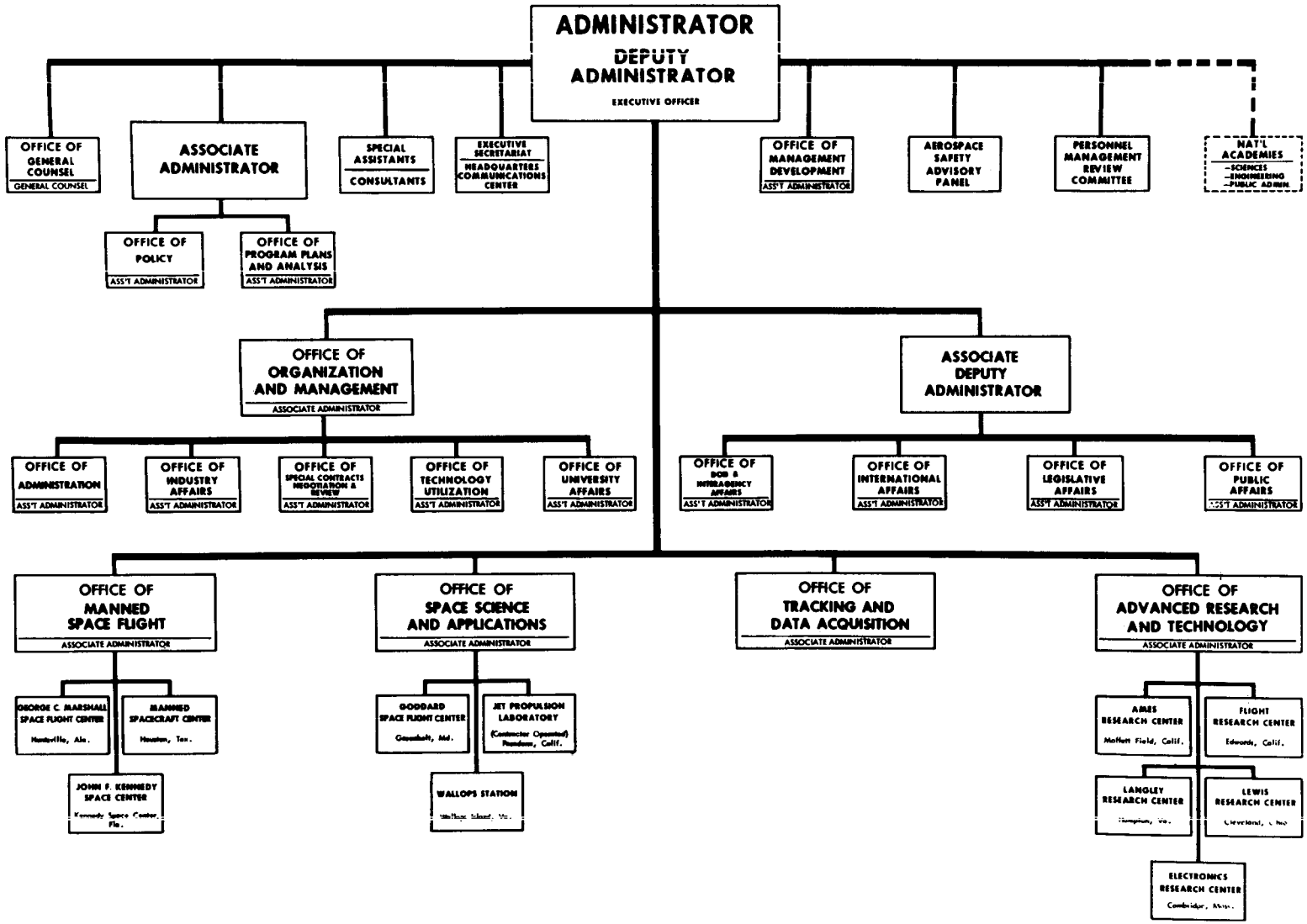
ADVANCED RESEARCH AND TECHNOLOGY: A continuing program to provide the technological base for significant future aerospace missions.

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 1971 budget estimate for the total program of $3,333,000,000 is provided in the following three volumes:

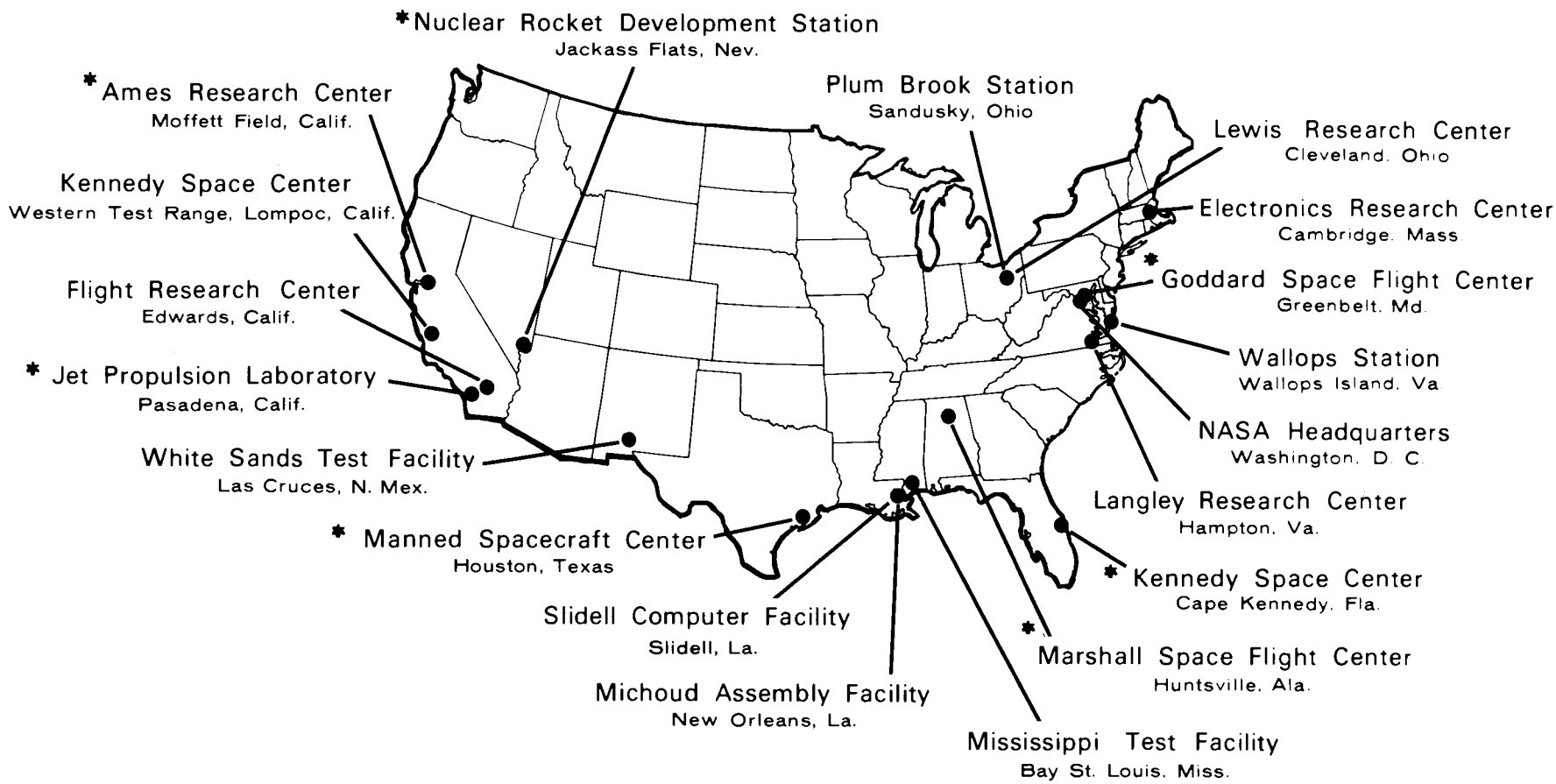
Volume	Amount
II Research and Development	$2,606,100,000
III Construction of Facilities	34,600,000
IV Research and Program Management	692,300,000
TOTAL	$3,333,000,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION



SUM 3

NASA INSTALLATIONS



* Installations for which construction projects are requested in the FY 1971 budget estimates.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1971 ESTIMATES

SUMMARY OF APPROPRIATIONS

(In thousands of dollars)

	Total	Research and Development	Construction of Facilities	Research and Program Management
FISCAL YEAR 1969				
Independent Offices and Department of Housing and Urban Development Appropriation Act, 1969 (82 Stat. 945)	$3,995,273	$3,370,300	$21,800	$603,173
NASA Appropriation Transfers (82 Stat. 945)	---	-56,358	+11,140	+45,218
Transfer to "Operating Expenses, Public Buildings Service," General Services Administration (82 Stat. 943)	-280	---	---	-280
Reserved from apportionment pursuant to P.L. 90-364	-117,473	-117,473	---	---
Appropriation available	$3,877,520	$3,196,469	$32,940	$648,111

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1971 ESTIMATES

SUMMARY OF APPROPRIATIONS (CONTINUED)

(In thousands of dollars)

	Total	Research and Development	Construction of Facilities	Research and Program Management
FISCAL YEAR 1970				
Independent Offices and Department of Housing and Urban Development Appropriation Act, 1970 (83 Stat. 229)	$3,696,633	$3,006,000	$53,233	$637,400
NASA Appropriation Transfers (83 Stat. 230)	---	-9,708	---	+9,708
Transfer to "Operating Expenses, Public Buildings Service," General Services Administration (83 Stat. 229)	-474	---	---	-474
Application of 1969 appropriation reserved from apportionment pursuant to P.L. 90-364.	+117,473	+117,473	---	---
Proposed supplemental for civilian pay act increase	+41,767	---	---	+41,767
Appropriation available and proposed	$3,855,399	$3,113,765	$53,233	$688,401
FISCAL YEAR 1971				
Appropriation request	$3,333,000	$2,606,100	$34,600	$692,300

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1971 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															
1969	2,177,500	382,800	1,070,028	680,333	50	100	---	145	---	---	250	---	---	43,794	---
1970	2,031,745	267,918	1,013,748	678,707	200	814	---	3,457	410	---	2,048	---	---	64,443	---
1971	1,474,200	223,700	603,200	559,700	---	---	---	1,870	---	---	330	---	---	85,400	---
Office of Space Science and Applications															
1969	453,238	3,450	10,861	2,176	201,989	61,246	1,447	34,404	3,478	---	25,448	51,580	---	57,150	---
1970	519,718	1,717	14,416	1,851	215,203	91,103	1,408	31,493	3,147	---	40,995	52,058	---	66,327	---
1971	565,700	3,068	14,030	2,350	255,825	73,235	1,085	37,760	---	---	45,370	67,273	---	65,704	---
Office of University Affairs															
1969	9,000	---	---	---	---	---	---	---	---	---	---	---	---	9,000	---
1970	7,000	---	---	---	---	---	---	---	---	---	---	---	---	7,000	---
1971	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Office of Advanced Research and Technology															
1969	278,220	---	4,961	11,104	8,790	23,163	1,073	25,675	20,493	15,079	57,048	60,446	31,497	15,699	3,192
1970	272,302	---	8,690	12,098	8,830	20,428	1,115	28,514	18,974	10,530	51,989	60,401	33,925	14,200	2,608
1971	264,200	---	6,300	13,783	8,440	17,410	100	34,222	---	13,365	57,538	64,510	35,600	11,397	1,535
Office of Tracking and Data Acquisition															
1969	279,672	---	5,300	300	208,221	47,694	5,409	---	100	2,000	1,450	---	---	9,198	---
1970	278,000	---	---	1,660	206,405	51,150	5,985	---	60	1,875	845	---	---	10,020	---
1971	298,000	---	---	400	212,127	66,143	6,240	---	---	1,630	1,160	---	---	10,300	---
Office of Technology Utilization															
1969	3,800	---	---	---	---	---	---	---	---	---	---	---	---	3,800	---
1970	5,000	---	---	---	---	---	---	---	---	---	---	---	---	5,000	---
1971	4,000	---	---	---	---	---	---	---	---	---	---	---	---	4,000	---
Total Budget Plan															
1969	3,201,430	386,250	1,091,150	693,913	419,050	132,203	7,929	60,224	24,071	17,079	84,196	112,026	31,497	138,650	3,192
1970	3,113,765	269,635	1,036,854	694,316	430,638	163,495	8,508	63,464	22,591	12,405	95,877	112,459	33,925	166,990	2,608
1971	2,606,100	226,768	623,530	576,233	476,392	156,788	7,425	73,852	---	14,995	104,398	131,783	35,600	176,801	1,535

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1971 ESTIMATES

SUMMARY OF BUDGET PLAN BY APPROPRIATION BY BUDGET ACTIVITY

(In thousands of dollars)

Appropriation Title	Total	Manned Space Flight	Scientific Investigations in Space	Space Applications	Space Technology	Aviation Technology	Supporting Activities
Fiscal Year 1969.....	$3,881,474	$2,508,219	$420,240	$130,404	$307,452	$168,148	$347,011
Research and development.....	3,201,430	2,177,500	341,440	109,404	185,866	94,748	292,472
Construction of facilities...	32,080	10,719	1,100	---	386	---	19,875
Research and program management.....	647,964	320,000	77,700	21,000	121,200	73,400	34,664
Fiscal Year 1970.....	$3,855,399	$2,374,895	$469,762	$162,501	$300,772	$186,247	$361,222
Research and development.....	3,113,765	2,031,745	380,467	138,801	176,372	96,380	290,000
Construction of facilities...	53,233	14,250	1,595	---	---	4,767	32,621
Research and program management.....	*688,401	328,900	87,700	23,700	124,400	85,100	38,601
Fiscal Year 1971.....	$3,333,000	$1,810,300	$469,200	$213,350	$292,575	$185,500	$362,075
Research and development.....	2,606,100	1,474,200	382,800	180,800	164,300	102,000	302,000
Construction of facilities...	34,600	2,000	700	5,350	6,275	---	20,275
Research and program management.....	692,300	334,100	85,700	27,200	122,000	83,500	39,800

* Includes $41,767,000 for the proposed supplemental for civilian pay act increase.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1971 ESTIMATES

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

(Thousands of dollars)

PROGRAM		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, TOTAL	1969	2,177,500	382,800	1,070,028	680,333	50	100	---	145	---	---	250	---	---	43,794	---
	1970	2,031,745	267,918	1,013,748	678,707	200	814	---	3,457	410	---	2,048	---	---	64,443	---
	1971	1,474,200	223,700	603,200	559,700	---	---	---	1,870	---	---	330	---	---	85,400	---
Apollo	1969	2,025,000	382,800	1,014,856	586,065	50	100	---	---	---	---	---	---	---	41,129	---
	1970	1,686,145	258,318	873,540	512,010	200	664	---	50	10	---	1,410	---	---	39,943	---
	1971	956,500	205,000	465,300	248,000	---	---	---	---	---	---	---	---	---	38,200	---
Space flight operations	1969	150,000	---	54,707	93,458	---	---	---	145	---	---	125	---	---	1,565	---
	1970	343,100	9,600	139,208	165,897	---	150	---	3,407	400	---	638	---	---	23,800	---
	1971	515,200	18,600	136,900	310,700	---	---	---	1,870	---	---	330	---	---	46,800	---
Advanced missions	1969	2,500	---	465	810	---	---	---	---	---	---	125	---	---	1,100	---
	1970	2,500	---	1,000	800	---	---	---	---	---	---	---	---	---	700	---
	1971	2,500	100	1,000	1,000	---	---	---	---	---	---	---	---	---	400	---
OFFICE OF SPACE SCIENCE AND APPLICATIONS, TOTAL	1969	453,238	3,450	10,861	2,176	201,989	61,246	1,447	34,404	3,478	---	25,448	51,580	---	57,159	---
	1970	519,718	1,717	14,416	1,851	215,203	91,103	1,408	31,493	3,147	---	40,995	52,058	---	66,327	---
	1971	565,700	3,068	14,030	2,350	255,825	73,235	1,085	37,760	---	---	45,370	67,273	---	65,704	---
Physics and astronomy	1969	128,850	60	666	777	99,422	537	838	2,017	47	---	886	---	---	23,600	---
	1970	111,835	---	490	1,214	83,700	920	734	3,094	40	---	773	---	---	20,870	---
	1971	116,000	---	450	1,500	86,800	650	860	4,910	---	---	740	---	---	20,090	---
Lunar and planetary exploration	1969	87,923	3	246	615	3,554	56,412	---	5,158	25	---	10,487	---	---	11,423	---
	1970	151,013	---	1,096	115	4,632	86,221	---	19,774	25	---	22,343	---	---	16,807	---
	1971	144,900	100	680	250	3,550	69,475	---	29,320	---	---	25,100	---	---	16,425	---
Bioscience	1969	37,900	---	---	135	86	2,003	80	27,129	---	---	190	---	---	8,277	---
	1970	19,670	---	300	372	50	1,614	30	8,450	---	---	127	---	---	8,727	---
	1971	12,900	---	400	400	100	1,100	25	3,330	---	---	100	---	---	7,445	---
Space applications	1969	98,665	58	9,949	447	72,193	2,029	529	100	2,124	---	980	1,125	---	9,131	---
	1970	128,400	---	12,530	150	91,622	1,858	644	175	1,825	---	4,170	1,095	---	14,331	---
	1971	167,000	---	12,500	200	131,400	1,500	200	200	---	---	4,300	1,700	---	15,000	---
Launch vehicle procurement	1969	99,900	3,329	---	202	26,734	265	---	---	1,282	---	12,905	50,455	---	4,728	---
	1970	108,800	1,717	---	---	35,199	490	---	---	1,257	---	13,582	50,963	---	5,592	---
	1971	124,900	2,968	---	---	33,975	510	---	---	---	---	15,130	65,573	---	6,744	---
OFFICE OF UNIVERSITY AFFAIRS	1969	9,000	---	---	---	---	---	---	---	---	---	---	---	---	9,000	---
	1970	7,000	---	---	---	---	---	---	---	---	---	---	---	---	7,000	---
	1971	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1971 ESTIMATES

SUMMARY OF BUDGET PLAN

OFFICE OF MANNED SPACE FLIGHT PROGRAMS

	(Thousands of dollars)		
	1969	1970	1971
Research and Development	$2,177,500	$2,031,745	$1,474,200
Apollo	2,025,000	1,686,145	956,500
Space flight operations	150,000	343,100	515,200
Advanced missions	2,500	2,500	2,500
Construction of Facilities	10,719	14,250	2,000
Kennedy Space Center	7,364	12,500	575
Manned Spacecraft Center	1,333	1,750	900
Marshall Space Flight Center	---	---	525
Michoud Assembly Facility	400	---	---
Various locations	1,622	---	---
Research and Program Management	310,968	323,688	330,583
Kennedy Space Center	95,794	97,445	98,150
Manned Spacecraft Center	98,840	104,546	107,758
Marshall Space Flight Center	116,334	121,697	124,675
TOTAL, MANNED SPACE FLIGHT	$2,499,187	$2,369,683	$1,806,783

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1971 ESTIMATES

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

(Thousands of dollars)

PROGRAM		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 ADVANCED RESEARCH AND TECHNOLOGY, TOTAL	1969	278,220	---	4,961	11,104	8,790	23,163	1,073	25,675	20,493	15,079	57,048	60,446	31,497	15,699	3,192
	1970	272,302	---	8,690	12,098	8,830	20,428	1,115	28,514	18,974	10,530	51,989	60,401	33,925	14,200	2,608
	1971	264,200	---	6,300	13,783	8,440	17,410	100	34,222	---	13,365	57,538	64,510	35,600	11,397	1,535
Basic research	1969	20,220	---	---	820	122	3,155	---	2,561	1,952	---	2,457	2,895	---	6,258	---
	1970	18,902	---	---	555	100	2,435	---	2,775	2,060	---	2,310	4,247	---	4,420	---
	1971	17,600	---	---	1,588	100	2,200	---	2,805	---	---	2,175	4,510	---	4,222	---
Space vehicle systems	1969	31,349	---	947	3,462	2,351	1,710	---	3,500	425	1,220	13,482	3,070	---	1,122	---
	1970	30,670	---	1,740	3,943	2,400	1,465	---	3,165	389	1,205	12,452	2,910	---	1,001	---
	1971	30,000	---	1,050	3,035	1,475	1,475	---	3,100	---	1,200	13,985	3,300	---	1,380	---
Electronics systems	1969	34,460	---	---	2,180	2,801	2,891	---	3,231	16,048	740	4,555	---	---	2,014	---
	1970	33,500	---	425	2,870	3,130	3,540	---	3,235	13,665	725	4,510	---	---	1,400	---
	1971	22,400	---	700	3,790	3,940	2,660	---	4,787	---	900	4,723	---	---	900	---
Human factor systems	1969	19,402	---	3,089	287	---	50	1,073	5,815	975	899	5,407	---	---	1,807	---
	1970	21,900	---	4,150	200	---	---	1,115	5,180	1,240	800	6,880	---	---	2,335	---
	1971	17,900	---	2,900	150	---	---	100	5,700	---	800	6,900	---	---	1,350	---
Space power and electric propulsion systems	1969	38,787	---	135	200	3,306	10,805	---	408	1,093	---	1,377	20,348	---	1,115	---
	1970	34,450	---	1,405	220	3,150	8,450	---	349	1,420	---	1,375	16,985	---	1,096	---
	1971	30,900	---	---	---	2,925	7,075	---	250	---	---	1,820	17,925	---	905	---
Nuclear rockets	1969	33,502	---	---	860	---	---	---	---	---	---	---	1,145	31,497	---	---
	1970	36,500	---	---	1,575	---	---	---	---	---	---	---	1,000	33,925	---	---
	1971	38,000	---	---	1,600	---	---	---	---	---	---	---	800	35,600	---	---
Chemical propulsion	1969	25,752	---	790	2,850	210	4,552	---	---	---	---	2,310	10,843	---	1,005	3,192
	1970	20,480	---	970	1,510	50	4,357	---	---	---	---	1,295	8,629	---	1,061	2,608
	1971	20,300	---	1,650	2,720	---	3,800	---	---	---	---	800	9,205	---	590	1,535
Aeronautical vehicles	1969	74,748	---	---	445	---	---	---	10,100	---	12,220	27,460	22,145	---	2,378	---
	1970	75,900	---	---	1,225	---	181	---	13,810	200	7,800	23,167	26,630	---	2,887	---
	1971	87,100	---	---	900	---	200	---	17,580	---	10,465	27,135	28,770	---	2,050	---
OFFICE OF TRACKING AND DATA ACQUISITION	1969	279,672	---	5,300	300	208,221	47,694	5,409	---	100	2,000	1,450	---	---	9,198	---
	1970	278,000	---	---	1,660	206,405	51,150	5,985	---	60	1,875	845	---	---	10,020	---
	1971	298,000	---	---	400	212,127	66,143	6,240	---	---	1,630	1,160	---	---	10,300	---
OFFICE OF TECHNOLOGY UTILIZATION	1969	3,800		---	---	---	---	---	---	---	---	---	---	---	3,800	---
	1970	5,000	---	---	---	---	---	---	---	---	---	---	---	---	5,000	---
	1971	4,000	---	---	---	---	---	---	---	---	---	---	---	---	4,000	---
TOTAL BUDGET PLAN	1969	3,201,430	386,250	1,091,150	693,913	419,050	132,203	7,929	60,224	24,071	17,079	84,196	112,026	31,497	138,650	3,192
	1970	3,113,765	269,635	1,036,854	694,318	430,938	163,495	8,300	62,164	22,591	12,405	85,877	112,459	33,925	166,990	2,608
	1971	2,606,100	226,768	623,530	576,233	476,392	156,788	7,425	73,852	---	14,995	104,398	131,783	35,600	176,801	1,535

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1971 ESTIMATES

SUMMARY OF BUDGET PLAN

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

	(Thousands of dollars)		
	1969	1970	1971
SPACE SCIENCE AND APPLICATIONS PROGRAMS AND PROJECTS			
Research and Development	$453,238	$519,718	$565,700
Physics and astronomy.....	128,850	111,835	116,000
Lunar and planetary exploration.....	87,923	151,013	144,900
Bioscience.....	37,900	19,670	12,900
Space applications.....	98,665	128,400	167,000
Launch vehicle procurement.....	99,900	108,800	124,900
Construction of Facilities	1,100	1,595	6,050
Goddard Space Flight Center.....	---	670	2,050
John F. Kennedy Space Center, NASA...	600	---	---
Jet Propulsion Laboratory.....	---	---	700
Wallops Station.....	500	500	---
Various locations.....	---	425	3,300
Research and Program Management	82,329	94,317	97,461
Goddard Space Flight Center.....	73,227	84,772	87,670
Wallops Station.....	9,102	9,545	9,791
TOTAL, SPACE SCIENCE AND APPLICATIONS.....	$536,667	$615,630	$669,211
UNIVERSITY AFFAIRS PROGRAM			
Research and Development			
Sustaining university program.....	$9,000	$7,000	---

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1971 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)		
	1969	1970	1971
ADVANCED RESEARCH AND TECHNOLOGY PROGRAMS AND PROJECTS			
Research and Development	$278,220	$272,302	$264,200
Basic research	20,220	18,902	17,600
Space vehicle systems	31,349	30,670	30,000
Electronics systems	34,460	33,500	22,400
Human factor systems	19,402	21,900	17,900
Space power and electric propulsion systems	38,787	34,450	30,900
Nuclear rockets	33,502	36,500	38,000
Chemical propulsion	25,752	20,480	20,300
Aeronautical vehicles	74,748	75,900	87,100
Construction of Facilities	386	4,767	6,275
Ames Research Center	386	---	1,525
Jet Propulsion Laboratory	---	---	1,250
Langley Research Center	---	4,767	---
Nuclear Rocket Development Station	---	---	3,500
Research and Program Management	193,890	208,578	201,521
Ames Research Center	34,032	36,359	38,248
Electronics Research Center	17,237	19,483	4,470
Flight Research Center	9,697	10,131	10,549
Langley Research Center	62,945	67,973	70,734
Lewis Research Center	67,844	72,398	75,218
Space Nuclear Propulsion Office	2,135	2,234	2,302
TOTAL, ADVANCED RESEARCH AND TECHNOLOGY	$472,496	$485,647	$471,996

	(Thousands of Dollars)		
	1969	1970	1971
TRACKING AND DATA ACQUISITION PROGRAMS AND PROJECTS			
Research and Development			
Tracking and data acquisition...	$279,672	$278,000	$298,000
Construction of Facilities	18,875	17,000	1,275
Various Locations.....	18,875	17,000	1,275
TOTAL, TRACKING AND DATA ACQUISITION.....	$298,547	$295,000	$299,275
TECHNOLOGY UTILIZATION - Research and Development	$3,800	$5,000	$4,000

375-328 O - 70 - 2

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1971 ESTIMATES

NUMBER OF PERSONNEL POSITIONS

	Fiscal Year 1969	Fiscal Year 1970	Fiscal Year 1971
MANNED SPACE FLIGHT.....	13,410	13,033	12,883
John F. Kennedy Space Center, NASA.....	2,877	2,779	2,748
Manned Spacecraft Center.....	4,384	4,250	4,200
Marshall Space Flight Center..	6,149	6,004	5,935
SPACE SCIENCE AND APPLICATIONS..	4,625	4,900	4,900
Goddard Space Flight Center...	4,141	4,412	4,412
Wallops Station.....	484	488	488
ADVANCED RESEARCH AND TECHNOLOGY	11,617	11,294	10,694
Ames Research Center.....	1,992	1,972	1,972
Electronics Research Center...	802	600	---
Flight Research Center.....	539	535	535
Langley Research Center.....	3,912	3,872	3,872
Lewis Research Center.....	4,268	4,215	4,215
Space Nuclear Propulsion Office.....	104	100	100
SUPPORTING OPERATIONS			
NASA Headquarters.....	2,093	2,123	2,073
TOTAL PERMANENT POSITIONS...	31,745	31,350	30,550
POSITIONS OTHER THAN PERMANENT.....	2,196	2,300	2,300
TOTAL POSITIONS.....	33,941	33,650	32,850

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1971 ESTIMATES

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

BUDGET ACTIVITY	OFFICE/PROGRAM	Fiscal Year 1969	Fiscal Year 1970	Fiscal Year 1971
	MANNED SPACE FLIGHT.....	$2,177,500	$2,031,745	$1,474,200
1a	Apollo.....	2,025,000	1,686,145	956,500
1b&c	Space flight operations.....	150,000	343,100**	515,200
1d	Advanced missions.....	2,500	2,500	2,500
	SPACE SCIENCE AND APPLICATIONS..	453,238	519,718	565,700
2a	Physics and astronomy.....	128,850	111,835	116,000
2b	Lunar and planetary exploration.....	87,923	151,013	144,900
2c	Bioscience.....	37,900	19,670	12,900
3	Space applications.....	98,665	128,400	167,000
*	Launch vehicle procurement....	99,900	108,800	124,900
	UNIVERSITY AFFAIRS			
6b	Sustaining university program.	9,000	7,000	---
	ADVANCED RESEARCH AND TECHNOLOGY.....	278,220	272,302	264,200
4&5	Basic research.....	20,220	18,902	17,600
4	Space vehicle systems.....	31,349	30,670	30,000
4&5	Electronics systems.....	34,460	33,500	22,400
4&5	Human factor systems.....	19,402	21,900	17,900
4&5	Space power and electric propulsion systems.....	38,787	34,450	30,900
4	Nuclear rockets.....	33,502	36,500	38,000
4	Chemical propulsion.....	25,752	20,480	20,300
5	Aeronautical vehicles.....	74,748	75,900	87,100
6a	TRACKING AND DATA ACQUISITION.	279,672	278,000	298,000
6c	TECHNOLOGY UTILIZATION.....	3,800	5,000	4,000
	TOTAL BUDGET PLAN.....	$3,201,430	$3,113,765	$2,606,100

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

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1971 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR

MANNED SPACE FLIGHT PROGRAMS

Program	(Thousands of dollars) 1969	1970	1971
Apollo	$2,025,000	$1,686,145	$956,500
Space flight operations	150,000	343,100*	515,200
Advanced missions	2,500	2,500	2,500
Total	$2,177,500	$2,031,745	$1,474,200

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

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1971 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 space technology developed in the Gemini and Apollo programs.

Initial Space Flight Operations will be conducted in the Apollo Applications program, which is built on the strong base of flight experience, ground facilities, and trained manpower developed in the Apollo program. Apollo Applications employs a Saturn Workshop, launched on the first two stages of a Saturn V, Apollo Telescope Mount for observing the sun, 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, earth resources, applications, technological, and medical investigations.

These Apollo Applications missions will be a prelude to the operation of a space station and space shuttle. The space station and space shuttle will provide the capability for conducting continuous manned missions in near-earth orbit, and supporting a great variety of experiments and activities that can be conducted in the unique environment of space.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1969	1970	1971
Apollo applications.....	$150,000	$300,052	$364,300
Operations.....	---	24,548	40,900
Space shuttle and station.....	(8,800)	18,500	110,000
Total.....	$150,000	$343,100	$515,200

BASIS OF FUND REQUIREMENTS:

Apollo Applications

Apollo Applications will be directed toward near-earth missions emphasizing the utilization and application of space for man's benefit and knowledge.

With flights commencing in 1972, the program is structured about an earth orbiting workshop containing a solar observatory, laboratories, work areas, control stations and crew living quarters. After the launch of the Workshop,

three manned missions using Apollo Command and Service Modules will visit and use the Workshop during its planned eight month operational life.

The program will be the precursor of space station operations that will begin in the last half of the decade. While Apollo Applications will investigate new technological concepts, conduct experiments, and develop operational techniques applicable to the station, its greater importance will be to demonstrate the inter-association of man and his experiments during long duration manned flights.

The first manned Apollo Applications flight will be a 28 day mission which is twice the duration of existing experience. The primary objectives are to determine the effects of prolonged weightlessness on man's health and behavior and on his ability to carry out his various duties and to test with the ATM the equipment and operating concepts for future manned or man-tended observations. The second and third flights are planned as lasting up to 56 days each, which approaches the regular crew cycles on a space station or space base.

During the summer of 1969, the Apollo Applications mission sequence was considerably altered. The principal changes resulted from the decision to develop a ground-outfitted Orbital Workshop using the first two stages of the Saturn V vehicle to launch it into space. Previously, the Workshop was to be set up inside the empty tank of a spent S-IVB after both that stage and the first stage of a Saturn IB vehicle had launched it into orbit. Later, the large solar observatory, (the ATM), was to be launched by a Saturn IB as a separate mission and rendezvous and dock with the Workshop after reaching orbit. With the greatly increased performance capability of the Saturn V, the Workshop will be launched with all the principal hardware elements, such as the Airlock, Multiple Docking Adapter, and ATM, integrated on the ground. Further, it will be launched into a higher inclination orbit to provide improved coverage for the earth resources survey. A final major change is that the Workshop will now provide its own electrical power, life support, and logistics supplies. In the previous mode of operation, the Workshop was to have relied on the Command and Service Module (CSM) for this support.

Following the orbiting of the Workshop, a Saturn IB with a modified Apollo Command and Service Module will be launched from Launch Complex 34 at the Kennedy Space Center sending the first flight crew toward a rendezvous and docking with the Workshop. The crew of this flight, as in each of the three manned missions, will consist of three astronauts.

After docking with the Workshop, the crew will leave the Command and Service Module and enter the Workshop, activate its systems and begin a mission planned to last up to 28 days. The Multiple Docking Adapter will provide access to both the Workshop and the Airlock. The Airlock will permit the crew to have access to space and perform extravehicular activity in pressure suits. This first mission will emphasize medical experiments and initiate the operation of the ATM. Upon completing this first manned mission, the Workshop systems will be shifted to a standby condition, and readied for the next crew visit.

Approximately two months after the first crew has left the Workshop, a second flight crew will be launched to revisit and reuse the Workshop. The planned duration of their mission will be up to 56 days; this mission will concentrate on extended operation of the ATM, solar observatory, additional medical experiments, and the conduct of earth resources, physics, biology, and technology experiments planned for the Workshop. Again, the Workshop will be placed in a standby condition upon the departure of the crew.

The third and last astronaut crew will revisit and reuse the Workshop in another mission that is also planned to last for about 56 days. Arriving about one month after the previous crew has returned to earth, they will continue making solar observations and performing the various scientific and technological experiments. With their leaving, the Workshop will be deactivated approximately eight months after its launch.

Operations

This activity funds the unique project requirements of the missions to be conducted within Space Flight Operations. The basic support for manned space flight launch, flight, and recovery operations, is funded under Apollo.

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. FY 1971 funds are required for: mission planning and analysis; procurement of an ATM simulator; modification of Apollo trainers to the AAP configurations; maintenance of Saturn IB launch capability; modification of launch checkout equipment, test and checkout procedures for previously deactivated equipment and systems as well as Apollo Applications unique hardware and reactivation of launch complexes for Apollo Applications.

Space shuttle and station

During the last half of this decade, this country will commence a new epoch in manned space flight. In the short age of flight, man's journeys into space have been both brief and intermittent, focused on limited exploration of this new region and primarily testing his ability to survive. The space station and space shuttle will transform this history.

To introduce this new epoch, when man will truly exploit the environment of space, this country must develop an economical system for ferrying men and materials to and from earth orbit. Without such a system, the performance of space tasks could become disproportionately expensive when compared with the knowledge and benefits obtained.

With the establishment of a space station and its continuous operation in near-earth orbit, and with the associated operation of the shuttle, the environment of space can be applied toward a tremendously quantitative and qualitative expansion in human knowledge--to obtain a better understanding of the earth, sun, solar system, and the universe beyond and of the phenomena that establish, control, and affect the environment of this planet.

The space shuttle, with its various capabilities, will be developed as a national vehicle which can be used by other government agencies and departments to assist them in meeting their responsibilities to the nation. Each space shuttle is composed of two stages - the booster and the orbiter. Both are reusable, and will be designed to perform 100 missions with a minimum of maintenance. It is expected that both stages will be manned, although the booster may have the capability of making an automated return and landing.

The space shuttle will be a reusable space vehicle and is expected to have a payload capability of up to 50,000 pounds to low earth orbit (a capability presently exceeded only by the Saturn V) with a payload compartment of 15 feet in diameter and 60 feet long and a volume of 10,000 cubic feet. The payload capability can be assigned to meeting a single requirement or distributed among several users. Once operational, the shuttle could be the only vehicle used by the United States to transport men to and from earth orbit. With a cabin environment similar to that found in today's commercial airliners, and with gravitational forces of no more than 3G's being exerted during the launch and re-entry phases, passengers without special training can be carried safely and efficiently to and from space. The shuttle, as currently conceived, will be able to carry at least 12 passengers.

During FY 1970, NASA plans to award two sets of definition contracts for the space shuttle. One set of competitive contracts will be awarded for a study of the basic shuttle vehicle, including the aerodynamics, integrated thermal protection system and structure, avionics, and auxiliary propulsion. These studies will emphasize the reusability, maintainability, and low cost operational features of the shuttle and produce alternative preliminary designs. The second set of competitive contracts will be for definition studies for the high performance liquid oxygen/liquid hydrogen engine to be used on the shuttle. The contractors will undertake preliminary design of the engine system, components and operative concepts including: performance limits, design margins, and requirements for engine test stand facilities. Also to be identified, are the areas where design can contribute economies in engine production and maintenance.

The FY 1971 funding request for the space shuttle is for: continuing Phase B definition efforts; initiating a detailed design of elements of the shuttle, especially the engine; and initiating prototype development of selected critical components. Other funding may be applied to develop a necessary test capability through facilities modifications at selected sites where existing engine test stands are located.

NASA is currently involved in the definition of a space station. The overall objectives of this effort are to obtain the technical and managerial information required so that the choice of a single approach to a space station can be made from the alternate approaches available.

The space station will primarily serve as the supporting platform for a very diversified group of scientific applications and technology experiments encompassing nearly all scientific disciplines. The experiments for the space station and space base will be conducted in various modes--some in modules attached to the station or base and with an environment of zero gravity or artifical gravity, and some free flying in various orbits, inclinations, and altitudes.

Flight crews using the station and base will be ferried to and from orbit by the space shuttle. The space shuttle will also provide the logistics support of the station and base and will be able to carry many of the experiment modules. Conceptual studies are underway on the design of experiment modules with special emphasis on commonality so that four or five basic types of module will be able to contain a wide variety of experiments with an extensive range of requirements. Basic structural design and the systems for power, thermal control, attitude control and life support are the principal elements where commonality appears achievable.

The space station is being designed as a long life maintainable system for men working and living in space. Initially, it is expected to operate in a zero gravity condition. The station and base will be quite autonomous, having on-board command and control centers and life support systems that are capable of regenerating the environment, and operating for extended periods. The major source of power will be a nuclear reactor subsystem. A data relay satellite will provide continuous communications coverage with the ground.

The definition effort is being conducted in two parallel studies with industry--one managed by the Manned Spacecraft Center and the other by the Marshall Space Flight Center. The effort is focused on space station preliminary systems design and appropriate development and operation plans. Additional space station supporting activity includes a number of small, competitive contracts for studies and technological investigations related to space station definition.

The first phase of the definition studies is scheduled for completion at the beginning of FY 1971. Funds, however, are requested in FY 1971 for up to six month extensions of definition studies with each contractor. This will allow additional work in selected areas where extension of selected analyses will be beneficial in refining data need for decisions.

375-328 O - 70 - 3

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1971 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 and organic materials 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)		
	1969	1970	1971
Supporting research and technology/ advanced studies	$8,900	$11,170	$9,400
Planetary quarantine	1,300	2,500	2,000
Biosatellite	27,700	6,000	1,500
Total	$37,900	$19,670	$12,900

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology/Advanced Studies

Emphasis in the area of advanced programs and technology is heavily oriented toward defining the scientific requirements for future biological space flight investigations. This activity, of necessity, begins with determining the scientific character of the experiments to be flown and the space flight situation under which the investigations will be conducted. Among these situations are the options between manned and unmanned flight; automated or man-tended experiments; and earth orbital, lunar orbital or heliocentric flight.

The classes of biological specimens under consideration fall into the following broad categories: primates; microorganisms; cells and tissue cultures; semi-microscopic animals and plants; small vertebrate animals; plants; and invertebrate animals.

Since several years are required to bring an investigator's hypothesis to flight in the space environment, it is necessary to establish experiment feasibility early to assure readiness to meet the various launch opportunities.

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, influences normal function in biologic systems removed from their normal earth habitat. A significant area of research is the study of the effects of lunar material on earth life such as growth enhancement in certain plants. 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 missions such as the Saturn Workshop and Space Station.

Behavioral biology seeks fundamental knowledge concerning the behavior of organisms, their behavioral mechanisms of adaptation to the space environment and the biologic bases of such behavior. This includes: (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 to various oscillatory activities in the thermoregulatory, cardiovascular, behavioral, and hormonal systems. Earth orbital satellites with space monitoring and position locating systems present a unique opportunity to study and monitor the earth's ecology and especially the earth's wildlife. Studies are being initiated to determine the feasibility of using or developing various systems for monitoring the behavior and physiology of wildlife and the interrelationship of the total bioecology of earth.

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 in the Martian surface is needed as a precursor to flight instrument developed for future Mars landers. 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 to support the planetary exploration program. The development of this instrumentation is considered to be one of the most important items in the Bioscience Supporting Research and Technology (SR&T) project.

RD 38

The Bioscience Communications project was established to increase effective communication among scientists on matters pertinent to space biology. 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.

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. Studies have continued 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 microorganisms in severe environments as may be encountered on Mars and Venus.

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.

Investigations in FY 1971 are directed towards further simplifying the sterilization requirements and in direct support of planetary missions.

Biosatellite

Automated biological satellites have been flown in low (200 nautical mile) Earth orbit to study the effects of weightlessness and radiation upon living specimens ranging from simple cellular material, small animals, and plants, to a pig-tailed monkey. During the flights of Biosatellite I and II, the engineering design and integrated operation of the spacecraft systems were thoroughly checked out. The 13 experiments carried in Biosatellite II were recovered and analysis showed that there was a definite interaction between radiation and weightlessness.

The Biosatellite III mission experiment subjected a small monkey to the near zero gravity environment for a period of eight and one-half days.

The Biosatellite III launch occurred on June 28, 1969, and a successful orbit of 212.8 nautical miles apogee and 195.2 nautical miles perigee was attained with all of the systems working satisfactorily. Excellent data

were obtained during the eight and one-half days of the mission. At the end of that time, the spacecraft was recovered because of a rapid decline in the physical condition of the monkey. A uniquely complete record of the animal's physiological and behavioral response in the space environment was obtained. A preliminary analysis of the data has revealed many significant effects of weightlessness, one of which was that the monkey experienced a high body fluid loss.

With the cancellation of the C, E and F missions, no further launches in the present Biosatellite series are planned. Funding for 1971 will provide for the continued analysis of the scientific data by the investigators, and for any claims resulting from the contract termination that could not be settled in FY 1970.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1971 ESTIMATES

SUMMARY

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY HUMAN FACTOR SYSTEMS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Human Factor Systems program provides critical information with respect to: (1) man's physiological, psychological, and behavioral reactions to the stresses of air and space missions, (2) the requirement for and nature of artificial gravity in space vehicles, (3) man's capabilities for performing useful tasks in flight vehicles and in extravehicular environments, (4) the environmental thermal requirements, the design criteria for life support and protective systems, and the technology which will allow and assist man to do useful work for extended periods of time, and (5) design criteria and requirements for equipment maintenance and reliability and for escape and rescue systems.

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

The objective of the aeronautics portion of the Human Factor Systems program is to ensure the proper man-machine interface in general, subsonic, V/STOL, and supersonic aircraft. To that end the program must also examine man's requirements, capabilities, and limitations and translate these into design criteria for future aeronautical systems.

The objective of the space portion of the Human Factor Systems program is to provide essential research data leading to an understanding of man physiologically, psychologically, behaviorally, and as an operator in and of space systems, and to supply technology for the hardware and systems tests which will provide for his support and enhance his operational capability. This understanding must be of sufficient depth to provide the data upon which future flight mission decisions may be based and to allow subsequent design and development of appropriate operational manned space flight experimentation, transportation, and exploration systems. This program generates data which are directly applicable to the problems of the next two decades in space flight, and in addition is of significant value in dealing with similar problems in other areas confronting our nation today. The program must progress at a rate commensurate with the development of the other systems required to achieve the goals and the specific objectives of the United States' space program.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1969	1970	1971
Aeronautics research and technology.....	$3,000	$3,595	$2,100
Space research and technology			
Supporting research and technology.....	14,329	16,010	14,200
Biotechnology flight projects.....	2,073	2,295	1,600
Total.....	$19,402	$21,900	$17,900

BASIS OF FUND REQUIREMENTS:

Aeronautics Research and Technology

An important feature of the Human Factor Systems program is the continuing study of community reaction to airport noise, to provide the basis for quantitative noise evaluation techniques and standards, for use by planners, aircraft manufacturers, airport operators, and the Department of Transportation. As part of the agency's contribution to the national aircraft noise abatement program, a psychoacoustic evaluation is being conducted to determine the effectiveness of the noise reducing acoustical treatment of aircraft engine nacelles. The issues related to pilot work load during reduced visibility landing operations are being studied. Finally, in the area of man-machine integration with special reference to information management, the aviation program has been expanded using as an example the human factor problems in air traffic control operations. This study is concentrating on the information management operations concerned, with a view to a possible better utilization of the human in such aeronautical man-machine systems.

A serious effort is being made to utilize the new knowledge and the technology from the Human Factor Systems program for maximum benefit to all. For example, a vibration research study which was started because of concern over the effects of vibration produced by launch vehicle rocket engines now is dealing with issues of vibration in public conveyances such as the Metroliner and STOL aircraft.

Space Research and Technology

Supporting Research and Technology

The Human Factor Systems program is determining the optimum use of man's capabilities in space missions, as well as the research essential to the support and the utilization of man in future space systems with particular reference to long-duration orbital space flights and extended lunar missions. Efforts are being made through support of basic and applied research in universities, government laboratories, and industry to solve the extremely complicated problems of the effects of weightlessness on cardiopulmonary function, radiation in the space environment, changes in circadian rhythms, potential changes in the natural microflora of man, and the possible need

for artificial gravity--to mention only a few. Problems of living in isolation and confinement for long periods of time are also being investigated. Considerable attention is being given to the various issues such as work space, food, waste disposal, clothing, and social dynamics which will affect the habitability of future manned operations in space as well as here on earth. Improved environmental control systems are being studied.

Biotechnology Flight Projects

The Biotechnology Flight projects complement the ground based research of the Human Factor System program. In some instances the variables of interest can not be simulated with sufficient validity to obtain meaningful research results. In these instances, the knowledge gap can be filled only through experiments conducted in actual flight. Work on flight experiments in FY 1971 will include analysis of data from the orbiting frog otolith experiment scheduled for launch early in 1970. This will increase our understanding of the vestibular system, the body's primary balance mechanism. Work will continue on the definition of experiments on the effects of weightlessness on major body systems. Other flight experiment efforts will be directed toward increasing understanding of the various regenerative life support processes in weightlessness as well as a quantification of the metabolic cost of performing useful work in space.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

RESEARCH AND DEVELOPMENT

For necessary expenses, not otherwise provided for, including research, development, operations, services, minor construction, maintenance, repair, and alteration of real and personal property, and purchase, hire, maintenance, and operation of other than administrative aircraft, necessary for the conduct and support of aeronautical and space research and development activities of the National Aeronautics and Space Administration, [$3,006,000,000] *$2,606,100,000*, 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, 1970; additional authorizing legislation to be proposed.*)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Research and Development

Program and Financing (in thousands of dollars)

Identification code 27-00-0108-0-1-250	Budget plan (amounts for research and development actions programed)			Costs and obligations		
	1969 actual	1970 estimate	1971 estimate	1969 actual	1970 estimate	1971 estimate
Program by activities:						
Direct program:						
1. Manned space flight:						
(a) Apollo	2,025,000	1,686,145	956,500	2,263,331	1,629,000	1,100,000
(b) Apollo applications program	150,000	324,600	405,200	167,144	341,000	470,000
(c) Space shuttle and station	----------	18,500	110,000	----------	10,000	65,000
(d) Advanced manned mission studies	2,500	2,500	2,500	5,086	5,400	3,000
2. Scientific investigations in space:						
(a) Physics and astronomy	145,283	129,535	127,600	150,856	139,400	120,500
(b) Lunar and planetary exploration	101,379	165,413	165,100	97,427	179,000	171,000
(c) Bioscience	39,100	19,670	12,900	39,762	21,200	14,200
(d) Launch vehicle development and support	55,678	65,849	77,200	73,186	64,300	77,800
3. Space applications	109,404	138,801	180,800	98,861	116,300	176,000
4. Space technology	185,866	176,372	164,300	211,537	198,400	176,900
5. Aviation technology	94,748	96,380	102,000	85,874	96,800	98,000
6. Supporting activities:						
(a) Tracking and data acquisition	279,672	278,000	298,000	326,136	285,000	289,000
(b) Sustaining university program	9,000	7,000	----------	27,167	21,000	15,000
(c) Technology utilization	3,800	5,000	4,000	3,939	4,000	4,000
Total direct program costs, funded	3,201,430	3,113,765	2,606,100	3,550,306	3,110,800	2,780,400
Reimbursable program:						
1. Manned space flight:						
(a) Apollo	1,257	685	725	592	1,500	725
(b) Apollo applications program	----------	----------	----------	----------	300	----------
2. Scientific investigations in space:						
(a) Physics and astronomy	3,711	1,347	895	1,104	3,200	895
(c) Bioscience	95	----------	----------	95	----------	----------
3. Space applications	37,246	48,774	16,180	39,472	86,600	16,180
4. Space technology	26,130	32,227	48,650	26,902	33,100	48,650
5. Aviation technology	999	3,300	3,350	2,673	5,900	3,350
6. Supporting activities:						
(a) Tracking and data acquisition	593	667	----------	726	699	----------
(b) Sustaining university program	27	----------	----------	----------	27	----------
(c) Technology utilization	144	----------	----------	2	142	----------
Total reimbursable program costs	70,202	87,000	69,800	71,566	131,468	69,800
Total program costs, funded	3,271,632	3,200,765	2,675,900	3,621,872	3,242,268	2,850,200
Change in selected resources [1]	----------	----------	----------	−209,134	124,813	−174,300
10 Total	3,271,632	3,200,765	2,675,900	3,412,738	3,367,081	2,675,900

RESEARCH AND DEVELOPMENT—Continued

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

Identification code 27-00-0108-0-1-250	Budget plan (amounts for research and development actions programed)			Costs and obligations		
	1969 actual	1970 estimate	1971 estimate	1969 actual	1970 estimate	1971 estimate
Financing:						
Receipts and reimbursements from:						
11 Federal funds	−47,720	−56,420	−63,828	−47,720	−56,420	−63,828
14 Non-Federal sources [2]	−22,482	−30,580	−5,972	−22,482	−30,580	−5,972
21 Unobligated balance available, start of year:						
For completion of prior year budget plans	----------	----------	----------	−311,148	−166,316	----------
Available to finance new budget plans	----------	−117,473	----------	----------	−117,473	----------
22 Unobligated balance transferred from other accounts	----------	----------	----------	−1,235	----------	----------
Reprograming to or from prior year budget plans	−4,961	----------	----------	----------	----------	----------
24 Unobligated balance available, end of year:						
For completion of prior year budget plans	----------	----------	----------	166,316	----------	----------
Available to finance new budget plans	117,473	----------	----------	117,473	----------	----------
Budget authority	**3,313,942**	**2,996,292**	**2,606,100**	**3,313,942**	**2,996,292**	**2,606,100**
Budget authority:						
40 Appropriation	3,370,300	3,006,000	2,606,100	3,370,300	3,006,000	2,606,100
41 Transferred to other accounts	−56,358	−9,708	----------	−56,358	−9,708	----------
43 **Appropriation (adjusted)**	**3,313,942**	**2,996,292**	**2,606,100**	**3,313,942**	**2,996,292**	**2,606,100**
Relation of obligations to outlays:						
71 Obligations incurred, net				3,342,536	3,280,081	2,606,100
72 Obligated balance, start of year				1,443,923	1,256,241	1,386,322
74 Obligated balance, end of year				−1,256,241	−1,386,322	−1,354,422
90 Outlays				3,530,218	3,150,000	2,638,000

Note.—Reconciliation of budget plan to obligations:	*1969 actual*	*1970 estimate*	*1971 estimate*
Total budget plan	3,271,632	3,200,765	2,675,900
Deduct portion of budget plan to be obligated in subsequent years	126,117	---------	---------
Add obligations of prior year budget plans	267,223	166,316	---------
Total obligations	3,412,738	3,367,081	2,675,900

[1] Selected resources as of June 30 are as follows:	*1968*	*1969 adjustments*	*1969*	*1970*	*1971*
Stores	35,357	13,704	40,492	40,492	40,492
Unpaid undelivered orders	969,409	------	766,858	891,671	717,371
Advances	12,123	------	14,109	14,109	14,109
Total selected resources	1,016,889	13,704	821,459	946,272	771,972

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

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1971 ESTIMATES

SUMMARY

OFFICE OF MANNED SPACE FLIGHT APOLLO PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

Having accomplished the national goal of landing a man on the moon and returning him safely to the earth, Apollo will continue the quest to expand man's knowledge, not only of the moon, but through a study of the moon, to better understand the earth, sun, and solar system.

Apollo 11 and 12 have discovered that the moon can be a most remarkable chronicle of the early years of the solar system. Nearly all rocks on the earth fall within the age range of a few million years to 500 million years, with the oldest being about 3.5 billion years. The lunar dust found at Tranquility Base was dated as being 4.6 billion years old. The crystalline rocks returned by the Apollo 11 astronauts were formed approximately 3.7 billion years ago by some volcanic event. A preliminary dating of the rocks from the Ocean of Storms site of Apollo 12 indicates that these may have been formed one billion years after those in the Sea of Tranquility. Both the Apollo 11 and 12 landings were made at sites in the lunar maria which are characterized by their flatness and a lack of rough surface features such as mountains or major craters. Many now believe, based on the analysis of Apollo samples, that the maria were formed by the flooding and cooling of a vast sea of lava. Future Apollo missions, beginning with Apollo 13, will include highland areas of the moon, which are believed to be older than the maria and where rocks dating back to the very beginning of the moon may be discovered. Another discovery resulting from the analysis of the Apollo 11 rocks is that the moon, having been directly exposed through the eons to solar radiation, has seemingly preserved the history of that radiation in its surface materials. By analyzing samples of the lunar surface and subsurface, scientists believe a record of the sun's activity over hundreds of millions of years can be developed, and man may be able to correlate the onset of ice ages or periods of near-tropical warmth with changes in solar activity. The most recent ice age covering the northern United States was less than 15,000 years ago and significant climatic changes have occurred in this millenium. From a study of lunar rocks, we may be able to associate patterns of solar activity with these major cyclic changes in the earth's climate.

During quarantine, terrestrial plants and animals were exposed to the lunar samples to observe any effects. An unexpected result was that some terrestrial plants thrived on a nutrient enriched with lunar soil and grew much larger than their counterparts planted in the control nutrient. The cause of this surprising growth is being investigated.

Greater understanding of the moon can also promote a greater understanding of the earth. The moon is invaluable because it has apparently preserved its history so well, thereby providing a comparative basis for examination of the early history of the earth and the earth's evolution. The laser reflector placed on the moon by the crew of Apollo 11 has been used to determine the relative earth-moon distance to an accuracy of one foot. Measurements using this reflector may prove that the earth's continents are drifting apart, and have been doing so for several hundred million years. Over a period of years, accurate distance measurements will give us precise information on the Chandler Wobble of the earth's axis which is thought to be related to major earthquakes and thus, possibly make such events predictable.

Future Apollo missions will produce a more complete understanding of the moon by visiting different sites, each characterized by a major surface feature. Among the candidate sites selected for future Apollo missions are: Fra Mauro, the site for the Apollo 13 mission this April, which is a hilly upland area believed to be material ejected from a nearby mare as a consequence of impact; Littrow, a mare region, adjoining the Tarus Mountains and a "Mascon" associated with the Sea of Serenity, and containing domes and a wrinkle; Censorinus, a highland site and the location of a fresh impact crater; Descartes, a highland with many long grooves and furrows reminiscent of volcanic regions on earth; the Marius Hills, a major ridge system with volcanic domes and cones; Copernicus, a major crater nearly 60 miles in diameter, with a central peak rising to a height of 2,500 feet, a crater floor with domes and flow areas, and crater walls towering about 13,000 feet above the floor; Hadley-Apennine, featuring a sinuous rille reminiscient of a stream-bed on earth at the foot of the 20,000 foot high Apennine mountain front; and Tycho, a large fresh impact crater in the highlands and the location of the Surveyor VII spacecraft.

Each of these sites is characterized by surface topography that is much rougher than the relatively smooth landing areas selected for Apollo 11 and 12. The Apollo 12 flight successfully proved the ability of the guidance and control system of the Lunar Module to land at a precisely targeted point. This ability is essential if successful landings are to be made at these future sites.

Some of the sites are located at areas quite distant from the lunar equator, the region to which the initial Apollo landings were restricted. Because of earth-moon positions, the Apollo spacecraft will be able to land at several of these sites only during a one to two month period every year. This will require a continuing precision of the entire Apollo team to meet these very exact launch windows.

A lunar roving vehicle is being developed to assist the astronauts in exploring the moon. It will be especially valuable in exploring the later sites where important features are somewhat dispersed over a large area.

During FY 1971 the Apollo 14 and 15 missions will be flown; production, final assembly, modification, and check out of Command and Service Modules and Lunar Modules will continue; and production of the remaining units of the Saturn V will be completed. Development and production of improved instrumentation and equipment to support enhanced lunar surface and orbital scientific effort on the remaining Apollo missions will be in progress during 1971.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1969	1970	1971
Spacecraft	$913,127	$778,978	$402,500
Saturn V	535,710	484,439	231,000
Operations	533,887	422,728	323,000
Saturn IB	42,276	---	---
Total	$2,025,000	$1,686,145	$956,500

BASIS OF FUND REQUIREMENTS:

Spacecraft

The three spacecraft modules - the Command Module, the Service Module, and the Lunar Module - developed for the Apollo program have, in every flight mission, successfully proven their capabilities. The Command Module has been manned six times, including four flights to and from the moon.

During FY 1970 and FY 1971, all remaining Command and Service Modules will be in various stages of production, checkout or storage. These Command and Service Modules will be used for additional lunar missions, and in the Apollo Applications program.

Five Lunar Module (LM) flights have been conducted, the first being an unmanned test in January 1968. This successful flight permitted the first manned flight in February of 1969, by the crew of Apollo 9. The Apollo 10 astronauts in May 1969, took the LM to within 50,000 feet of the surface of the moon. Apollo 11 and 12 conclusively demonstrated the LM's capability to perform its mission. The next two Lunar Modules assigned to land on the moon, are presently at the Kennedy Space Center where checkout of their systems is underway. During FY 1971, final assembly, checkout, and modification of the last four Lunar Modules will be in progress. Production of Lunar Modules will be phased to provide the most effective and economical production cycle.

Saturn V

Fifteen Saturn V launch vehicles are being produced for the Apollo program. Of the eight vehicles that have not yet been flown, one is positioned on Pad A, Launch Complex 39, at the Kennedy Space Center being readied for an April launch of Apollo 13 to the moon. Another launch vehicle for Apollo 14

has also been delivered to KSC. One vehicle is in storage and five others are in the final phases of production and testing. One of these has been assigned to Apollo Applications to launch the Saturn Workshop in 1972. Further production of the Saturn V launch vehicle has been suspended.

Operations

This project provides for crew training, launch, flight and recovery and for the programwide 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. Seven additional lunar missions are planned in the Apollo program; two in 1970, two in 1971, one in 1972 and two in 1974.

Saturn IB

FY 1969 was the last year of Apollo funding for the Saturn IB launch vehicle. Seven unused Apollo Saturn IB launch vehicles have been transferred to the Apollo Applications for use in that program. Production of the Saturn IB has been concluded.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1971 ESTIMATES

SUMMARY

OFFICE OF MANNED SPACE FLIGHT — ADVANCED MISSIONS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

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

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1969	1970	1971
Advanced missions studies.....	$2,500	$2,500	$2,500
Total.....	$2,500	$2,500	$2,500

BASIS OF FUND REQUIREMENTS:

Advanced Missions Studies

Advanced studies enable this country to efficiently direct future manned space flight program planning. The studies use the capabilities of industry to perform conceptual designs and provide comparative technical data to supplement in-house activities. During FY 1970, emphasis is being reoriented to study the elements of the integrated program endorsed by the President's Space Task Group. Studies during this fiscal year include: Requirements associated with future manned missions, focusing on applying hardware to be developed for the Space Station, Space Base, and future lunar missions; prescribing the desired characteristics of nuclear stages and chemical stages for use in transporting men and payloads to and from synchronous orbit, lunar orbit, the lunar surface, and the planets, and between various low earth orbits; examining methods for conducting manned exploration of the moon after completion of Apollo; and evaluating the effect of introducing various degrees of self-support in conducting future manned space flight missions; and reviewing critical aspects of proposed future missions, to promote their operational safety.

Funding in FY 1971 will continue to concentrate on the future activities included in the integrated program:

(a) Escape and rescue systems studies will be conducted to establish the best methods and techniques for performing escape and rescue missions from low earth and synchronous orbit space stations and bases, from lunar orbit, and from the lunar surface.

(b) Integrated mission management and operations planning studies will be performed to develop a concept that supports all missions, and develop its evolution through the next decade.

(c) Space base studies will be directed toward the support requirements for major space operations, including the erection of large structures in earth orbit, geosynchronous missions, lunar missions and possible planetary missions. Also to be investigated is the practicality of using the space base for support of a refueling station, as a personnel and cargo staging platform, and as a hardware assembly area. Examination of the performance and operational characteristics of a reusable vehicle, such as a space tug, for manuevering men, equipment and modules in space will be conducted.

(d) Advanced lunar studies will be undertaken to determine the characteristics of a lunar orbit station and a lunar surface base as the integral part of an advanced lunar exploration and exploitation program. An assessment of the compatability of the proposed mission mode with the objectives of this future lunar program will include: personnel and equipment transfer mechanisms between the lunar surface, lunar orbit, and earth orbit; crew sizings for orbital operations; the commonality of a lunar orbit station with earth orbit space station modules; the modification of space station systems for use in a lunar surface base; and the design and operational characteristics of a reusable lunar landing vehicle.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1971 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR

SPACE SCIENCE AND APPLICATIONS PROGRAMS

Program	(Thousands of dollars) 1969	1970	1971
Physics and astronomy	$128,850	$111,835	$116,000
Lunar and planetary exploration	87,923	151,013	144,900
Bioscience	37,900	19,670	12,900
Space applications	98,665	128,400	167,000
Launch vehicle procurement	99,900	108,800	124,900
Total	$453,238	$519,718	$565,700

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1971 ESTIMATES

SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS — PHYSICS AND ASTRONOMY PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

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

To attain this goal, a variety of techniques are used to gather information. These include theoretical and laboratory research; aircraft, balloon and sounding rocket flights; as well as observations using small and large automated spacecraft and manned systems. The latter category covers manned earth orbital flights (AAP) as well as observations conducted from the lunar surface under the Apollo program. Research groups participating in this effort are distributed all over the United States and the free world. Groups are located at most of the NASA centers, at several other government laboratories, and at many universities and industrial laboratories. Foreign participation is arranged through the science ministry of each of the participating countries.

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

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1969	1970	1971
Supporting research and technology/advanced studies	$22,497	$17,500	$17,500
Airborne research	1,000	1,600	3,000
Data analysis	3,412	3,000	3,000
Sounding rockets	19,234	18,500	18,500
Solar observatories	13,812	14,700	16,100
Astronomical observatories	36,392	31,600	27,100
Geophysical observatories	13,072	6,000	5,200
Explorers	19,431	18,935	25,600
Total	$128,850	$111,835	$116,000

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology/ Advanced Studies

The Supporting Research and Technology/Advanced Studies programs enhance the overall scientific and technological return from NASA flight projects and help assure continued excellence and viability of the future research program in space science. The objectives can be stated in the following three broad categories: (1) enhancement of the value of current space missions by a full supplement of simultaneous ground-based, aircraft, and balloon observations; (2) development of theories to explain observed phenomena and predict new ones; and (3) optimization of the return expected from future missions by problem definition, development of advanced experiments and concepts, and the careful definition of proposed new missions.

These funds provide partial support for the Goddard Institute for Space Studies, the Space Science Board, and the Research Associate Program. About 250 research tasks are carried out by universities, non-profit and industrial research institutions, NASA Centers, and other Government agencies.

Airborne Research

The Airborne Research project provides for space flight research using high flying jet aircraft. The project supports auroral and airglow research, solar corona studies during total eclipses, and stellar, planetary, and solar astronomy in a previously unexplored region of the infrared portion of the electromagnetic spectrum.

Data Analysis

The objective of this effort 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 cataloguing, the availability of the data is made known to the world scientific community through periodic announcements by the NSSDC.

The funding in FY 1971 provides for a continuation of the data collection effort of the NSSDC. The FY 1971 funding also provides for limited support of correlative studies which utilize data from several separate investigations as well as new approaches to the analysis of available data.

Sounding Rockets

A wide variety of experiments in aeronomy, planetary atmospheres, ionospheres and radio physics, energetic particles and electric fields, galactic and radio astronomy, and solar physics can be accommodated on rockets since a flexible stable of vehicles is available. The relatively short lead time required to arrange a rocket flight, usually less than a year, makes it

possible to utilize rockets to conduct timely and cost-effective flight tests of advanced instrumentation being developed for satellites, observatories, spacecraft, etc. Finally, rockets offer the unique means of conducting scientific experiments designed to study unpredictable, scientifically important phenomena, such as, polar cap absorption events, solar flares, dayglow, airglow, aurora, noctilucent clouds, and eclipses.

Fiscal Year 1971 funds will provide continuation of the Physics and Astronomy sounding rocket flight program at about 90 flights per year. Emphasis on the stellar and solar astronomy disciplines will continue with the utilization of advanced stellar and solar fine pointing control systems recently developed within the program.

Solar Observatories

The Orbiting Solar Observatory (OSO) provides a specialized space observing platform to contribute to our understanding of the sun. The spacecraft design provides a capability for experiments requiring solar and celestial pointing, solar scanning, or scanning of the celestial sphere.

Four missions, including correlated ground-based observations of the sun, are scheduled through the mid-1970's. Seven OSO's were launched in the period from 1962 to 1969. These missions have made major contributions to our understanding of the sun and, in particular, the observational models of flares. OSO-V and VI are continuing to provide valuable observations in support of our research objectives.

In FY 1971 funds will provide for continuing OSO-V and VI observations and for data analysis and publication of results of these missions; for the completion of development, testing, launch, and initial operation of the first of the next four missions; and for continuing development of the instruments and spacecraft hardware for the remaining three missions.

Astronomical Observatories

The Orbiting Astronomical Observatory II (OAO-II) mission, launched December 7, 1968, is making major contributions to our understanding of the universe by providing critical information in the ultraviolet region of the electromagnetic spectrum. This observatory has successfully conducted scientific observations for over a year. Measurements have been made on the emission characteristics of diffuse nebulae and the extension of the opacity of the interstellar medium into the ultraviolet by the Wisconsin Experiment Package (WEP). The Smithsonian Astrophysical Observatory Celescope has provided sky mapping and brightness characteristics of nebulae and of hot stars. Of major interest, are data from the WEP which indicate that most nearby galaxies are generally brighter in the ultraviolet than previously theorized. The ultraviolet measurements will provide an important input to cosmology.

The OAO was developed as an accurately stabilized automated space observatory system for telescopic observations of celestial objects in the electromagnetic spectral range from the X-ray region through the ultraviolet into the visible region.

FY 1971 funds will provide for completion of the OAO-B 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 completion of qualification tests of the experiments; acceptance tests of the flight experiments; integration of the experiments, and initiation of the observatory tests.

Geophysical Observatories

The Orbiting Geophysical Observatory (OGO) project has as a primary objective the accomplishment of a series of coordinated scientific studies of the earth's environment and the effect of solar activity on that environment. Six observatories have been launched at the rate of one each year, starting in 1964. The launch phase of this project was completed in June 1969 with the successful launch of OGO-VI. This observatory carries instrumentation for 25 experiments and has successfully accomplished its initial objectives.

The scientific accomplishments of the OGO project have had a significant impact on our understanding of earth's space environment, particularly its complex and dynamic nature. The technology evolved in the development of a large, complex laboratory type system has benefited other space programs and provides a basis for advanced space laboratory concepts.

FY 1971 funds provide for operational support of OGO-V and VI, special operations of earlier OGO's as appropriate, and continuation of data analysis.

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, other Government agencies, 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 Scout and Delta launch vehicle capability and instrumentation, they have become versatile and sophisticated tools for specialized space investigations as well as explorations.

FY 1971 funds provide for the development, testing, and launching of small satellites in support of X-ray and radio astronomy; and atmosphere, radiation belt, and magnetospheric boundary investigations. This includes support for interagency and international cooperative projects.

SCHEDULE OF LAUNCHES

Project	Mission	Calendar Year
Solar Observatories	OSO-H	1971
	OSO-I	1973
	OSO-J	1974
	OSO-K	1976
Astronomical Observatories	OAO-B	1970
	OAO-C	1971
Explorers (Including International Cooperative Satellites)	3 - 5 Scout launches per year	
	1 - 3 Delta launches per year	
Sounding Rockets	About 90 launches per year	

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1971 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 observations and laboratory 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. 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 recently completed have advanced considerably our knowledge of the moon and provided a wealth of data which have aided, and will continue to aid in unraveling the mysteries of our nearest neighbor. The Ranger project, the initial step in this effort, provided the first close-up detail of the moon's surface through vidicon pictures transmitted to earth. The subsequent Lunar Orbiter project provided large scale, detailed photographs of the moon that were required for the selection and certification of sites for the Apollo landing missions and improved photo coverage of the entire moon, nearside and farside. The Surveyor project, by soft landing a spacecraft on the moon, provided a critical demonstration of the proposed Apollo technique. In addition, Surveyor made valuable contributions to our knowledge of the moon by taking hundreds of high resolution photographs of the lunar terrain, by measuring lunar surface bearing strength, and by making the first rudimentary chemical analyses of lunar surface materials.

The exploration of the moon is now concentrated in the manned Apollo program. Funds are requested under the Supporting Research and Technology and Data Analysis program to provide the basic planning for scientific experimentation and data interpretation of the manned exploration phase.

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 Mariner VI and VII missions to Mars. 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 1964-1965 provided the first close-up photography of the planet's cratered surface and established 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 last operational spacecraft in the current series 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. Mariner VI and VII, launched on February 24 and March 27, 1969, respectively completed their missions to Mars in July-August 1969, when both spacecraft returned the most comprehensive body of scientific data ever obtained from another planet.

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 Orbiter missions to Mars are scheduled for 1971. In 1973 a single Mariner spacecraft will be used to study both Venus and Mercury. The Viking project which combines the orbiter/soft lander approach used successfully in exploring the moon is our most ambitious planetary undertaking consisting of two flight missions to Mars on the new Titan-Centaur configuration in 1975. An evolution of the successful Pioneer spacecraft design will permit missions beyond Mars to the Asteroid Belt and Jupiter; Pioneer F and G launches are scheduled for the 1972 and 1973 Jovian opportunities. Concurrent with and complementary to these missions will be an active program of planetary observations from the vicinity of earth. This planetary astronomy project has been funded in previous years by the Supporting Research and Technology/Advanced Studies budget.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1969	1970	1971
Supporting research and technology/ advanced studies	$18,571	$17,980	$17,400
Planetary astronomy	3,700	3,800	4,800
Data analysis	2,337	2,600	3,900
Pioneer	4,700	20,800	32,900
Mariner Mars 1969	26,130	4,491	200
Mariner Mars 1971	20,058	60,342	29,600
Mariner Mercury 1973	---	1,000	21,100
Viking	12,427	40,000	35,000
Total	$87,923	$151,013	$144,900

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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 1971, effort in the lunar science area will largely be devoted to increasing our scientific knowledge of the moon by continuing laboratory investigations and theoretical studies related to the moon and by drawing on data from ground-based research and from Ranger, Surveyor, Lunar Orbiter, and Apollo missions. Research in the advanced technical development program will: concentrate in the areas of Grand Tour missions; provide more emphasis to the critical technologies for Venus probes and buoyant Venus stations; and develop concepts for advanced Mars exploration in the late 1970's.

Planetary Astronomy

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

Data Analysis

The primary purpose of spacecraft missions to the moon or to the planets is to conduct experimental investigations which will advance our knowledge and understanding. Data 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 1971 lunar data analysis will include data from the Lunar Orbiters, with emphasis shifted to areas of scientific interest outside the equatorial belt of the initial Apollo landing zone, and from the Apollo orbital and landing missions themselves, giving vital science support to later Apollo missions.

Pioneer

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

This project consists of three series of missions; Pioneers VI-IX Pioneers F and G, and Helios A and B. The first series of spacecraft weighed about 140 pounds each and were launched in 1965, 1966, 1967, and 1968. A fifth spacecraft, Pioneer E, was lost during launch in 1969 when the launch vehicle failed. The four Pioneers now in solar orbit are all functioning, and Pioneer VI has operated longer in interplanetary space than any other spacecraft. These interplanetary outposts are essential elements of our network of deep space "weather stations."

The development of Pioneers F and G was initiated in FY 1969. These spacecraft are to be launched into trajectories permitting the exploration of interplanetary space between one and five Astronomical Units (AU) from the sun including the asteroid belt and Jupiter. (One AU is equal to the mean earth-to-sun distance, 93,000,000 miles.) With this trajectory, we should be able to study the possibly hazardous region of the asteroid belt, to measure the gradient of the sun's influence on interplanetary space and the penetration of galactic cosmic radiation into the solar system. While the spacecraft are passing Jupiter, instruments will measure important properties of the planet and its environment. These missions will require new features on the Pioneer spacecraft to compensate for the lessening of solar radiation as a power source and the more demanding communications and thermal conditions. For example Radioisotope Thermoelectric Generators (RTG's) rather than the more conventional solar cells will be utilized to provide electrical power to the spacecraft.

In FY 1969, NASA initiated its largest international cooperative project as part of the Pioneer program. The objective of this project, called Helios, in cooperation with the Federal Republic of Germany is to investigate the

properties of and processes in interplanetary space in the direction of and close to the sun (about 0.3 AU). The spacecraft will be developed in West Germany with about one-third of the scientific experiments supplied by NASA.

Fiscal year 1971 funds will be used for design and development work on the Pioneer F and G spacecraft and its selected experiments. Operational support for the four active Pioneer spacecraft and for data analysis will continue. Development of U. S. experiments for Helios will continue.

Mariner

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

On July 31 and August 5, 1969, Mariner VI and VII passed within 2,000 miles of the Martian surface, completing the most ambitious and successful planetary reconnaissance ever achieved by any nation. The scientific data returned greatly exceeded that planned for the missions, including more than 200 pictures of the planet taken by the spacecraft on their approach trajectories. Mariner VII, which flew over the south polar cap region, found the polar cap to be composed of carbon dioxide and cratered in the same fashion as the land surfaces. The possibilities of life on Mars remains one of the major unanswered scientific questions and the combined spectroscopic and imaging data from the Mariner VII provided interesting and likely regions for future missions to concentrate their efforts in pursuit of this question.

The scientific investigations of Mars using orbiting spacecraft will begin in 1971. The Mars 1971 spacecraft, which will use many of the proven subsystems of the Mariner 1969 exploratory flyby missions, will begin detailed

375-328 O - 70 - 4

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 1969 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 months. During their first 90 days in orbit, the Mariner H and I spacecraft will observe approximately 70 percent of the planet's surface including the wave of darkening, cloud movements and any other dynamic and seasonal changes in the planet's atmosphere and 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 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 1971 will support post-launch operations for the Mariner Mars 1969 spacecraft and continued analysis of scientific and engineering data. Fiscal year 1971 funds requested for Mariner Mars 1971 will be used for spacecraft system testing, launch operations and the initial portion of mission operations. Fiscal year 1971 funds will also be used to prepare functional specifications for the Mariner Mercury 1973 spacecraft in order to permit initial flight hardware procurement activities. A system contractor will be selected during the year.

Viking

The exploration of Mars initiated in 1965 by the Mariner series of spacecraft will be extended to surface exploration with a Viking landing in 1975, rescheduled from the previously planned 1973 date. While the prior missions studied the planet from orbital or flyby distances, the 1975 missions will be the first opportunity to obtain data from direct measurements in the Mars atmosphere and on its surface. Particular emphasis will be placed on obtaining biological, chemical, and environmental factors relevant to the existence of life on the planet at this time, at some time in the past, or the possibility of life existing at a future date.

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

Fiscal year 1971 funds will be used to continue the development of critical long lead items, such as the landing radar system, the landing propulsion system and many of the science instruments. Design effort will continue and funds will be provided for scientific investigator support.

Schedule of Launches

Project	Mission	Calendar Year
Pioneer	Pioneer F	1972
	Pioneer G	1973
	Helios A	1974
	Helios B	1975
Mariner	Mars 1971 (2)	1971
	Mercury 1973 (1)	1973
Viking	Mars 1975 (2)	1975

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1971 ESTIMATES

SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS — SPACE APPLICATIONS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objectives of the Space Applications program are to: (1) expand the knowledge of atmospheric and space phenomena; (2) conduct a broad program of research and technical development oriented toward the application of space techniques for the benefit of mankind; (3) develop and test procedures, instruments, subsystems, spacecraft, and interpretive techniques for the various applications; (4) fulfill NASA's responsibilities under the Communications Satellite Act of 1962; (5) develop and implement for the Environmental Science Services Administration (ESSA), Department of Commerce, the operational meteorological satellite system; (6) cooperate with the user government agencies, such as the Departments of Agriculture, Commerce, Interior, and Navy, through the Earth Resources Survey Program Review Committee to achieve practical benefits to mankind in earth resources; and (7) cooperate to the extent possible with foreign countries in the general advancement of space applications.

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

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars) 1969	1970	1971
Supporting research and technology/ Advanced studies	$19,600	$24,900	$25,900
TIROS/TOS improvements	5,800	3,700	3,200
Nimbus	31,800	27,300	28,000
Synchronous meteorological satellite	---	2,700	15,600
Meteorological soundings	3,000	3,000	3,100
Cooperative applications satellite	100	100	100
Global atmospheric research program study	---	---	1,000
Applications technology satellites	24,700	39,000	31,100
Geodetic satellites	2,465	1,700	3,500
Navigation/traffic control satellite studies	---	---	3,000
Earth resources survey	11,200	26,000	52,500
Aircraft program	(8,900)	(11,000)	(11,000)
Earth resources technology satellite	(2,300)	(15,000)	(41,500
Total	$98,665	$128,400	$167,000

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

The objectives of the supporting research and technology are to conduct programmatic studies, basic and supporting research, advanced technological developments and the testing of new concepts, techniques, materials, components, sensors, instrumentation, data systems, and subsystems which have application to future aircraft and satellite projects. The disciplinary areas of effort in the space applications program include applications technology, communications, earth resources, geodesy, meteorology, navigation/traffic control, radio interference, and interdisciplinary applications. Fiscal year 1971 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 radio interference and propagation, and information networks in the communications disciplines.

TIROS/TOS Improvements

The objectives of this project are to: (1) provide research and development toward advanced operational meteorological satellite systems, (2) provide maximum interim operational data for use in weather analysis and forecasting, (3) measure emitted infrared and reflected solar radiation in

selected spectral regions, (4) observe cloud patterns and cloud cover, (5) measure the earth-atmosphere heat balance, and (6) use system concepts and basic configurations which will maximize success and minimize costs when used in subsequently operational systems.

Nine TIROS research and development spacecraft funded by NASA and nine operational spacecraft funded by ESSA have been successfully launched. TIROS-M, being developed by NASA as the operational prototype of the second-generation operational satellite series, the Improved TIROS Operational Satellite (ITOS), is scheduled for launch during January 1970. Under TOS Improvements, effort will be continued in the development of advanced sensors and subsystems such as high-resolution radiometers and altitude-determination systems which will be incorporated into future operational spacecraft. Fiscal year 1971 funds are required for post-launch support and data acquisition and handling efforts for TIROS-M for continued sensor and subsystems development for TOS Improvements, and for in-depth studies for future operational satellite systems.

Nimbus

The objectives of this project are to develop a significantly improved meteorological satellite to provide data on atmospheric parameters 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.

The first two spacecraft in the planned series of seven Nimbus satellites were Nimbus I, launched on August 28, 1964, and Nimbus II, launched on May 15, 1966. Nimbus B, a third spacecraft launched May 18, 1968, was lost due to a launch vehicle failure. In June, 1968, NASA approved launch of a replacement spacecraft identical to the Nimbus B configuration, which was designated B-2 prior to launch. It was successfully launched April 14, 1969, whereupon it was designated Nimbus III. Nimbus D, scheduled to be launched in CY 1970, will test an advanced control system, advanced experiments for determining the vertical temperature structure, and additional experiments such as a temperature/humidity infrared radiometer, a monitor of the water content of the atmosphere, and a more refined worldwide data collection system that will include the first meaningful spacecraft wind measurement experiment. Nimbus E and F, scheduled to be launched in CY 1972 and CY

1973 respectively, will test advanced infrared radiometric and spectrometric and microwave experiments designed to allow penetration of cloud layers for the global determination of the vertical structure of the atmosphere.

Fiscal year 1971 funds are required for continued acquisition and analysis of the data from the Nimbus D spacecraft in orbit and to continue the development of the Nimbus E and F spacecraft and selected experiments.

Synchronous Meterological Satellite

The objectives of the Synchronous Meteorological Satellite (SMS) are to: (1) demonstrate a prototype operational SMS, (2) permit continuous observation of major weather systems routinely, thus enhancing the ability to predict and locate severe short-lived storms, (3) derive important wind field data over considerably large areas and in much less time than heretofore possible, and (4) provide capability for rapid dissemination of processed meteorological data to local meteorologists.

Fiscal year 1970 funds were used for initiating the design and development of the two SMS spacecraft and sensors. Fiscal year 1971 funds will be used to initiate procurement of SMS A and B spacecraft and to continue development of sensors.

Meteorological Soundings

The objectives of this project are to determine the structure and characteristics of the atmosphere in the 30 to about 100 kilometer (km) region through the use of research and development type sounding rockets and to develop a meteorological sounding rocket system amenable to research, range support, and routine operational requirements. Three areas of effort are involved: (1) large research sounding rockets to explore the characteristics and phenomena of the atmosphere between 30 and about 100 km. This region is important to meteorological science, and cannot be reached except by sounding rocket. Nike Apache and occasionally Tomahawk class rockets are used to explore the relations and mechanisms operating between and within the various regions of the atmosphere, and the effects of solar energy and its variations upon the structure and circulation in the atmosphere; (2) small sounding rocket systems are utilized to obtain measurements in the region of approximately 30 to 60 kilometers above the earth. Included in this effort is 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) the 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. Fiscal year 1971 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 project, being carried out jointly by the United States and France, 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, especially in-situ measurements of speed and wind direction at various altitudes. The data obtained will be used by U. S. and French scientists to assist in the understanding of the structure of the atmosphere and extending weather forecasting capabilities. One spacecraft and one backup with instruments will be provided by France. The spacecraft will be launched by NASA in 1970 to gather data from approximately 500 balloons. The instrumented balloons will be developed and launched by France in the Southern Hemisphere. Satellite tracking and data acquisition, reduction, and analysis will be provided by France. The U. S. will provide the Scout vehicle, and backup if required, launch services, initial satellite tracking, and data analysis, along with France, of the reduced data.

Fiscal Year 1971 funds are required to continue technical support and provide launch and post-launch support.

Global Atmospheric Research Program (GARP) Study

The Global Atmospheric Research program (GARP) is an international cooperative program directed toward obtaining data for increasing understanding of the general circulation of the atmosphere and for laying the mathematical and physical basis for methods of long range weather prediction. GARP is directed jointly by the governments of interested nations through the World Meteorological Organization (WMO) and the world scientific community through the International Council for Scientific Unions; national and international organizations have been established to plan and execute the program. The major event, a global exercise planned for 1975, is currently seen as requiring seven (7) meteorological satellites in simultaneous operation for about a year. International commitments to provide these satellites have not been made.

Long term weather forecasting cannot be achieved without first achieving the GARP goals. In FY 1970, NASA initiated studies to determine the nature of its possible support to the GARP experiment. The Phase B study planned for FY 1971 will involve detailed study, comparative analysis, and preliminary system design directed toward facilitating the choice of a single

project approach for NASA support to GARP. The Phase B study will also identify facilities, logistics operations, additional advanced technology, and advanced development tasks required to furnish spacecraft, ground support, and related data management for the Global Experiment.

Applications Technology Satellites

The objectives of the Applications Technology Satellites project are to design, develop, flight test, and evaluate a variety of scientific and technological experiments within the applications disciplines by use of a series of spacecraft, most of which are launched into synchronous orbit. Of the seven spacecraft in the series, five have been launched to date. Because of launch vehicle anomalies, the desired orbits for ATS-II, launched April 6, 1967, and for ATS-IV, launched August 10, 1968, were not achieved, thus limiting the experimental value of these spacecraft. ATS-V, launched April 12, 1969, experienced problems with the active stabilization system prior to planned despinning of the satellite and the deployment of the gravity gradient system. However, many objectives from seven of the twelve experiments flight tested on the mission will be obtained. ATS-I, launched December 7, 1966, and ATS-III, launched November 5, 1967, into synchronous orbits have performed successfully and continue to operate. Two spacecraft, ATS-F and G, are scheduled for launch in calendar years 1973 and 1975, respectively. Utilizing three-axis active spacecraft stabilization, these spacecraft will be launched into synchronous orbit and will flight test a space erectable, parabolic antenna, approximately 30 feet in diameter, and capable of high pointing accuracy. A number of additional scientific and technological experiments will also be flight tested on these missions. Effort will also continue in fiscal year 1971 to develop promising advanced experiments which have been defined but have not been assigned to a specific flight mission.

Fiscal year 1971 funds will be used for continuation of ATS-F and G spacecraft development and experiment, and for continued development of advanced applications experiments.

Geodetic Satellites

The purpose of the Geodetic Satellite project is to support the National Geodetic Satellite program (joint NASA/DOD/DOC program) and to develop the technology of geodetic satellites for solid-earth geophysics and oceanography.

Three geodetic satellites have been launched: Pageos-I in June 1966; GEOS-I on November 6, 1965; and GEOS-II on January 11, 1968. Data obtained from these launches are utilized in the establishment of a unified worldwide geodetic datum. One additional mission, GEOS-C, is planned for launch in 1972 to complete 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 ocean. Fiscal year 1971 funds will be used for continued analysis of GEOS-II data and to continue the development of GEOS-C spacecraft and experiments.

Navigation/Traffic Control Satellite Studies

The objective here is to study the design of a spacecraft system which will be capable of: (1) improving air traffic control services in the over-ocean areas; (2) providing communication and navigation services to ships and aircraft; and (3) providing aid in search and rescue operations and collision prevention system operations for marine and aviation vehicles.

Earth Resources Survey

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

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

The objective of the Earth Resources Technology Satellite project is to design, develop, launch, and test a series of spacecraft to conduct experiments which will lead to a reliable assessment of the utility of spaceborne sensors for applications to problems related to natural and cultural resources. This assessment will lead to the capability to design spacecraft and related data handling systems to support these national programs on an operational basis. It will also lead to an evaluation of the complementary roles of aircraft and spacecraft in acquiring data on the earth's resources. This effort is progressing in FY 1970 through the performance of two parallel detailed system design studies that encompass both the first two spacecraft and the related ground data handling system. A selection of the more promising system will be made very early in FY 1971 so that the system can enter into the detailed engineering and fabrication stage in FY 1971. The two

satellites, which are planned for sun-synchronous orbit, are to be launched successively in CY 1972 and CY 1973. These satellites will carry instrumentation that will meet the requirements of the user community in terms of spatial and spectral resolution as well as repetitive coverage. Both framing and line scanning sensors will be flown in order to assess the advantages of each. The satellite system will also concurrently relay data from remote ground sensors such as rain gauges, stream gauges, and seismometers to assess the value of such a network for complementing the spaceborne sensors.

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

Fiscal year 1971 funds are being requested to continue aircraft operations, sensor procurement, and data processing to conduct about 30 flights over 60 test sites, and to initiate spacecraft and sensor hardware procurement for the first two ERTS spacecraft.

SCHEDULE OF LAUNCHES

Schedule of Significant Research and Development Events

Project	Mission	Calendar Year
TIROS	Launch of TIROS M	1970
TOS and ITOS*	Launch of ITOS A-G	1970-1974 (about 2 per yr, subject to call-up by ESSA)
Nimbus	Launch of Nimbus D	1970
	Launch of Nimbus E	1972
	Launch of Nimbus F	1973
Synchronous Meteorological Satellites	Launch of SMS-A	1972
	Launch of SMS-B	1973
Cooperative Applications Satellite	Launch of CAS-A	1970
	Launch of Back-up (If Required)	1971
Applications Technology Satellites	Launch of ATS-F	1973
	Launch of ATS-G	1975
Geodetic Satellites	Launch of Geos C	1972
Earth Resources Technology Satellites	Launch of ERTS-A	1972
	Launch of ERTS-B	1973
INTELSAT**	Launch of INTELSAT III & IV Series	1970-1972 (subject to call-up by COMSAT)

*ESSA funded
**COMSAT funded

375-328 O - 70 - 5

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1971 ESTIMATES

SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS LAUNCH VEHICLE PROCUREMENT PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Launch Vehicle Procurement program objective is to provide launch vehicles and launch services to support mission requirements. Major activities include the procurement of vehicle hardware, launch operational services, engineering and maintenance support, and product improvements to flight vehicles and support equipment. Vehicles being procured are: Scout, Delta, Thor Agena, Atlas Centaur, Titan III Centaur, and Titan III C.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1969	1970	1971
Supporting research and technology/ advanced studies	$4,400	$4,000	$3,000
Scout	12,600	13,700	15,100
Delta	24,300	32,100	34,000
Agena	11,300	5,300	---
Centaur	44,200	50,000	68,100
Titan III C	3,100	3,700	4,700
Total	$99,900	$108,800	$124,900

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology/Advanced Studies

The objective of the SR&T/Advanced Studies project is to provide data for management decisions required for future automated missions by conducting a systematic program of studies and research.

Scout

Scout is the smallest launch vehicle in the NASA vehicle family and is used for small scientific satellites, space probes and high speed reentry experiments. FY 1971 funds for procurement will be utilized for purchase of new hardware, to sustain the Scout launch capability at two launch sites and to continue efforts related to vehicle improvements.

Delta

Delta is a three stage vehicle consisting of the first stage Thor booster, the Delta second stage and a solid propellant third stage. Through 1969, it has performed successfully 68 times in 74 attempts. It has been used to launch communication, meteorological, scientific and biological satellites. In FY 1971 funds will be utilized to continue hardware contracts initiated in FY 1970, and continue support of launch operations and maintenance of ground support equipment. In addition,improvements on the TE-364 motor and the inertial guidance system for use with Delta will be made with FY 1971 funds.

Agena

The Thrust Augumented Thor Agena vehicle is used by NASA for polar orbital missions launched from the Western Test Range in California. No FY 1971 funds are required since there are no NASA missions currently planned for this vehicle system after the launching of the SERT IIA and Nimbus D missions during the first half of 1970.

Centaur

The Centaur is a high energy upper stage vehicle using liquid hydrogen and liquid oxygen propellants. To date, this vehicle has been used exclusively with the Atlas booster in support of NASA's Surveyor, Mariner, Orbiting Astronomical Observatory and Applications Technology Satellite missions. A new configuration, Titan III-D/Centaur, is based on integration of an improved Centaur stage with the Titan III booster. This vehicle configuration will become operational in 1974. During FY 1971, funds will be required to continue the procurement of vehicle hardware for the Pioneer, Mariner Mars 1971, the Proof Flight Test, and the OAO missions. In addition, purchase of new hardware and support will be initiated for the Mariner Mercury 1973 and the Helios A missions along with the continuation of vehicle improvement begun in prior years.

Titan III-C

The Titan IIIC launch vehicle is a four stage solid and liquid fuel vehicle developed and managed by the Department of Defense. During FY 1971, funds are necessary to continue vehicle hardware procurements and supporting services initiated in prior years in support of the ATS F and G missions which are planned for launch in 1973 and 1975.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1971 ESTIMATES

SUMMARY

OFFICE OF UNIVERSITY AFFAIRS — SUSTAINING UNIVERSITY PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

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

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

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1969	1970	1971
Sustaining university program.....	$9,000	$7,000	---
Total.....	$9,000	$7,000	---

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1971 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR

ADVANCED RESEARCH AND TECHNOLOGY PROGRAMS

Program	(Thousands of dollars) 1969	1970	1971
Basic research	$20,220	$18,902	$17,600
Space vehicle systems	31,349	30,670	30,000
Electronics systems	34,460	33,500	22,400
Human factor systems	19,402	21,900	17,900
Space power and electric propulsion systems	38,787	34,450	30,900
Nuclear rockets	33,502	36,500	38,000
Chemical propulsion	25,752	20,480	20,300
Aeronautical vehicles	74,748	75,900	87,100
Total	$278,220	$272,302	$264,200

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1971 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 space shuttle.

The Basic Research program is divided into four broad disciplines: Fluid Physics, Electrophysics, Materials, and Applied Mathematics. These are discussed below, as applicable to aeronautics and space. The division of the Basic Research program into these two categories is somewhat arbitrary where the program is applicable to both categories.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1969	1970	1971
Aeronautics research and technology...	$5,900	$6,190	$6,600
Space research and technology.....	14,320	12,712	11,000
Total.....	$20,220	$18,902	$17,600

BASIS OF FUND REQUIREMENTS:

Aeronautics Research and Technology

The Fluid Physics subprogram promotes basic research on aerodynamic and gas dynamic problems relevant to NASA objectives in aeronautics. During the past year, new research programs have been initiated on air pollution from aeronautics source, noise generation from turbofan systems,

and supersonic engine exhaust jets. Substantial progress has been made in the understanding and reducing of sonic boom and noise, and also, in understanding the origin and mechanisms of clear air turbulence.

The Materials subprogram conducts basic studies to understand the relationship between the structure and properties of materials that are used in aircraft. Typical examples are studies of surface physics to understand and improve the performance of avionics devices, alloys research to increase the performance of both structural and power plant materials and basic studies to better understand such failure mechanisms as fatigue and corrosion.

The objective of the Applied Mathematics subprogram is to develop new mathematical models and methods so that problems in aeronautics may be solved more readily or efficiently than possible today. Research is currently being carried out in data representation, ranking of alternatives, and in new methods of representing stochastic processes. Future plans include work in simulation, information retrieval, and adaptive control.

Space Research and Technology

The Fluid Physics subprogram promotes basic research on aerodynamic and gas dynamic problems relevant to NASA objectives in space. During the past year, entry gas-dynamic research has been continued with studies primarily concerned with experimental simulation and verification of theories regarding high speed entry. A significant advancement in gas dynamic laser research has been made by the recent demonstration of an all chemical laser.

The Materials subprogram is conducting basic studies to understand the behavior and properties of materials for use in space. The research is concerned with materials for use in electronic devices such as semiconductors and thin films, and with structural materials for spacecraft, in particular for their use at high temperature. In the next year, a sizable portion of these studies will be directed toward materials for the space shuttle.

The Electrophysics subprogram is devoted to increasing our understanding of the behavior of electrons, nuclei, atoms and molecules comprising gases, liquids and solids under the influence of acoustic, electric, and magnetic forces. Such new information is applicable toward the advancement of the technologies of electronics, space power and propulsion. In electronics, new paths will be made toward stable wide-band modulated optical and infrared lasers capable of transmitting and receiving increased information, and higher temperature super conductors. For space power and propulsion, progress is being made to achieve stable high density plasmas and to minimize energy losses so that the magnetoplasmadynamic technique may become practical.

The goal of the Applied Mathematics subprogram is to achieve new mathematical techniques for the solution of problems related to space flight. Future plans include work in mathematical approaches to pattern recognition, information retrieval, automatic theorem proving, and adaptive systems. This work will be applicable to many social and technological problems in addition to the NASA requirements.

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. The primary objectives within the disciplinary areas of aerothermodynamics, structures, and space environmental protection and control are to (1) conduct focused research and technology efforts on critical problems associated with the reusable space shuttle, the space station, lunar exploration, and planetary vehicles, and (2) conduct carefully selected advanced technological research of particular importance to provide a balanced program for all types of unmanned and manned space vehicles.

The program also includes the formulation of space vehicle design criteria documents, as well as a special activity concerning aerospace safety.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1969	1970	1971
Research and Technology:			
Space vehicle aerothermodynamics.....	$9,116	$9,673	$7,300
Space vehicle structures.....	9,496	10,355	12,050
Space environmental protection and control.....	10,603	8,048	7,800
Space vehicle design criteria.....	1,669	1,394	1,350
Aerospace safety research.....	465	1,200	1,500
Total.....	$31,349	$30,670	$30,000

BASIS OF FUND REQUIREMENTS:

Research and Technology

A major part of the space vehicle aerothermodynamics and structures subprograms in FY 1971 will be focused on critical problems associated with the reusable space shuttle--such as evaluating conceptual vehicle configurations; investigating aerodynamic performance, stability, control and flying qualities of promising configuration concepts; determining the aerodynamic heating and developing effective reusable heat protection systems; and developing lightweight, highly efficient structures that are a prerequisite for a successful space shuttle. The cooperative NASA and USAF lifting-body flight research

program will continue to investigate piloting problems and flying qualities of advanced manned reentry vehicles during the terminal phases of flight from supersonic speeds to landing. Fifty-five glide and powered flights have been accomplished as of January 1.

A substantial part of the space environmental protection and control subprogram will be focused in FY 1971 on providing engineering technologies required for the space station and extended lunar exploration systems. These include laboratory and flight investigations of the space radiation and meteoroid environments, of advanced meteoroid protection systems, of improved vehicle thermal control systems, and on the problem of space vehicle optical surfaces becoming contaminated in space.

Research will continue on promising concepts for advanced unmanned planetary vehicles. This includes research on the meteoroid hazard of such spacecraft passing through the asteroid belt, on thermal control problems associated with long duration travel to the far reaches of the inner and outer planets of the solar system, on structures for lightweight erectable antennas for long distance communication, and on aerodynamic heating, performance, deceleration and landing characteristics of unmanned probe vehicles for soft landing on the planet surfaces.

Although each of the research and technology program elements discussed above is focused primarily on the potential applications noted, each program element is also of underlying importance to several space vehicle needs. To provide a balanced program for all types of space vehicles, the program also includes advanced technological research on additional problems such as the complex interactions of ablation by-products with the surrounding flow, the design and fabrication of advanced lightweight tanks for storing cryogenic fluids for long duration flights, the testing of ultralightweight erectable orbital telescope structures, the mechanics of hypervelocity meteoroid impact, and improved thermal vacuum simulation and testing techniques.

In the space vehicle design criteria subprogram, criteria and models of the environment applicable to the design of space vehicle structures, propulsion systems, and guidance and control systems are developed, documented and published. The FY 1971 funds will be used to contract for the services of technical experts outside the Government.

Aerospace Safety Research

The Aerospace Safety Research and Data Institute (ASRDI), which was recently established, has played an active and increasing role in support of aerospace safety improvement. A key responsibility of the ASRDI is the Aerospace Safety Data Bank which was established to collect and disseminate information on aerospace safety.

The objective of the program planned for FY 1970 is to achieve a modest expansion of the activities of the ASRDI in order to provide increased attention to the improvement of fire safety in manned spacecraft. Special

attention is planned in support of the Space Shuttle program. Activities associated with the Technical Data Bank have progressed approximately as planned, and initial operation of the Bank is planned for early 1970 on an experimental basis. At that time, the Data Bank will have direct hard line access to several major information centers throughout the country. The program thrust in FY 1971 will emphasize the collection, analysis, evaluation, and storage of safety data from many sources.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1971 ESTIMATES

SUMMARY

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY — ELECTRONICS SYSTEMS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

Modern aircraft and space missions rely heavily upon electronic systems for internal functional operations and coupling to the external environment or terrestrial world. The objectives of the Electronics Systems program are to provide advances in technology which significantly improve the performance, cost effectiveness and reliability of aerospace electronic systems; offer important new functional capabilities; and provide the components subsystems and systems needed to assure continued operational efficiency in the Nation's civil aeronautics and space activities. These objectives are pursued through a selected program of applied research and development on key pacing items or problems in the functional areas of guidance, control, communications, tracking, data handling and instrumentation backed by a more general research effort on the electronic techniques and components which are fundamental building blocks in all electronic systems.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1969	1970	1971
Aeronautics research and technology.....	$11,100	$10,495	$5,800
Space research and technology.....	23,360	23,005	16,600
Supporting research and technology.....	(22,960)	(22,705)	(16,600)
Flight projects.....	(400)	(300)	(---)
Total.....	$34,460	$33,500	$22,400

BASIS OF FUND REQUIREMENTS:

Aeronautics Research and Technology

That portion of the Electronics Systems program devoted to avionics research and development seeks solutions to specific problems in the civil aeronautics field. In FY 1971, emphasis will be placed on the development of techniques to alleviate air traffic congestion on and near airport runways. Integration of inertial system technology with conventional navigation and landing aids will be investigated with the objective of permitting more precise control and all-weather landing operation of commerical aircraft. V/STOL avionics research will continue with emphasis on flight tests of advanced components and systems to improve flight characteristics during terminal operations.

375-328 O - 70 - 6

The advent of complex aircraft such as the jumbo jet and supersonic transport require better understanding of the role of a human operator as an active element in the control and guidance systems. Research will be continued to define the characteristics of optimum pilot-display-vehicle control systems and develop improved display and control systems.

Development of fluidic components for simple, low cost autopilots suitable for general aviation applications will continue. Flight testing of a potentially light and inexpensive pilot warning indicator system suitable for general aviation will conclude in FY 1971. Results will be compiled and turned over to FAA and industry for further development.

A substantial effort in instrumentation needed to facilitate aircraft development and operation will be continued. Emphasis will be placed on the development of precision altimeters, low speed indicators for V/STOL aircraft and systems and techniques for the detection and prediction of clear air turbulence.

Space Research and Technology

Funds requested for FY 1971 are needed to support the Space Shuttle and Space Station/Base technology programs as well as future unmanned scientific missions. Research in guidance systems will emphasize development of precision electromagnetic sensors for attitude control of earth-orbiting vehicles such as the Space Station/Base and techniques for on-board guidance of planetary spacecraft as they approach their target planets. Advanced inertial components and automated systems for reentry, approach and landing of Space Shuttle vehicles will be investigated. Development of an optical radar for automatic rendezvous and docking of the Space Shuttle will continue.

Control systems research will continue the development of long-life, precision control components for manned and unmanned spacecraft. Techniques for passive stabilization of satellites using gravity gradient techniques will receive increased emphasis with applications to earth resources satellites as a primary goal. Continued development of control moment gyro systems will be directed toward the long term reliability requirements of the Space Station/Base.

Research on communications and tracking systems will emphasize the development of electronically steered antennas, higher frequency components and extended system lifetimes. Particular effort will be devoted to transmitting and receiving systems required for Space Shuttle operations. Development of telescope technology and optional communication systems will continue.

The complexity of automated systems and high volumes of data generated through space exploration require major advances in computer performance and data processing techniques. Development of high density computer memories will be continued with emphasis on magneto optic materials and holographic storage systems for Space Station applications. Research on redundant system organizations and improved components to obtain long life operation will continue. Techniques for pattern recognition and data compression will be pursued to maximize the return of information from recorded data.

Instrumentation research will emphasize the development of improved sensors with broader spectral response and increased sensitivity. Particular effort will be applied to the development of optical instrumentation such as gratings, light intensifiers, and image recording systems needed to fully utilize diffraction limited space telescopes.

Research on electronic techniques and components will center on the development of solid state materials, components and techniques for device fabrication and test. Solid state display devices, data storage and microwave components will be developed to support Space Station system developments. Automated screening and testing techniques for large scale integrated circuits will receive major emphasis to insure the availability of reliable components for the Space Shuttle and Space Station programs.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1971 ESTIMATES

SUMMARY

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY: SPACE POWER AND ELECTRIC PROPULSION SYSTEMS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The principal objective of the Space Power and Electric Propulsion program is to provide the advanced technology base necessary for the development of electric power generation and electric propulsion systems for anticipated aeronautical and space applications.

The power distribution, regulation, and control systems presently employed in aircraft are based on design concepts that are twenty or more years old. The objective of the aeronautics portion of the electric power generation program is to determine whether more recent technology concepts emanating from the space program can be employed to advantage in aircraft systems.

Future missions such as the space station/base, shuttle, applications satellites and outer-planets exploration require the development of electric power systems having power levels, endurances, and reliabilities far beyond those attainable with current systems which were designed to meet the relatively short duration, low power requirements associated with the first ten years of the Nation's space program. Within the power program, the need for nuclear system technology is becoming particularly pressing as the NASA mission requirements begin to exceed the capability of solar power systems.

The Electric Propulsion Systems program continues to aim at early applications to achieve the potential advantages of mission flexibility and increased payload. The need for long-life auxiliary electric propulsion systems for future manned space stations and synchronous satellites to perform station keeping is becoming evident. Studies continue to show the advantages of primary electric propulsion in performing difficult interplanetary missions. Continuing good progress is being achieved in both the auxiliary and primary propulsion systems technology areas as demonstrated by ground tests and the SERT II flight program.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars) 1969	1970	1971
Aeronautics Research and Technology:			
Supporting research and technology....	---	$200	$400
Space Research and Technology:			
Supporting research and technology....	$37,287	33,750	30,225
Space electric rocket test (SERT).....	1,500	500	275
Total.....	$38,787	$34,450	$30,900

BASIS OF FUND REQUIREMENTS:

Aeronautics Research and Technology

A thorough study of present and future needs in aircraft electrical systems is underway, together with a low level effort toward reducing the maintenance requirements, weight and complexity of aircraft electrical systems. This work will continue in FY 1971.

Space Research and Technology

The Nuclear Flight Safety program continues to include: (1) the coordination and direction of the NASA portion of the joint AEC/DOD/NASA reviews and analyses of proposed missions utilizing nuclear space power systems, (2) providing guidelines to the NASA Centers for future mission applications, (3) developing specific design information in such areas as reentry aerodynamics where NASA has special competence and facilities, and (4) the recovery of NASA launched spacecraft carrying significant quantities of nuclear materials in those cases where a determination is made that recovery is feasible and desirable.

The major reasons for interest in electric propulsion technology are: (1) the potential for increased mission capability and flexibility and, (2) reduced launch vehicle size and/or costs as compared with existing chemical propulsion systems. The ion engine, an electric thruster of the class which accelerate charged particles in electrostatic fields, will continue to receive the major emphasis in this program during FY 1971. Resistojet thrusters, which produce thrust by means of expansion of an electrically heated gas, and plasma thrusters which depend upon interactions between electric current and magnetic fields, are the subject of the remainder of the program.

A major milestone in the resistojet effort was passed in FY 1970 with the successful conclusion of long term life tests on ammonia and hydrogen units. In FY 1971, further testing will be performed on resistojets capable of

operating on biowastes and the subsystem technology required for integration with life support systems will be initiated. Electron bombardment ion thruster systems continue to show significant promise for interplanetary spacecraft prime propulsion.

The primary objective of the nuclear electric power technology program is to obtain the experimental and analytical data needed to permit the ultimate development of the energy conversion equipment to be used in advanced nuclear electric power generating systems required for such future missions as space station/base and outer-planets exploration. The conversion systems will utilize isotope and nuclear reactor heat sources furnished by the AEC, hence this program is closely coordinated with AEC programs.

Two nuclear power generation programs are aimed at supporting the space station/space base program to cover power needs which have now been identified by mission studies to range up to 100KWe, perhaps higher. These are the SNAP-8 and Brayton cycle programs.

The advanced alkali metal Rankine program is aimed at achieving low power system weights for power in the hundreds of kilowatts. Eventual applications are very high power near earth and electric propulsion planetary exploration missions.

Continuing progress is being made in FY 1970 in work aimed at developing the technology of thermionic reactor systems. Problem solving efforts on fuel/emitter technology and on uninsulated externally-fueled diode concept will be continued in FY 1971.

Progress was made in FY 1970 in the application of AEC developed radioisotope thermoelectric generators (RTG's) to NASA flight missions (e.g., SNAP-19 generators were tested on NIMBUS B2 and selected for future use on Pioneer spacecraft and Viking landers; a SNAP-27 was left on the moon by the Apollo 12 crew to power the ALSEP experiment.) During FY 1971 NASA will continue work to identify and resolve RTG/spacecraft interactions and operational problems, and will continue testing of RTG's for stability and long-term reliability.

An urgently needed facility, Isotope Thermoelectric Systems Applications Laboratory, for RTG/spacecraft interactions work is described under the FY 1971 Construction of Facilities.

Goals of the Solar Power System program continue to be: (1) investigation of methods for compact stowage and reliable, automatic deployment of large area, lightweight solar cell arrays; (2) adaptation of such arrays to the requirements for manned space station power; (3) understanding the structural and flight dynamic interactions of large, flexible solar cell arrays with

guidance, control and propulsion subsystems; (4) development of reliable, long-life mechanical drive mechanisms for large solar cell arrays; (5) development of solar cell array designs for application to spacecraft flights on Venus-Mercury flybys, solar probes, Mars landers and Jupiter flybys and orbiters; (6) substantial improvement in the resistance of solar cells to degradation in the space radiation environment; (7) better metal-to-silicon contacts needed to withstand new extremes of temperature and thermal cycling; and (8) new solar cells having greatly improved efficiency and reduced cost.

The Chemical Power Generation program is aimed at achieving a new technological plateau for batteries, fuel cells and engine generator systems. The space shuttle has re-emphasized the need for fuel cells, so that the current low level effort on basic electrochemistry and engineering is being increased to provide the necessary technology. Work will continue on long-life rechargeable batteries, on sterilizable batteries for planetary landers such as Viking and on batteries suitable to power launch vehicles and atmospheric balloons.

Solid state power distribution systems, circuits and devices are needed with every power generation source and on almost every launch vehicle and spacecraft. Work in this area will need to be expanded to develop the technology needed for future vehicles such as the shuttle and space station. Increased emphasis must also be given to power processing and distribution systems for future planetary spacecraft, especially those designed to explore the outer planets.

Space Electric Rocket Test (SERT)

The SERT II spacecraft is to be launched in the first quarter of CY 1970 from the Western Test Range into a near polar sunlit orbit. Primary power from a 1.5KW solar array will be used to sequentially power two 1KW thrusters. The objective is the verification of long-term ion thruster performance in space.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1971 ESTIMATES

SUMMARY

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY — NUCLEAR ROCKETS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The overall aim of the Nuclear Rockets program is to provide a significant increase in propulsion capability for future space activities. The principal objective is to develop a 75,000 pound thrust engine, NERVA, for incorporation in a reusable nuclear stage.

The advantages of nuclear propulsion over chemical propulsion result from its high payload performance, propulsion efficiency, and versatility. In the types of missions involving high energy and large payloads, specific impulse becomes an extremely important performance requirement. The first generation nuclear rocket engine, NERVA, on which work is now underway will provide approximately twice the specific impulse of the best chemical rockets. As an integral part of a new capability for space transportation, this engine incorporated in a reusable nuclear stage can be used to move men, spacecraft and supplies between earth orbit and lunar orbit and between low earth orbit and geosynchronous orbit. It also offers major advantages for transporting heavy payloads into deep space. The increased propulsion energy it makes available can be used for any of a variety of purposes in such missions, e.g., to increase payloads, to reduce trip times and to provide greater reliability for the completion of the mission.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1969	1970	1971
Supporting research and technology.....	$6,002	$8,000	$5,000
NERVA.....	23,000	27,085	32,000
NRDS operations.....	4,500	1,415	1,000
Total.....	$33,502	$36,500	$38,000

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

The supporting research and technology effort covers a broad spectrum of activities. The general aims of this program are (1) to provide support to the NERVA engine design and development, (2) to provide for the continued

improvement of nuclear rocket performance, (3) to provide the base of information for the development of a nuclear stage, and (4) to investigate the feasibility of advanced propulsion concepts.

NERVA

The NERVA engine is being designed as a throttleable and restartable, reusable system, so that it can be used over a long period of time for a number of missions. The engine is being designed so that any improvements in reactor fuel element capability, and thereby in lifetime, which are the result of the continuing AEC research and technology program, can be incorporated in the NERVA engine. The engine will be approximately 34 feet in length from the bottom of the propellant tank to the exit plane of the nozzle. Its largest diameter will be approximately 10 feet. The engine reactor will have a rating of 1,500 megawatts. Engine weight will be approximately 20,000 pounds, including a shield weight of approximately 3,000 pounds. For certain missions, additional shielding may be required, depending upon the design of the payload and the command module structure. Engine performance goals are as follows:

Thrust	75,000 pounds
Specific impulse	825 seconds
Endurance	Up to 10 hours
Operating cycle	Up to 60 cycles

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. Overall management of the site is provided by the AEC/NASA Space Nuclear Propulsion Office-Nevada Extension. The funding in this area provides for NASA's share of the general site operations.

SUMMARY

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY — CHEMICAL PROPULSION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Chemical Propulsion program is designed to provide the engineering theory and experimental data on which new and advanced propulsion capabilities necessary to support the Nation's space goals can be projected. The program (1) identifies future mission propulsion requirements, (2) researches fundamental propulsion concepts to meet the requirements, (3) studies principal design parameters, (4) investigates key design problems with a view to sound technical solutions, (5) develops experimental design, fabrication, and test techniques, (6) tests component designs and demonstrates experimental engines and motors, and (7) evaluates concepts and provides technical verification of capability to accomplish mission requirements. This effort is a precursor to actual system development.

Research and experimental work is conducted on two principal types of propulsion: systems using propellants in liquid form, and motors which use cast solid propellants. Thrust levels range from millipounds, used in attitude stabilization of spacecraft, to millions of pounds for first stage booster application. The goals of the future space program demand extension of both the performance and long service life of propulsion systems, and these must not jeopardize reliability of the operational system.

Propulsion processes, performance improvements, combustion, engine design, engine materials and fabrication technology are major categories of active research. Propellant properties, gas dynamics, heat transfer, fluid and solid mechanics, elastic properties, and chemical reaction are studied, both theoretically and experimentally, in their relationship to chemical propulsion. Basic theory and experimental findings are supported by complementary demonstrations to establish the validity and practicality of the propulsion systems concepts generated by the program.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1969	1970	1971
Supporting research and technology....	$25,752	$20,480	$20,300
Total.....	**$25,752**	**$20,480**	**$20,300**

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

High performance liquid and solid 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. Significant liquid propulsion program funds are identified with the Earth-to-Orbit Shuttle Vehicle propulsion problems. These efforts are designed to ease the development difficulties of both main engine and auxiliary propulsion systems.

Research on solid propellant motor systems includes nondestructive testing techniques for inspection and qualification of loaded motors, methods of combustion termination and restart, lower burning rate propellants, improved nozzles, long term space storability and investigation of ancillary applications.

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 1971 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 leadership in the application of principles developed in basic research programs for improvements in safety, efficiency and utility of all classes of military and civil aircraft. In order to provide this leadership necessary for the United States to retain its preeminent position in aeronautics, the NASA conducts a very broad program aimed at the application of vehicle oriented disciplinary technologies of aircraft aerodynamics, aircraft loads and structures, aircraft propulsion, operating environment problems and aircraft flight dynamics to the following classes of vehicles: general aviation aircraft, V/STOL aircraft, subsonic aircraft, supersonic aircraft and hypersonic aircraft - both civil and military. In the Advanced Research program, the disciplinary technologies are not focused on any one specific class of vehicle whereas in the Vehicle Technology program these disciplinary approaches are focused on specific vehicles. To further reinforce the research and to assist in ferreting out problems which may be overlooked or not evident in analytical and small-scale experimental approaches, emphasis is placed, as required, on flight test programs and proof-of-concept or large-scale experimental hardware evaluations.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1969	1970	1971
Advanced research	$16,857	$31,005	$31,565
General aviation aircraft technology	507	950	925
V/STOL aircraft technology	8,060	9,560	15,030
Subsonic aircraft technology	19,291	9,425	11,900
Supersonic aircraft technology	20,348	18,900	21,905
Hypersonic aircraft technology	9,685	6,060	5,775
Total	$74,748	$75,900	$87,100

375-328 O - 70 - 7

BASIS OF FUND REQUIREMENTS:

Advanced Research

Advanced research information and techniques are required to better predict and to improve the aerodynamic characteristics of various aircraft types. A continuing in-house and contract activity is warranted, not only for achieving aerodynamic refinement of conventional airframes, but also for fostering advanced aerodynamic concepts leading to revolutionary aeronautical vehicles. The scope of the work includes critical investigations of the shock-wave flow fields generated by supersonic lifting wings and wing-body combinations, of their propagation from the source through the atmosphere, and of minimizing their effects (sonic boom) on the earth.

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 objectives of the research in air breathing propulsion is to examine advanced energy conversion processes and problems either identified over a broad range of aircraft applications or else not readily identified with specific aircraft applications. Analytical and experimental studies will be conducted on advanced bearings and lubrication systems, high speed shafting and gearing, and engine seals. Limited research will be conducted on selected reactor containment, to provide the information necessary for a technological assessment of nuclear power for aircraft use.

The programs in the aircraft operating environment research area are aimed at solving problems related to runway surface and atmospheric environment, operational hazards, flight instrumentation, noise and sonic boom effects. They involve theoretical analyses and laboratory and flight test experiments to validate current engineering procedures and to explore solutions to aircraft operational problems. The results will provide both the basic technology for safer and quieter aircraft operations and the basic environmental data for application to design of specific classes of aircraft.

Research in aircraft flight dynamics is aimed at achieving increased knowledge and understanding of the basic elements which influence aircraft handling qualities and piloting performance, at obtaining expanded fundamental knowledge on the flight behavior of aircraft, and at developing, evaluating and applying improved theories, control techniques and piloting

aids pertinent to a variety of aircraft types. This research involves theoretical analyses, ground-based simulator tests, wind tunnel studies and in-flight investigations with variable-stability aircraft. The research program also includes studies to evolve improved flight-test analysis techniques and continued compilation and codification of aircraft flight dynamics characteristics and handling qualities data.

NASA's aeronautical research facilities are key to the research effort as well as being essential for the support of other agencies. Thus it is necessary to continue to provide for the upgrading of these facilities in terms of new equipment, instrumentation, and computerization of data acquisition reduction and analysis, and to provide for the maintenance and support of aircraft necessary to the conduct of flight research programs.

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. Emphasis is therefore on aerodynamics, flight dynamics and design with specific attention being paid to safety aspects and on flight tests of pilot warning indicator systems.

V/STOL Aircraft Technology

In the V/STOL aircraft disciplinary technology area, emphasis is being shifted to increase basic experimental and analytical studies leading to improved understanding of helicopter rotor performance, loading, and flutter characteristics. The feasibility of obtaining a rotor test vehicle enabling more realistic evaluations of the characteristics of advanced rotor concepts evolved from such investigations will be studied.

Flight studies recently initiated to examine VTOL and STOL operational problems in the descent and landing phases of flight will be augmented.

The jet-augmentor wing flight-research program is aimed specifically at providing technology applicable to the design of improved STOL transports, with both civil and military applications. In this joint program, Canada will provide the required propulsion system and the NASA will modify its CV-7A aircraft to incorporate an augmentor wing and the Canadian propulsion package. A study of the feasibility of modifying an existing transport aircraft to incorporate another jet STOL concept -- the externally-blown flap -- to provide a NASA research vehicle is also planned.

In another phase of research in this area, the advanced lift-fan aircraft program is being continued to advance information on lift-fan technology to the point where design of a commercial lift-fan V/STOL transport can be initiated with more confidence.

Subsonic Aircraft Technology

As during the past several years, the primary concentration in subsonic aircraft technology will be on the reduction of noise.

Progress in development of the supercritical wing concept has warranted a concerted effort to integrate this technology along with new structural and propulsion concepts into an overall supercritical design technology applicable to a new family of near-sonic transports.

In addition, a modest effort in critical disciplinary technologies is being continued to establish a foundation for the next generation of subsonic transports.

Supersonic Aircraft Technology

The design of advanced and highly maneuverable military and commercial supersonic aircraft with high performance levels is dependent upon factors such as increased aerodynamic efficiency, decreased structural weight, and improvement of power plant characteristics. A wide range of research activity in the various technologies is being carried out to achieve these goals and to provide the knowledge for the conception of advanced supersonic vehicles.

Aerodynamics data will be derived on such items as high-lift devices, effects of engine power, engine-airframe integration, buffet, and effects of variations in wing geometry. A number of metallic and non-metallic materials that may be suitable for use in supersonic aircraft structural applications are being investigated. Structural specimens of titanium reinforced with boron or graphite fibers will be subjected to an experimental program including loading and environmental exposure.

Propulsion system technology for advanced military and commercial aircraft will continue in the area of inlets and nozzles with particular emphasis on the mutual interaction problems that result from integrating these components into a complete airframe and propulsion system. Several approaches to reduce compressor and fan component weight and improve performance will be investigated. Multistage compressors will incorporate the most promising advanced concepts investigated in single stage compressors. The afterburner research program will evaluate and improve the performance, stability, and lift of afterburners designed for high temperature engines.

Under the turbine aerodynamics research programs, investigations will be made on a number of methods of increasing blade loading in order to reduce turbine size and heat transfer surface area.

Flight dynamics research is being conducted to develop criteria for aircraft systems that will allow the pilot to easily, economically, and safely control and maneuver supersonic aircraft in accordance with operational requirements. A cooperative research program is directed to providing the information necessary for the FAA to establish certification regulations for supersonic transports and for developing revisions in certification test maneuvers.

The NASA-USAF YF-12 flight research program is obtaining design information applicable to aircraft that have a high sustained supersonic mach number capability. Air Force interests are oriented primarily toward a further definition of the tactical performance of an advanced interceptor. The NASA programs are obtaining data in areas such as airplane structural characteristics, flight loads and deformations, aeroelastic effects on stability and control, propulsion airframe interaction, internal diffuser dynamics, and aerodynamic boundary layer characteristics.

Hypersonic Aircraft Technology

The technology is being developed from continuing theoretical and experimental studies in the various disciplines for long range hypersonic aircraft systems suitable for transports and reuseable boosters. Investigations will be conducted to determine the performance, stability and control, and heat transfer characteristics of complete hypersonic airbreathing aircraft configurations including jet interference effects. Structural-material design concepts and thermal protection systems will be explored further. Advanced airbreathing cycle concepts and system effects will be evaluated as well as continuing the effort to establish design criteria and evaluate the performance characteristics of propulsion components and systems.

The Hypersonic Research Engine program has progressed through the definition and design of all of the components. Assembly of the aerothermodynamic integration model is continuing.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1971 ESTIMATES

SUMMARY

OFFICE OF TRACKING AND DATA ACQUISITION

TRACKING AND DATA ACQUISITION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The purpose of this program is to provide responsive and efficient tracking and data acquisition support to meet the requirements of all NASA flight projects. 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 earthorbital and suborbital missions; for lunar and planetary missions; and for space probes.

Types of support provided included: (a) tracking to determine the position and trajectory of vehicles in space, (b) acquisition of scientific data from onboard experiments, (c) acquisition of engineering data on the performance of spacecraft and launch vehicle systems, (d) transmission of commands from ground stations to spacecraft, (e) communication with astronauts and acquisition of medical data on their physical condition, (f) communication of information between various ground facilities and mission control centers, and (g) processing of data acquired from the space vehicles. Such support is essential for achieving the scientific objectives of all flight missions, for executing the critical decisions which must be made to assure the success of these flight missions, and, in the case of manned missions, to insure the safety of the astronauts.

Tracking and data acquisition support is provided by a worldwide network of NASA ground stations 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

scientific and engineering data which are collected from flight projects. In addition, instrumentation facilities are provided for support of sounding rocket launchings and flight testing of research aircraft.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1969	1970	1971
Operations	$229,354	$233,400	$229,600
Equipment	39,162	32,200	55,500
Supporting research and technology	11,156	12,400	12,900
Total	$279,672	$278,000	$298,000

BASIS OF FUND REQUIREMENTS:

Operations

Funds required for maintenance and operation of the worldwide tracking and data acquisition facilities constitute 77 percent of the FY 1971 request for tracking and data acquisition. Substantial adjustments in network support requirements in FY 1970 have resulted in an overall reduction in the funds requested for network operations. The success of Apollo 11, the reduction in the number of Apollo flights to two per year, and support reductions in the scientific and applications satellite areas have permitted station closures and downward adjustments in requirements for ships, aircraft, and communications support.

The only significant increase within network operations is the request for the Deep Space Network. This increase is necessary to provide for the upcoming Mariner '71 launch and for the engineering effort associated with the network capability required in the early and mid-1970's. Among the approved projects to be supported in that time period are Pioneer F and G missions to Jupiter, Venus/Mercury '73, Helios, and Viking.

Equipment

The tracking and data acquisition support requirements placed on the networks establish needs for equipments which are essential to provide the continual on-going support to approved 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 programs. In FY 1971, emphasis will

continue on sustaining the existing capability of the networks along with significant augmentations of equipment to meet the requirements of upcoming planetary programs (Pioneer F and G, Venus/Mercury '73 2nd Helios.) Some equipment additions will also be required for AAP, ERTS, RAE-B, Nimbus, and other approved scientific satellite programs.

Supporting Research and Technology

The Tracking and Data Acquisition Supporting Research and Technology (SR&T) program has two primary objectives: the investigation and development of advanced systems, components, and techniques required for support of future NASA space flight programs; and the development of systems and techniques to provide more cost-effective and reliable network operations. The latter item is becoming increasingly important and the effort in this area has been increased in recognition of this. Overall, the SR&T effort in FY 1971 will continue at a constrained level with a small increase for studies on the Tracking and Data Relay Satellite System (TDRSS) and on X-band telecommunications techniques.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1971 ESTIMATES

SUMMARY

OFFICE OF TECHNOLOGY UTILIZATION — TECHNOLOGY UTILIZATION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The primary objectives of the NASA Technology Utilization program are: (1) to increase the return on the national investment in aerospace research and development by encouraging additional uses of the knowledge gained in those programs; (2) to shorten the time gap between the discovery of new knowledge and its effective use in the marketplace; (3) to aid the movement of new knowledge across industry, disciplinary, and regional boundaries; (4) to contribute to the knowledge of better means of transferring technology from its points of origin to its points of potential use.

New technological developments of use to the aerospace industry are applied almost automatically within that industry. Many of these innovations have potential benefit as well to the nonaerospace community. It is the primary purpose of this program to establish systems and mechanisms to identify, evaluate, publish, and transfer these technological innovations to the general public. This program provides a similar service with regard to management techniques developed for large scale complex research and development activities by creating awareness of and giving wide spread dissemination to new systems and concepts in this area.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Thousands of Dollars)		
	1969	1970	1971
New technology identification and evaluation...	$1,350	$1,300	$800
Publication.....	550	1,100	900
New technology dissemination.....	1,900	2,200	1,900
Program evaluation.....	---	400	400
Total.....	$3,800	$5,000	$4,000

BASIS OF FUND REQUIREMENTS:

New Technology Identification and Evaluation

Technology Utilization Officers at NASA field installations and specialists from universities, research institutes, and private industry identify and document those inventions, innovations, improvements, and discoveries that have potential utility to the nonaerospace sector of the economy.

Publication

Transfer of technology is accomplished through publications ranging from reports of single innovations to surveys of contributions to the state-of-the-art in broad technology areas. These are prepared by both private and nonprofit contractors.

New Technology Dissemination

Regional dissemination centers 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. Technology applications teams are assisting in developing cooperative programs with several other agencies such as the National Air Pollution Control Administration, Federal Water Pollution Control Administration, Law Enforcement Assistance Administration, Social Rehabilitation Service of HEW, Small Business Administration, and others. These joint efforts are designed to bring applicable aerospace technology to bear on technical problems in areas of major national concern such as environmental quality, law enforcement, and rehabilitation of the handicapped.

Program Evaluation

Research institute personnel evaluate technology transfer mechanisms and furnish recommendations for their improvement.

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, [$53,233,000] *$34,600,000*, 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, 1970: additional authorizing legislation to be proposed.)*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Construction of Facilities

Program and Financing (in thousands of dollars)

Identification code 27-00-0107-0-1-250	Budget plan (amounts for construction of facilities actions programed)			Costs and obligations		
	1969 actual	1970 estimate	1971 estimate	1969 actual	1970 estimate	1971 estimate
Program by activities:						
Direct program:						
1. Manned space flight	10,719	14,250	2,000	20,026	16,100	16,600
2. Scientific investigations in space	1,100	1,595	700	7,622	3,600	3,000
3. Space applications	----------	----------	5,350	----------	----------	900
4. Space technology	386	----------	6,275	12,494	10,100	7,300
5. Aviation technology	----------	4,767	----------	6,761	6,700	5,300
6. Supporting activities	19,875	32,621	20,275	5,389	23,500	30,900
Total direct program costs, funded	32,080	53,233	34,600	52,292	60,000	64,000
Reimbursable program:						
3. Space applications	----------	----------	----------	59	42	----------
Total program costs, funded	----------	----------	----------	52,351	60,042	64,000
Change in selected resources [1]	----------	----------	----------	2,451	19,893	−8,696
10 Total	32,080	53,233	34,600	54,802	79,935	55,304
Financing:						
21 Unobligated balance available, start of year: For completion of prior year budget plans	----------	----------	----------	−69,269	−47,406	−20,704
Reprograming to prior year budget plans	860	----------	----------	----------	----------	----------
24 Unobligated balance available, end of year: For completion of prior year budget plans	----------	----------	----------	47,406	20,704	----------
Budget authority	32,940	53,233	34,600	32,940	53,233	34,600

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	21,800	53,233	34,600	21,800	53,233	34,600
42 Transferred from other accounts	11,140	----------	----------	11,140	----------	----------
43 **Appropriation (adjusted)**	**32,940**	**53,233**	**34,600**	**32,940**	**53,233**	**34,600**
71 Relation of obligations to outlays:						
72 Obligations incurred, net				54,802	79,935	55,304
74 Obligated balance, start of year				83,464	72,998	92,933
Obligated balance, end of year				−72,998	−92,933	−76,237
90 Outlays				65,269	60,000	72,000

Note.—Reconciliation of budget plan to obligations:	*1969 actual*	*1970 estimate*	*1971 estimate*
Total budget plan	32,080	53,233	34,600
Deduct portion of budget plan to be obligated in subsequent years	7,766	12,347	------
Add obligations of prior year budget plans	30,488	39,049	20,704
Total obligations	54,802	79,935	55,304

[1] Selected resources as of June 30 are as follows:	*1968*	*1969 adjustments*	*1969*	*1970*	*1971*
Unpaid undelivered orders	52,498	−30	54,889	74,782	66,086
Advances	------	----	30	30	30
Total selected resources	52,498	−30	54,919	74,812	66,116

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1971 ESTIMATES

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

Location	Fiscal Year 1969	Fiscal Year 1970	Fiscal Year 1971
Ames Research Center.....	$386	---	$1,525
Goddard Space Flight Center...	---	$670	2,050
Jet Propulsion Laboratory.....	---	---	1,950
John F. Kennedy Space Center, NASA.....	7,964	12,500	575
Langley Research Center.....	---	4,767	---
Manned Spacecraft Center.....	1,333	1,750	900
Marshall Space Flight Center..	---	---	525
Michoud Assembly Facility.....	400	---	---
Nuclear Rocket Development Station.....	---	---	3,500
Wallops Station.....	500	500	---
Various Locations.....	20,497	29,546	18,575
Facility Planning and Design..	1,000	3,500	5,000
Total Plan.....	$32,080	$53,233	$34,600

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 1971 budget are identified thereon.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

INSTALLATION SUMMARY

CONSTRUCTION OF FACILITIES

FISCAL YEAR 19 71 BUDGET ESTIMATES

(Dollars in thousands)

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

INSTALLATION MISSION

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

PROJECT LINE ITEM	COGNIZANT OFFICE	FY 1959 THRU CURRENT YR	FY 19 71 (Estimated)	FUTURE YEARS (Estimated)	TOTAL ALL YEARS (Estimated)
Polymer Research Laboratory	OART	70	1,525		1,595
TOTAL			1,525		

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

INSTALLATION SUMMARY

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1971 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 1971 (Estimated)	FUTURE YEARS (Estimated)	TOTAL ALL YEARS (Estimated)
Earth Resources Technology Laboratory	OSSA	67	2,050		2,117
TOTAL			2,050		

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

INSTALLATION SUMMARY

CONSTRUCTION OF FACILITIES

FISCAL YEAR 19 71 BUDGET ESTIMATES

(Dollars in thousands)

NASA INSTALLATION		COGNIZANT PROGRAM OFFICE FOR INSTALLATION
Jet Propulsion Laboratory		Office of Space Science and Applications
LOCATION OF INSTALLATION	COUNTY	NEAREST CITY
Pasadena, California	Los Angeles	Pasadena

INSTALLATION MISSION

The Jet Propulsion Laboratory (JPL) is a government-owned research and development facility, operated by the California Institute of Technology under a contract with the National Aeronautics and Space Administration. The laboratory carries out research programs and unmanned lunar and planetary space projects for NASA, and conceives and executes advanced development and experimental engineering investigations to further the technology required for the nation's space program.

PROJECT LINE ITEM	COGNIZANT OFFICE	FY 1959 THRU CURRENT YR	FY 19 71 *(Estimated)*	FUTURE YEARS *(Estimated)*	TOTAL ALL YEARS *(Estimated)*
Solar Simulator Modifications	OSSA	1,721	700		2,421
Isotope Thermoelectric Systems Application Laboratory	OART	60	1,250		1,310
TOTAL			1,950		

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

INSTALLATION SUMMARY

CONSTRUCTION OF FACILITIES

FISCAL YEAR 19 71 BUDGET ESTIMATES

(Dollars in thousands)

NASA INSTALLATION		COGNIZANT PROGRAM OFFICE FOR INSTALLATION
John F. Kennedy Space Center, NASA		Manned Space Flight
LOCATION OF INSTALLATION Cape Kennedy and Merritt Island	COUNTY Brevard	NEAREST CITY Cocoa Beach, Florida

INSTALLATION MISSION

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

PROJECT LINE ITEM	COGNIZANT OFFICE	FY 1959 THRU CURRENT YR	FY 19 71 *(Estimated)*	FUTURE YEARS *(Estimated)*	TOTAL ALL YEARS *(Estimated)*
Launch Support Facilities	MSF	33	575		608
TOTAL			575		

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

INSTALLATION SUMMARY

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1971 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

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 aircraft project.

PROJECT LINE ITEM	COGNIZANT OFFICE	FY 1959 THRU CURRENT YR	FY 1971 (Estimated)	FUTURE YEARS (Estimated)	TOTAL ALL YEARS (Estimated)
Calibration Laboratory	MSF	60	900		960
TOTAL			900		

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

INSTALLATION SUMMARY

CONSTRUCTION OF FACILITIES

FISCAL YEAR 19 71 BUDGET ESTIMATES

(Dollars in thousands)

NASA INSTALLATION		COGNIZANT PROGRAM OFFICE FOR INSTALLATION
Marshall Space Flight Center		Manned Space Flight
LOCATION OF INSTALLATION	COUNTY	NEAREST CITY
Huntsville, Alabama	Madison	Huntsville, Alabama

INSTALLATION MISSION

The mission of the Marshall Space Flight Center is the development of launch vehicles, engines and vehicle systems for Manned Space Flight programs. The Center also performs advanced studies and research in the general field of astronautics.

PROJECT LINE ITEM	COGNIZANT OFFICE	FY 1959 THRU CURRENT YR	FY 19 71 (Estimated)	FUTURE YEARS (Estimated)	TOTAL ALL YEARS (Estimated)
Multi-Spectral Photographic Laboratory	MSF	36	525		561
TOTAL			525		

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

INSTALLATION SUMMARY

CONSTRUCTION OF FACILITIES

FISCAL YEAR 19 71 BUDGET ESTIMATES

(Dollars in thousands)

NASA INSTALLATION		COGNIZANT PROGRAM OFFICE FOR INSTALLATION
Nuclear Rocket Development Station		Office of Advanced Research and Technology
LOCATION OF INSTALLATION	COUNTY	NEAREST CITY
Jackass Flats, Nevada	Nye	Las Vegas

INSTALLATION MISSION

The mission of the Nuclear Rocket Development Station is to provide a site for ground static testing of the reactors, engines, and stages associated with nuclear rocket development.

PROJECT LINE ITEM	COGNIZANT OFFICE	FY 1959 THRU CURRENT YR	FY 19 71 (Estimated)	FUTURE YEARS (Estimated)	TOTAL ALL YEARS (Estimated)
Engine/Stage Test Stand No. 2	OART		3,500	45,000	48,500
TOTAL			3,500		

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

INSTALLATION SUMMARY

CONSTRUCTION OF FACILITIES

FISCAL YEAR 19 71 BUDGET ESTIMATES

(Dollars in thousands)

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

INSTALLATION MISSION

PROJECT LINE ITEM	COGNIZANT OFFICE	FY 1959 THRU CURRENT YR	FY 19 71 (Estimated)	FUTURE YEARS (Estimated)	TOTAL ALL YEARS (Estimated)
Rehabilitation and Modification of Facilities	O&M	10,360	14,000		24,360
Alterations to Launch Complex 2	OSSA	4,641	3,300		7,941
Power Plant Addition, 210' Antenna Facility	OTDA	35	750		785
Relocation of a Transportable Facility	OTDA	25	525		550
TOTAL			18,575		

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

INSTALLATION SUMMARY

CONSTRUCTION OF FACILITIES

FISCAL YEAR 19 71 BUDGET ESTIMATES

(Dollars in thousands)

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

INSTALLATION MISSION

PROJECT LINE ITEM	COGNIZANT OFFICE	FY 1959 THRU CURRENT YR	FY 19 71 (Estimated)	FUTURE YEARS (Estimated)	TOTAL ALL YEARS (Estimated)
Facility Planning and Design	O&M	59,131	5,000		Not Applicable
TOTAL			5,000		

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

RESEARCH AND PROGRAM MANAGEMENT

For necessary expenses of research in Government laboratories, management of programs and other activities of the National Aeronautics and Space Administration, not otherwise provided for, including uniforms or allowances therefor, as authorized by law (5 U.S.C. 5901–5902); minor construction; awards; *purchase of not to exceed one and* hire, maintenance and operation of administrative aircraft; purchase (not to exceed [thirty-five] *thirty-nine* for replacement only) and hire of passenger motor vehicles; and maintenance, repair, and alteration of real and personal property; [$637,400,000] *$692,300,000*: *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, 1970; additional authorizing legislation to be proposed.)*

GENERAL PROVISIONS

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

Not to exceed $35,000 of the appropriation "Research and Program Management" in this Act for the National Aeronautics and Space Administration shall be available for scientific consultations or extraordinary expense, to be expended upon the approval or authority of the Administrator and his determination shall be final and conclusive. *(Independent Offices and Department of Housing and Urban Development Appropriation Act, 1970.)*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND PROGRAM MANAGEMENT

Program and Financing (in thousands of dollars)

Identification code 27-00-0103-0-1-250	Budget plan			Costs and obligations		
	1969 actual	1970 estimate	1971 estimate	1969 actual	1970 estimate	1971 estimate
Program by activities:						
Direct program:						
1. Manned space flight	320,000	328,900	334,100	320,600	331,200	334,700
2. Scientific investigations in space	77,700	87,700	85,700	78,300	87,400	85,800
3. Space applications	21,000	23,700	27,200	21,100	23,600	27,000
4. Space technology	121,200	124,400	122,000	119,100	125,400	122,700
5. Aviation technology	73,400	85,100	83,500	78,500	84,800	82,700
6. Supporting activities	34,664	38,601	39,800	34,722	38,400	39,400
Total direct program costs, funded	647,964	688,401	692,300	652,322	690,800	692,300
Reimbursable program:						
1. Manned space flight	1,342	1,898	1,775	1,250	1,898	1,775
3. Space applications	977	1,733	1,356	894	1,733	1,356
4. Space technology	481	569	569	460	569	569
Total reimbursable program costs	2,800	4,200	3,700	2,604	4,200	3,700
Total program costs, funded	650,764	692,601	696,000	654,926	695,000	696,000
Change in selected resources [1]	----------	----------	----------	−4,162	−2,399	----------
10 Total	650,764	692,601	696,000	650,764	692,601	696,000

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

	1968	*1969 adjustments*	*1969*	*1970*	*1971*
Unpaid undelivered orders	35,806	−2,546	29,259	26,860	26,860
Advances	342	-------	181	181	181
Total selected resources	36,148	−2,546	29,440	27,041	27,041

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

Identification code 27-00-0103-0-1-250	Budget plan 1969 actual	Budget plan 1970 estimate	Budget plan 1971 estimate	Costs and obligations 1969 actual	Costs and obligations 1970 estimate	Costs and obligations 1971 estimate
Financing:						
Receipts and reimbursements from:						
11 Federal funds				−2,544	−3,744	−3,360
14 Non-Federal sources [2]				−256	−456	−340
17 Recovery of prior year obligations				−1,235	----------	----------
23 Unobligated balance transferred to other accounts				1,235	----------	----------
25 Unobligated balance lapsing				147	----------	----------
Budget authority				**648,111**	**688,401**	**692,300**
Budget authority:						
40 Appropriation				603,173	637,400	692,300
41 Transferred to other accounts				−280	−474	----------
42 Transferred from other accounts				45,218	9,708	----------
43 **Appropriation (adjusted)**				**648,111**	**646,634**	**692,300**
44.20 **Proposed supplemental for civilian pay act increase**				----------	**41,767**	----------
Relation of obligations to outlays:						
71 Obligations incurred, net				646,729	688,401	692,300
72 Obligated balance, start of year				86,373	75,407	84,408
74 Obligated balance, end of year				−75,407	−84,408	−83,708
77 Adjustments in expired accounts				−1,475	----------	----------
90 Outlays, excluding pay increase supplemental				656,220	640,000	690,633
91.20 Outlays from civilian pay act supplemental				----------	39,400	2,367

[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 1971 ESTIMATES

RESEARCH AND PROGRAM MANAGEMENT

SUMMARY OF OBLIGATIONS BY INSTALLATION
(In thousands of dollars)

	Fiscal Year 1969	Fiscal Year 1970	Fiscal Year 1971
MANNED SPACE FLIGHT.....	$310,968	$323,688	$330,583
John F. Kennedy Space Center, NASA	95,794	97,445	98,150
Manned Spacecraft Center.....	98,840	104,546	107,758
Marshall Space Flight Center.....	116,334	121,697	124,675
SPACE SCIENCE AND APPLICATIONS.....	$82,329	$94,317	$97,461
Goddard Space Flight Center.....	73,227	84,772	87,670
Wallops Station.....	9,102	9,545	9,791
ADVANCED RESEARCH AND TECHNOLOGY....	$193,890	$208,578	$201,521
Ames Research Center.....	34,032	36,359	38,248
Electronics Research Center.....	17,237	19,483	4,470
Flight Research Center.....	9,697	10,131	10,549
Langley Research Center.....	62,945	67,973	70,734
Lewis Research Center.....	67,844	72,398	75,218
Space Nuclear Propulsion Office...	2,135	2,234	2,302
SUPPORTING OPERATIONS			
NASA Headquarters.....	$60,777	$61,818	$62,735
TOTAL.....	$647,964	$688,401	$692,300

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1971 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																
1969	$463,675	$204,076	$43,325	$69,285	$91,466	$61,853	$56,252	$5,601	$159,744	$28,477	$11,979	$7,522	$51,899	$57,987	$1,880	$38,002
1970	516,175	222,000	46,630	76,307	99,063	74,994	68,728	6,266	177,252	31,059	13,847	8,221	57,744	64,351	2,030	41,929
1971	515,108	222,019	46,161	77,173	98,685	77,409	70,929	6,480	173,027	32,385	3,670	8,503	59,269	67,111	2,089	42,653
Travel																
1969	14,003	6,247	566	3,562	2,119	1,782	1,665	117	3,435	694	321	200	1,134	898	188	2,539
1970	16,712	7,395	811	4,177	2,407	2,422	2,265	157	3,760	736	351	219	1,237	1,013	204	3,135
1971	18,200	7,854	874	4,463	2,517	2,759	2,584	175	4,325	921	200	234	1,669	1,088	213	3,262
Automatic Data Processing																
1969	23,808	12,453	1,044	5,501	5,908	6,066	5,987	79	2,953	324	1,206	58	933	432	---	2,336
1970	21,548	13,884	943	5,743	7,198	5,104	5,042	62	1,001	115	590	9	240	47	---	1,559
1971	22,710	14,915	943	5,930	8,042	5,788	5,723	65	433	115	---	9	256	53	---	1,574
Facilities Services																
1969	85,841	58,304	39,649	10,278	8,377	7,097	4,825	2,272	20,013	3,659	1,822	1,257	6,394	6,881	---	427
1970	80,872	54,551	38,559	8,825	7,167	6,684	4,472	2,212	19,311	3,696	2,317	1,072	6,116	6,110	---	326
1971	84,083	59,469	39,933	10,195	9,341	6,253	4,048	2,205	18,035	4,073	100	1,118	6,749	5,995	---	326
Technical Services																
1969	18,026	3,583	---	1,956	1,627	1,018	967	51	1,831	41	866	47	73	737	67	11,594
1970	15,272	3,694	---	2,317	1,377	860	801	59	1,172	9	981	73	73	36	---	9,546
1971	14,327	3,734	---	2,275	1,459	854	796	58	249	9	---	77	73	90	---	9,490
Administrative Support																
1969	42,611	26,305	11,210	8,258	6,837	4,513	3,531	982	5,914	837	1,043	613	2,512	909	---	5,879
1970	37,822	22,164	10,502	7,177	4,485	4,253	3,464	789	6,082	744	1,397	537	2,563	841	---	5,323
1971	37,872	22,592	10,239	7,722	4,631	4,398	3,590	808	5,452	745	500	608	2,718	881	---	5,430
Total																
1969	647,964	310,968	95,794	98,840	116,334	82,329	73,227	9,102	193,890	34,032	17,237	9,697	62,945	67,844	2,135	60,777
1970	688,401	323,688	97,445	104,546	121,697	94,317	84,772	9,545	208,578	36,359	19,483	10,131	67,973	72,398	2,234	61,818
1971	692,300	330,583	98,150	107,758	124,675	97,461	87,670	9,791	201,521	38,248	4,470	10,549	70,734	75,218	2,302	62,735

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1971 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 1969							
Personnel compensation	$427,898	$427,898	---	---	---	---	---
Personnel benefits	32,564	32,564	---	---	---	---	---
Benefits for former personnel	286	286	---	---	---	---	---
Travel & transp. of persons	15,633	150	$14,003	---	---	---	$1,480
Transportation of things	3,706	387	---	---	---	$156	3,163
Rents, communications, and utilities	45,025	---	---	$12,599	$18,823	---	13,603
Printing and reproduction	6,649	---	---	---	1	534	6,114
Other services	93,575	2,385	---	9,043	55,964	16,324	9,859
Supplies and materials	15,624	---	---	---	7,885	503	7,236
Equipment	5,328	5	---	2,157	1,614	509	1,043
Lands and structures	1,554	---	---	---	1,554	---	---
Grants, subsidies and contributions	44	---	---	9	---	---	35
Insurance claims and indemnities	78	---	---	---	---	---	78
Totals	$647,964	$463,675	$14,003	$23,808	$85,841	$18,026	$42,611
Fiscal Year 1970							
Personnel compensation	$475,809	$475,809	---	---	---	---	---
Personnel benefits	37,185	37,185	---	---	---	---	---
Benefits for former personnel	24	24	---	---	---	---	---
Travel & transp. of persons	18,408	220	$16,712	---	---	---	$1,476
Transportation of things	3,953	424	---	---	---	$95	3,434
Rents, communications, and utilities	44,704	---	---	$12,338	$19,237	2	13,127
Printing and reproduction	6,120	---	---	---	3	539	5,578
Other services	84,972	2,513	---	9,169	52,229	13,840	7,221
Supplies and materials	13,520	---	---	---	6,959	447	6,114
Equipment	2,370	---	---	35	1,194	349	792
Lands and structures	1,250	---	---	---	1,250	---	---
Grants, subsidies and contributions	54	---	---	---	---	---	54
Insurance claims and indemnities	32	---	---	6	---	---	26
Totals	$688,401	$516,175	$16,712	$21,548	$80,872	$15,272	$37,822
Fiscal Year 1971							
Personnel compensation	$471,276	$471,276	---	---	---	---	---
Personnel benefits	39,311	39,311	---	---	---	---	---
Benefits for former personnel	1,460	1,460	---	---	---	---	---
Travel & transp. of persons	19,874	208	$18,200	---	---	---	$1,466
Transportation of things	3,668	416	---	---	---	$95	3,157
Rents, communications, and utilities	44,308	---	---	$13,017	$18,248	---	13,043
Printing and reproduction	5,939	---	---	---	---	475	5,464
Other services	89,568	2,437	---	9,693	54,486	13,293	9,659
Supplies and materials	13,223	---	---	---	7,035	199	5,989
Equipment	2,239	---	---	---	1,164	265	810
Lands and structures	1,350	---	---	---	1,350	---	---
Grants, subsidies and contributions	54	---	---	---	---	---	54
Insurance claims and indemnities	30	---	---	---	---	---	30
Totals	$692,300	$515,108	$18,200	$22,710	$82,283	$14,327	$39,672

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1971 ESTIMATES

RESEARCH AND PROGRAM MANAGEMENT

DISTRIBUTION OF OBLIGATIONS BY OBJECT CLASSIFICATION BY INSTALLATION

(Thousands of dollars)

Object Classification	Total NASA	Subtotal OMSF	J. F. Kennedy Space Center, NASA	Manned Spacecraft Center	Marshall Space Flight Center	Subtotal OSSA	Goddard Space Flight Center	Wallops Station	Subtotal OART	Ames Research Center	Electronics Research Center	Flight Research Center	Langley Research Center	Lewis Research Center	Space Nuclear Propulsion Office	NDOTRS.
FISCAL YEAR 1969																
Personnel compensation	427,898	188,717	40,161	64,170	84,386	57,076	51,941	5,135	147,770	26,464	11,015	6,957	47,877	53,763	1,694	34,335
Personnel benefits	32,564	14,032	2,915	4,720	6,397	4,307	3,911	396	11,263	1,995	820	521	3,684	4,064	179	2,962
Benefits to former personnel	286	155	---	---	155	---	---	---	23	---	---	---	---	23	---	108
Travel & transportation of persons	15,633	7,709	1,730	3,769	2,210	1,901	1,710	191	3,461	713	325	201	1,134	899	189	2,562
Transportation of things	3,7[illegible]	1,933	1,493	356	84	1,111	990	121	387	21	54	14	193	101	4	275
Rents, communications, and utilities	45,025	21,991	7,803	8,005	6,183	8,372	7,935	437	11,958	3,041	2,116	204	2,818	3,779	---	2,704
Printing and reproduction	6,6[illegible]	4,611	3,226	885	500	182	123	59	413	6	88	7	242	70	---	1,443
Other services	93,575	60,767	32,725	14,111	13,931	5,625	4,327	1,298	12,944	1,289	2,243	1,408	4,236	3,699	69	14,239
Supplies and materials	15,624	8,869	4,412	2,275	2,182	2,055	1,064	991	4,157	453	380	217	2,154	953	---	543
Equipment	5,328	1,295	841	191	263	1,276	923	353	1,231	40	196	96	423	476	---	1,526
Lands and structures	1,554	875	475	358	42	423	302	121	256	1	---	72	183	---	---	---
Grants, subsidies & contributions	44	---	---	---	---	---	---	---	9	9	---	---	---	---	---	35
Insurance claims and indemnities	78	14	13	---	1	1	1	---	18	---	---	---	1	17	---	45
Totals	647,964	310,968	95,794	98,840	116,334	82,329	73,227	9,102	193,890	34,032	17,237	9,697	62,945	67,844	2,135	60,777
FISCAL YEAR 1970																
Personnel compensation	475,809	205,018	42,995	70,631	91,392	69,074	63,332	5,742	163,784	28,835	12,695	7,609	53,187	59,611	1,847	37,933
Personnel benefits	37,185	15,607	3,243	5,263	7,101	5,383	4,930	453	12,759	2,170	986	597	4,215	4,611	180	3,436
Benefits for former personnel	24	---	---	---	---	---	---	---	24	24	---	---	---	---	---	---
Travel and transportation of persons	18,408	8,892	1,999	4,416	2,477	2,559	2,328	231	3,799	743	362	234	1,237	1,016	207	3,158
Transportation of things	3,953	1,917	1,481	356	80	1,108	981	127	697	32	340	15	210	100	---	231
Rents, communications, and utilities	44,704	22,300	7,525	8,100	6,675	7,865	7,438	427	11,471	3,102	1,998	176	2,695	3,500	---	3,068
Printing and reproduction	6,120	4,473	3,173	800	500	171	120	51	368	6	92	10	200	60	---	1,108
Other services	84,972	56,177	31,995	12,840	11,342	5,496	4,228	1,268	11,219	792	2,499	1,093	3,785	3,050	---	12,080
Supplies and materials	13,520	7,714	4,075	1,839	1,800	1,984	1,075	909	3,390	442	374	225	2,100	249	---	432
Equipment	2,370	723	344	200	179	412	200	212	918	207	137	96	278	200	---	317
Lands and structures	1,250	849	599	100	150	265	140	125	136	---	---	75	61	---	---	---
Grants, subsidies & contributions	54	---	---	---	---	---	---	---	7	6	---	1	---	---	---	47
Insurance claims and indemnities	32	18	16	1	1	---	---	---	6	---	---	---	5	1	---	8
Totals	688,401	323,688	97,445	104,546	121,697	94,317	84,772	9,545	208,578	36,359	19,483	10,131	67,973	72,398	2,234	61,818
FISCAL YEAR 1971																
Personnel compensation	471,276	204,521	42,496	71,290	90,735	71,333	65,409	5,924	157,281	29,751	2,000	7,815	54,218	61,616	1,881	38,141
Personnel benefits	39,311	16,128	3,342	5,481	7,305	5,510	5,025	485	13,753	2,604	210	673	4,709	5,352	205	3,920
Benefits for former personnel	1,460	---	---	---	---	---	---	---	1,460	---	1,460	---	---	---	---	---
Travel & transportation of persons	19,874	9,329	2,036	4,691	2,602	2,906	2,656	250	4,352	928	200	249	1,669	1,090	216	3,287
Transportation of things	3,668	1,895	1,440	356	99	1,227	1,100	127	359	33	---	16	210	100	---	187
Rents, communications, and utilities	44,308	22,395	7,480	8,240	6,675	8,718	8,290	428	10,033	3,384	100	184	2,865	3,500	---	3,162
Printing and reproduction	5,939	4,363	3,063	800	500	172	120	52	346	6	---	10	270	60	---	1,058
Other services	89,568	62,782	33,493	14,860	14,429	4,962	3,630	1,332	9,638	844	500	1,143	4,101	3,050	---	12,186
Supplies and materials	13,223	7,679	4,040	1,739	1,900	2,054	1,100	954	3,110	482	---	252	2,127	249	---	380
Equipment	2,239	723	344	200	179	339	200	139	818	210	---	127	281	200	---	359
Lands and structures	1,350	750	400	100	250	240	140	100	360	---	---	79	281	---	---	---
Grants, subsidies & contributions	54	---	---	---	---	---	---	---	7	6	---	1	---	---	---	47
Insurance claims and indemnities	30	18	16	1	1	---	---	---	4	---	---	---	3	1	---	8
Totals	692,300	330,583	98,150	107,758	124,675	97,461	87,670	9,791	201,521	38,248	4,470	10,549	70,734	75,218	2,302	62,735

375-328 O - 70 (Face blank p. 12ft)

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1971 ESTIMATES

JOHN F. KENNEDY SPACE CENTER

MISSION:

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

375-328 O - 70 - 9

of Florida has dedicated to the United States exclusive use rights to some 53,553 acres of State-owned submerged lands.

In addition to the operation and maintenance of all facilities at the Kennedy Space Center, the Center is responsible for certain facilities within the national Eastern Test Range launch area. The total capital investment at the Kennedy Space Center, including fixed assets in progress and contractor held facilities at various locations as of June 30, 1969, was $1,047,293,000.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Dollars in Thousands)		
	1969	1970	1971
Authorized permanent positions, end of year.....	2,877	2,779	2,748
Research and Program Management.....	$95,794	$97,445	$98,150

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1971 ESTIMATES

MANNED SPACECRAFT CENTER

MISSION:

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

MSC is now engaged in Apollo Lunar Exploration and is proceeding with necessary spacecraft modifications for limited extension of exploration capabilities. Spacecraft are also being modified to support the requirements of the Apollo Applications project. MSC is responsible for:

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

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

3. Conduct of a program of spacecraft environmental testing.

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

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

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

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

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

In the period ahead, MSC will participate in Manned Space Flight efforts to produce a preliminary design and design verification of a space shuttle engine and air frame, and a space station module. Additional supporting studies will be required for these efforts.

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 and contractor held facilities at various locations, and the White Sands Test Facility, as of June 30, 1969 was $472,737,000.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Dollars in Thousands)		
	1969	1970	1971
Authorized permanent positions, end of year.....	4,384	4,250	4,200
Research and Program Management.....	$98,840	$104,546	$107,758

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1971 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 program management and payload integration of the Apollo Applications 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 on-going programs:

1. The Saturn vehicles which serve to launch manned lunar and earth orbital missions, and very large earth orbital payloads.

2. The Apollo Applications Saturn workshop mission including selected scientific payloads such as the Apollo Telescope Mount.

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

In the period ahead, MSFC will participate in Manned Space Flight efforts on a preliminary design and design verification of a space shuttle engine and air frame, and a space station module. Additional supporting studies will be required for these efforts.

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 AAP or subsequent missions.

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

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. The capital investment as of June 30, 1969, was $353,942,000. 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, 1969, was $147,190,000. Michoud facility space totals about 3.5 million 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 booster stages at this location. The Michoud Assembly Facility is on the Gulf Intra-Coastal Waterway, and has deepwater 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, 1969, was $276,203,000. 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 deepwater 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 progress and contractor-held facilities at various locations, as of June 30, 1969, was $943,682,000.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Dollars in Thousands)		
	1969	1970	1971
Authorized permanent positions, end of year	6,149	6,004	5,935
Research and Program Management	$116,334	$121,697	$124,675

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1971 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.

During 1969, twenty-two major spacecraft launchings were conducted by NASA of which fourteen were directly managed by the Goddard Space Flight Center. Of the remaining eight missions, including four Apollo flights, two Mariner space probes and two scientific satellites, Goddard played a major data acquisition, tracking and/or launch vehicle management role.

Major Goddard achievements during the year included:

Scientific Satellites - Launch of the sixth and last spacecraft in the Orbiting Geophysical Observatory (OGO) series, bringing to more than 120 individual experiments orbited in the series to conduct inter-disciplinary, time-correlated studies of Earth-Sun relationships; launch of two Orbiting Solar Observatories (OSO 5 and OSO 6), to continue the pioneering solar studies during the current solar cycle; launch of the Goddard-built Explorer

41 (Interplanetary Monitoring Platform) to continue a highly successful series designed primarily to study the Earth's magnetosphere; completion of first year operation of Orbiting Astronomical Observatory (OAO) II providing the most prolonged astronomical observations above the Earth's atmosphere ever conducted.

International Scientific Satellites - An increasingly important mission for the Center is its responsibility for carrying out the international cooperative space program under NASA auspices. During the year three international scientific satellites were successfully launched. These included the Canadian-built International Satellite for Ionosphere Studies (ISIS) I; a spacecraft for the European Space Research Organization (ESRO) to study energetic particles in space; the first satellite in a cooperative program with the Federal Republic of Germany called Azur I to make measurements of the Earth's radiation belt, the aurorae and solar particle events. Additionally, numerous sounding rocket launchings were conducted in cooperation with scientists throughout the world, often from foreign launch sites.

Applications Satellites - Goddard is the primary NASA Center for weather, communications and Earth resources satellite efforts. During the year the third Nimbus research and development spacecraft was successfully launched carrying several advanced weather sensing devices which may eventually provide the technology to make possible long-range computerized weather predictions on a global basis; two other weather satellites in the TIROS Operational System were orbited for the U.S. Weather Bureau. In the communications area two synchronous orbit satellites were launched for the Communications Satellite Corporation, and the first British-built Skynet military communications satellite was successfully placed in synchronous orbit. A major milestone was achieved with the initiation of a program for development of the first two U.S. Earth Resources Technology Satellites.

Sounding Rockets - During 1969 more than 120 sounding rocket launchings were conducted by Goddard, bringing to more than 1,270 the number of launchings in the program since 1959.

Tracking and Data Acquisition - The Goddard-managed Space Tracking and Data Acquisition Network provided communications and tracking coverage for all of NASA's scientific and applications satellites launched during the year. The Manned Space Flight Network provided global tracking support for four Apollo manned flights, including the historic first landing of man on the Moon during Apollo 11.

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.

The total capital investment for the Goddard Space Flight Center, including fixed assets in progress and contractor held facilities at various locations as of June 30, 1969, was $563,331,000 (includes capital type facilities of the MSF and STADAN network and other supporting activities including equipment aboard ships and aircraft).

SUMMARY OF RESOURCES REQUIREMENTS:

	(Dollars in Thousands)		
	1969	1970	1971
Authorized permanent positions, end of year.....	4,141	4,412	4,412
Research and Program Management.....	$73,227	$84,772	$87,670

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1971 ESTIMATES

WALLOPS STATION

MISSION:

Wallops Station is primarily an operational base for launching rockets, satellites, space probes and other scientific experiments and for conducting aeronautical research. Its basic mission is to prepare, assemble, launch, and track space vehicles and to acquire scientific data. The facilities of Wallops Station are used by scientists and engineers from the laboratories and research centers of NASA, other government agencies, colleges and universities, and the world-wide scientific community. Wallops Station personnel assist these scientific research teams with their project; develop, as necessary, special types of instrumentation and equipment to complement the missions; and manage NASA sponsored research projects. Research at Wallops is directed toward gathering information about the Earth's atmosphere, its near-space environment, and in the field of aeronautics.

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, helicopter and aircraft noise abatement projects, slow speed landing techniques for jet aircraft, anti-skid tests on grooved runways, V/STOL terminal area research, collision avoidance program, and laser and radar tracking of aircraft and satellites. A portion of Wallops' effort is devoted to NASA's program of international cooperation in space research. Sixty 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. 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), the 1970 Solar Eclipse project, the German barium project, a Bio-Space Technology Training Program for bioscientists, operation of remote site launching and tracking facilities, and an Arctic launch site at Point Barrow, Alaska.

In the early years, research at Wallops was concentrated on obtaining aerodynamic data at transonic and low supersonic speeds as part of the 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. Wallops has launched more than 7,500 research vehicles consisting of from one to seven stages in the quest for scientific knowledge.

Wallops Station's achievements during the past calendar year include: the

launching of 309 sounding rockets, conducting the fifth annual Bio-Space Technology Training Program, launching the last in a series of four Gravity Preference experiments, the 5 1/2-ton Astrobee cosmic radio noise experiment, the Aerobee 350 artificial auroras experiment, the Pacemaker materials experiment, and the first two launchings of the Canadian Black Brant IIIB vehicle. Four 175-foot diameter research balloons were launched with a variety of experiments on board in a joint AFCRL/NASA project. Wallops air recovery team successfully completed another aerial recovery. One hundred forty-five foreign nationals representing 18 countries visited the installation to observe its operations or seek assistance in establishing a sounding rocket facility of their own.

DESCRIPTION:

Wallops Station includes three separate areas on the Atlantic Coast of Virginia's eastern shore: the main base (formerly Chincoteague Naval Air Station), the Wallops Island launching site and the Wallops mainland. 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 unusable marsh land. The Eastville tracking site consists of an additional 53 acres of government-owned property. The total capital investment at Wallops Station, including fixed assets in progress and contractor held facilities at various locations as of June 30, 1969, was $108,521,000.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Dollars in Thousands)		
	1969	1970	1971
Authorized permanent positions, end of year.....	484	488	488
Research and Program Management.....	$9,102	$9,545	$9,791

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1971 ESTIMATES

AMES RESEARCH CENTER

MISSION:

The programs at the Ames Research Center are directed at research and development in the fields of aeronautics 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, the 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.

This installation has flight project management responsibility for the Pioneer project. Pioneer provides scientific observations of phenomena in interplanetary space from an unmanned spacecraft.

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 small effort directed at studies involving lunar approach, lunar landing, and rendezvous. The research and technology 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 including an active participation in defining the science package for Viking; 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 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 Department of the Navy. The capital investment at the Ames Research Center, including fixed assets in progress, and contractor held facilities at various locations as of June 30, 1969, was $237,827,000.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Dollars in Thousands)		
	1969	1970	1971
Authorized permanent positions, end of year.....	1,992	1,972	1,972
Research and Program Management.....	$34,032	$36,359	$38,248

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RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1971 ESTIMATES

ELECTRONICS RESEARCH CENTER

MISSION:

The Electronics Research Center was established in September 1964 to provide the knowledge and advanced technology needed to improve performance and reliability of space and aeronautical electronic systems and components.

The decision to suspend operations at the Electronics Research Center was made during the space agency's fiscal year 1971 budget process and in planning the future course of the nation's space program over the next decade. This action is part of a larger picture which includes our current requirements, the new directions for the Seventies, and budget constraints within which we must work.

It is anticipated that personnel and other costs of approximately $4.5 million will be necessary in FY 1971 to complete the closing of the Center.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Dollars in Thousands)		
	1969	1970	1971
Authorized permanent positions, end of year.....	802	600	---
Research and Program Management.....	$17,237	$19,483	$4,470

FLIGHT RESEARCH CENTER

MISSION:

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

The current and projected programs at this Center include: aeronautical projects concerning general aviation 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 heavyweight lifting bodies are studied; and electronic systems projects such as display, guidance, and control in advanced flight missions and improvements on systems and sensors used in biomedical monitoring, tracking, and data acquisition.

Most important of the facilities and special equipment for conducting programs at the Flight Research Center are the aircraft. They range from general aviation aircraft for handling qualities investigations to supersonic aircraft, such as the YF-12A, used for various research investigations having application to both civil and military aviation. Special purpose vehicles such as lifting bodies, 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, communications building, and

an aircraft maintenance dock. The main station of the two station radar range operated by the Center is located on the third floor of the office-laboratory building. The total capital investment of the Flight Research Center, including fixed assets in progress, and contractor held facilities at various locations as of June 30, 1969, was $47,132,000.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Dollars in Thousands)		
	1969	1970	1971
Authorized permanent positions, end of year.....	539	535	535
Research and Program Management.....	$9,697	$10,131	$10,549

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1971 ESTIMATES

LANGLEY RESEARCH CENTER

MISSION:

The Langley Research Center conducts a comprehensive range of research and technology programs to identify and evaluate new opportunities for advanced aeronautical and space flight activities; to expose and solve the basic technical problems confronting flight progress; to evolve, improve, and validate the technological basis for the design, construction, and operation of advanced aircraft and space vehicles; to support the conduct of nationally important flight projects; and to promote the broad diffusion and application of aerospace research knowledge.

A significant portion of this research and technology program is directed to developing, evaluating, and refining specific aircraft designs; and to exploring and understanding improved concepts and technology on which future aircraft with more advanced performance, increased operational capabilities, and enhanced safety and economy may be based. In this effort, special emphasis is placed on the evolution of aircraft configurations which maximize flight efficiency, as in the supercritical wing development for high-subsonic-speed transports, variable-sweep-wing and optimized-integrated-design approaches for supersonic military and civil aircraft, and the study of improved concepts for ramjet-propelled hypersonic vehicles and V/STOL aircraft designs. Associated research is aimed at the prediction of critical operating loads and aeroelastic characteristics of advanced designs, and the evolution of new materials and structural concepts with improved efficiency under critical environments. Related programs are providing insight into the stability and control problems of new generations of vehicles, and particularly those associated with all-weather and terminal-area operations, cooperative or competitive maneuvering, and other complex flight tasks. Studies are also underway on the technology for detecting clear-air turbulence and aircraft trailing vortices; on simplified lower-cost approaches to collision-hazard-warning systems, and on integrated and automated controls for light aircraft. Considerable work is underway investigating the basic causes of aircraft propulsion noise and sonic boom, the characterization of their annoyance effects, and the study of practicable methods for noise reduction. Advances are being accomplished in the study of tire, braking system, and runway surface design requirements for improved aircraft traction and control on water and slush covered runways, and are finding important applications in the automotive safety field. The technical support of the Departments of the Air Force, Navy, and Army, the Federal Aviation Administration, and the aerospace industry is a continuing portion of the Langley program.

Another significant portion of Langley's skills and resources is devoted to advancing the Nation's space flight capabilities, and to the management and support of important space flight projects. Especially noteworthy are research efforts relative to: atmosphere-entry aerothermodynamics and heat shielding for return from earth-orbital, lunar, and planetary missions; the structural-dynamic characteristics of large launch vehicles and complex modular spacecraft; advanced configurations for lifting-entry and controlled-landing spacecraft, refurbishable space vehicles, long-duration orbital and planetary systems, and expandable space structures; the effects of heat, vacuum, loads, noise, micrometeoroids, and radiation on the performance of vehicle systems and materials; the technology of improved electronic, propulsion, information, structures, and life support systems; and man's functional capabilities and systems accommodations for performance of complex manned space missions involving space assembly and maintenance, rendezvous and docking, extravehicular operations, and extraterrestrial landings.

Responsibility has been assigned to Langley for the Viking project which plans to orbit and soft land unmanned instrumented vehicles on Mars in 1975 for study of Martian geophysics, atmospheric characteristics, local surface properties, and life-form indicators. Langley is also prominently engaged in the definition and provision of advanced technology required for the selection and development of manned systems and operations for future national space shuttle, space station, space base, and planetary mission projects. This includes investigations of mission flight mechanics and operations; configuration performance and aerothermal characteristics; structural efficiency, aeroelasticity, dynamics, and thermal protection; the technology of practicable navigation, guidance, control, power, propulsion, information, tracking, communications, and long-duration life-support systems; criteria for human factors and crew activities; and the definition, development, and integration of worthy mission experiments. Langley is also responsible for the development and operation of the Scout launch vehicle in its various national and international satellite and entry-vehicle applications; for the provision of ranges of technology and experiments for the continuing phases of the Apollo lunar and applications programs; and for broad technological support of a number of other space flight projects.

DESCRIPTION:

The Langley Research Center, Hampton, Virginia, is located approximately 100 air miles south of Washington, D.C. The Center occupies 773 acres of Government-owned land, divided into two areas by the runway facilities of Langley Air Force Base. The West Area consists of 750 acres, 430 owned by NASA and 320 under permit from the Air Force. The East Area comprises 23 acres under Air Force permit. Runways, some utilities, and certain other facilities are used jointly by NASA and the Air Force. In addition,

there are 110 acres of NASA-owned land located in the City of Newport News, Virginia, 3,277 acres under permit from the Air Force, and 9 acres under lease. The total acreage presently owned, under permit or leased, is 4,169. The total capital investment at the Langley Research Center, including fixed assets in progress, and contractor held facilities at various locations as of June 30, 1969, was $389,907,000.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Dollars in Thousands)		
	1969	1970	1971
Authorized permanent positions, end of year.....	3,912	3,872	3,872
Research and Program Management.....	$62,945	$67,973	$70,734

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1971 ESTIMATES

LEWIS RESEARCH CENTER

MISSION:

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

The emphasis is predominantly on research and technology; however, the entire spectrum of activities is undertaken from basic research to development. The scope of technology ranges from work on individual components through complete systems.

Most of the critical areas which limit the performance of engines and power systems are the subjects of in-house effort at this Center. Research by commercial and university laboratories is also conducted under contracts directed by Lewis Research Center personnel.

Several large development programs are assigned to this Center. The Atlas and Centaur programs are supervised, as well as part of the Titan program. The SNAP-8 nuclear powered electric generating system, SERT (Space Electric Rocket Test) and Quiet Engine contracts are directed and there is also considerable supporting in-house research effort on these projects.

The research and technology activities cover many technical fields. Some examples of major activity are discussed i the following paragraphs.

It is expected that engines for future supersonic planes will be of a turbofan design incorporating high by-pass 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. A flight test program is being conducted with an F-106 airplane to determine the interaction of engine inlets and exhaust nozzles with wings and fuselage at transonic speeds, because such data obtained from transonic wind tunnels of current size is unreliable.

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 nearing completion 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 has been installed and operated in the Spacecraft Propulsion Research Facility. This vehicle will be equipped with a prototype tank pressurizing system replacing the current pump system for feeding the propellants to the engine during the coming year.

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 are approximated.

Many devices for power generation in space are being studied. The solar cell converts sunlight directly into electricity. Batteries and fuel cells convert stored chemicals into electricity. For a large and sustained power supply, however, an adaptation of the familiar turbine driven generator seems most practical. To achieve the tremendous weight reduction necessary means many years of intensive research and technology. 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 has been placed in operation at Plum Brook where nuclear powered electric generating systems can be operated under simulated space environment conditions for long periods of time. The first system to be installed was a compressor-turbine unit for a Brayton cycle electric power generating system.

Another type of electric generator and another source of energy are more distant prospects. A stream of ionized plasma flowing through a coil will generate electricity in that coil (magnetohydrodynamics). The success of this effort and of related activities depends largely on the development of superconducting electric magnets. The Lewis Research Center has been a leader in this field and has constructed a magnet with a field of 150,000 gauss over a twelve-inch bore.

The performance of propulsion and power generation systems, launch vehicles, spacecraft, and practically all hardware is paced by physical limitations of available materials. We have 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 liquified 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.

The NASA Aerospace Safety Institute is located at the Center. Its staff of specialists survey the research needs and direct research efforts in this field. A data bank of research information is being compiled and cataloged for ready access.

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. Here there are over 90 buildings, including two large supersonic wind tunnels, two Zero Gravity research facilities (free drop shafts, one of which is an underground evacuated shaft 477 feet deep in which Zero Gravity durations of about 10 seconds are obtained), a large Propulsion Systems Laboratory in which full-scale engines are operated under simulated high altitude conditions, three rocket laboratories, five materials research buildings, eighteen major space simulation facilities ranging from four to thirty feet in diameter, a 50-foot diameter Space Power Chamber 120 feet long in which altitudes up to 100,000 feet are simulated, an Energy Conversion Laboratory, an Instrument Research Laboratory, a High Energy Fuels Laboratory, a Chemistry Laboratory, an Engine Research Building containing 64 test cells and covering nearly four acres, four office buildings, machine shops and other service buildings.

A newer site, established in 1956, is located south of Sandusky, Ohio, about 50 miles west of Cleveland on land occupied by the Plum Brook Ordnance Works. Known as the Plum Brook Station, it occupies 6,031 acres of which 5,981 are owned by the Government and 50 are in easements. Funds for the

purchase of additional land to serve as a buffer zone around the present site have been appropriated. Purchase negotiations are near completion for approximately 2,000 acres of this buffer zone. Negotiations for an additional 110 acres are underway.

There are over 200 buildings on the Plum Brook site, 55 built by the NASA and the rest by the former tenants. The major facilities include a Reactor Facility, an Altitude Rocket Test Facility, a Cryogenic Propellant Research Facility, Heat Transfer Facility, a Spacecraft Dynamics Research Facility, a Rocket Pump Laboratory, a Rocket Turbine Laboratory, a Rocket Turbo-pump Laboratory, a Rocket Systems Hydraulic Laboratory, a Fluorine Pump Laboratory and a temporary site for testing rockets at sea level conditions. The latest major research facilities to be completed are the Spacecraft Propulsion Research Facility and the Space Power Facility. The former is used to test the ignition and operation of full-scale rocket engines after a prolonged shut-down period in a space environment. The latter is for testing full-scale nuclear powered electric generating systems. Nearing completion is a Hypersonic Tunnel Facility in which burning ramjet engines can be operated at speeds up to Mach 7. The research programs at Plum Brook are under the technical direction of personnel located at Cleveland. They are conducted at the larger site because of the need for large separation distances to minimize hazards.

The total capital investment of the Lewis Research Center, including fixed assets in progress, and contractor held facilities at various locations as of June 30, 1969, was $379,435,000, of which $111,082,000 represents facilities located at the Plum Brook Station.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Dollars in Thousands)		
	1969	1970	1971
Authorized permanent positions, end of year.....	4,268	4,215	4,215
Research and Program Management.....	$67,844	$72,398	$75,218

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1971 ESTIMATES

SPACE NUCLEAR PROPULSION OFFICE

MISSION:

The joint AEC-NASA Space Nuclear Propulsion Office is responsible for the formulation and execution of a research and development program for nuclear rockets. The general objective of the Nuclear Rocket Program is to provide a significant increase in propulsion capability for future space activities. A principal specific objective is to develop a 75,000 pound thrust engine, NERVA, for incorporation in a reusable nuclear stage.

In addition to NERVA development, effort is directed to the advancement of the technology of nuclear rocketry with emphasis being placed on the areas of: (1) continued improvement to nuclear rocket performance, (2) to provide the base of information for the development of a nuclear stage, and (3) to investigate the feasibility of advanced propulsion concepts.

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 at various locations, as of June 30, 1969, was $50,256,000.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Dollars in Thousands)		
	1969	1970	1971
Authorized permanent positions, end of year.....	104	100	100
Research and Program Management....	$2,135	$2,234	$2,302

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1971 ESTIMATES

NASA HEADQUARTERS

MISSION:

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

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

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

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

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

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

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

Apollo - Based on the national capability for manned space exploration, as demonstrated by the manned lunar landing missions of Apollo 11 and Apollo 12, to conduct scientific exploration of the moon through lunar orbital and lunar surface operations.

Space Flight Operations - To expand the participation and capabilities of men in scientific technological and applied observations in space through flights of increasing duration and complexity, initially using Apollo hardware or derivatives of Apollo hardware and progressing to an orbital space station resupplied by a fully reusable logistics system.

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

Office of Space Science and Applications - Responsible for the NASA automated space flight program directed toward scientific investigations of the solar system utilizing ground based, airborne, and space techniques including sounding rockets, earth satellites, and deep space probes; for scientific experiments to be conducted by man in space and for assisting in the 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.

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

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

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

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)		
	1969	1970	1971
Authorized Permanent Positions, end of year.....	2,093	2,123	2,073
Research and Program Management....	$60,777	$61,818	$62,735

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1971 ESTIMATES

SUMMARY OF APPROPRIATION BUDGET PLANS BY INSTALLATION

(In millions of dollars)

Installation	Research and Development			Construction of Facilities			Research and Program Management			Total		
	1969	1970	1971	1969	1970	1971	1969	1970	1971	1969	1970	1971
John F. Kennedy Space Center, NASA....	386.2	269.6	226.8	8.0	12.5	.6	95.8	97.5	98.2	490.0	379.6	325.6
Manned Spacecraft Center.....	1,091.1	1,036.9	623.5	1.3	1.7	.9	98.9	104.5	107.8	1,191.3	1,143.1	732.2
Marshall Space Flight Center.....	693.9	694.3	576.2	---	---	.5	116.3	121.7	124.7	810.2	816.0	701.4
Michoud Assembly Facility.....	---	---	---	.4	---	---	---	---	---	.4	---	---
Goddard Space Flight Center.....	419.1	430.6	476.4	---	.7	2.0	73.2	84.8	87.7	492.3	516.1	566.1
Wallops Station.....	7.9	8.5	7.4	.5	.5	---	9.1	9.5	9.8	17.5	18.5	17.2
Jet Propulsion Laboratory.....	132.2	163.5	156.8	---	---	2.0	---	---	---	132.2	163.5	158.8
Ames Research Center.....	60.2	63.5	73.9	.4	---	1.5	34.0	36.4	38.2	94.6	99.9	113.6
Electronics Research Center.....	24.1	22.6	---	---	---	---	17.2	19.5	4.5	41.3	42.1	4.5
Flight Research Center.....	17.1	12.4	15.0	---	---	---	9.7	10.1	10.5	26.8	22.5	25.5
Langley Research Center.....	84.2	95.9	104.4	---	4.8	---	63.0	68.0	70.7	147.2	168.7	175.1
Lewis Research Center.....	112.0	112.5	131.8	---	---	---	67.9	72.4	75.2	179.9	184.9	207.0
Space Nuclear Propulsion Office.....	31.5	33.9	35.6	---	---	3.5*	2.1	2.2	2.3	33.6	36.1	41.4
NASA Headquarters:	(141.9)	(169.6)	(178.3)	(---)	(---)	(---)	(60.8)	(61.8)	(62.7)	(202.7)	(231.4)	(241.0)
Headquarters.....	138.7	167.0	176.8	---	---	---	59.1	60.0	60.8	197.8	227.0	237.6
NASA Pasadena Office.....	3.2	2.6	1.5	---	---	---	1.7	1.8	1.9	4.9	4.4	3.4
Various Locations.....	---	---	---	20.5	29.5	18.6	---	---	---	20.5	29.5	18.6
Facility Planning and Design.....	---	---	---	1.0	3.5	5.0	---	---	---	1.0	3.5	5.0
Total Budget Plan.....	3,201.4	3,113.8	2,606.1	32.1	53.2	34.6	648.0	688.4	692.3	3,881.5	3,855.4	3,333.0

* Nuclear Rocket Development Station.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1971 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															
1969	2,177,500	382,800	1,070,028	680,333	50	100	---	145	---	---	250	---	---	43,794	---
1970	2,031,745	267,918	1,013,748	678,707	200	814	---	3,457	410	---	2,048	---	---	64,443	---
1971	1,474,200	223,700	603,200	559,700	---	---	---	1,870	---	---	330	---	---	85,400	---
Office of Space Science and Applications															
1969	453,238	3,450	10,861	2,176	201,989	61,246	1,447	34,404	3,478	---	25,448	51,580	---	57,159	---
1970	519,718	1,717	14,416	1,851	215,203	91,103	1,408	31,493	3,147	---	40,995	52,058	---	66,327	---
1971	565,700	3,068	14,030	2,350	255,825	73,235	1,085	37,760	---	---	45,370	67,273	---	65,704	---
Office of University Affairs															
1969	9,000	---	---	---	---	---	---	---	---	---	---	---	---	9,000	---
1970	7,000	---	---	---	---	---	---	---	---	---	---	---	---	7,000	---
1971	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Office of Advanced Research and Technology															
1969	278,220	---	4,961	11,104	8,790	23,163	1,073	25,675	20,493	15,079	57,048	60,446	31,497	15,699	3,192
1970	272,302	---	8,690	12,098	8,830	20,428	1,115	28,514	18,974	10,530	51,989	60,401	33,925	14,200	2,608
1971	264,200	---	6,300	13,783	8,440	17,410	100	34,222	---	13,365	57,538	64,510	35,600	11,397	1,535
Office of Tracking and Data Acquisition															
1969	279,672	---	5,300	300	208,221	47,694	5,409	---	100	2,000	1,450	---	---	9,198	---
1970	278,000	---	---	1,660	206,405	51,150	5,985	---	60	1,875	845	---	---	10,020	---
1971	298,000	---	---	400	212,127	66,143	6,240	---	---	1,630	1,160	---	---	10,300	---
Office of Technology Utilization															
1969	3,800	---	---	---	---	---	---	---	---	---	---	---	---	3,800	---
1970	5,000	---	---	---	---	---	---	---	---	---	---	---	---	5,000	---
1971	4,000	---	---	---	---	---	---	---	---	---	---	---	---	4,000	---
Total Budget Plan															
1969	3,201,430	386,250	1,091,150	693,913	419,050	132,203	7,929	60,224	24,071	17,079	84,196	112,026	31,497	138,650	3,192
1970	3,113,765	269,635	1,036,854	694,316	430,638	163,495	8,508	63,464	22,591	12,405	95,877	112,459	33,925	166,990	2,608
1971	2,606,100	226,768	623,530	576,233	476,392	156,788	7,425	73,852	---	14,995	104,398	131,783	35,600	176,801	1,535

CAPITALIZED VALUE OF NASA'S FACILITIES
AS OF JUNE 30, 1969
(IN-HOUSE AND CONTRACTOR-HELD FACILITIES)
(DOLLARS IN THOUSANDS)

Reporting Installation	Land	Buildings	Other Structures and Facilities	Leasehold improvements	Equipment	Fixed Assets in Progress	Total
OFFICE OF MANNED SPACE FLIGHT							
Kennedy Space Center	$ 71,018	$ 281,739	$ 423,552	$ -	$ 81,348	$101,215	$ 958,872
Western Test Range Operation Div.	-	-	-	-	3,464	-	3,464
Various Locations (Contractor-Held)	-	-	-	-	84,957	-	84,957
Manned Spacecraft Center	5,459	131,558	28,712	-	177,748	15,852	359,329
White Sands Test Facility	-	8,976	17,754	-	4,035	1,205	31,970
Various Locations (Contractor-Held)	3,570	24,415	5,142	8	48,303	-	81,438
Marshall Space Flight Center	95	109,762	45,238	93	194,893	3,861	353,942
Michoud Assembly Facility	7,504	63,220	25,039	-	40,998	-	136,761
Mississippi Test Facility	19,729	64,716	166,900	-	23,677	1,181	276,203
Sidell Computer Facility	63	4,446	823	-	5,097	-	10,429
Various Locations (Contractor-Held)	3,491	27,046	38,739	23	83,038	14,010	166,347
Total	$110,929	$ 715,878	$ 751,899	$124	$ 747,558	$137,324	$2,463,712
OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY							
Ames Research Center	$ 2,372	$ 167,099	$ 2,987	$ -	$ 58,434	$ 4,510	$ 235,402
Various Locations (Contractor-Held)	-	47	-	1	2,377	-	2,425
Electronics Research Center	1,384	-	4	-	20,341	14,713	36,442
Various Locations (Contractor-Held)	-	-	-	-	272	-	272
Flight Research Center	-	7,658	2,135	-	36,650	595	47,038
Various Locations (Contractor-Held)	-	-	-	-	94	-	94
Langley Research Center	110	106,180	134,424	-	111,395	19,370	371,479
Various Locations (Contractor-Held)	6	15,217	25	-	3,180	-	18,428
Lewis Research Center	310	110,301	39,240	140	57,349	9,979	217,319
Plum Brook Station	1,287	74,746	17,728	-	10,252	7,069	111.082
Various Locations (Contractor-Held)	99	4,240	4,007	5	32,369	10,314	51,034
Space Nuclear Propulsion Office	-	18,957	6,917	-	3,987	17	29,878
Various Locations (Contractor-Held)	-	-	-	-	20,146	232	20,378
Total	$ 5,568	$ 504,445	$ 207,467	$146	$ 356,846	$ 66,799	$1,141,271
OFFICE OF SPACE SCIENCE AND APPLICATIONS							
Goddard Space Flight Center	$ 1,205	$ 68,626	$ 11,681	$297	$ 182,616	$ -	$ 264,425
*Tracking Stations	339	17,305	41,839	-	201,326	-	260,809
Various Locations (Contractor-Held)	-	88	45	4	37,960	-	38,097
Jet Propulsion Laboratory	1,067	44,012	6,563	414	79,515	-	131,571
Tracking Stations (Deep Space Net.)	-	9,160	21,403	-	31,291	-	61,854
Wallops Station	986	21,423	41,629	-	34,954	2,809	101,801
Various Locations (Contractor-Held)	-	2,544	270	-	3,906	-	6,720
NASA Pasadena Office	-	-	-	-	11	-	11
Total	$ 3,597	$ 163,158	$ 123,430	$715	$ 571,579	$ 2,809	$ 865,288
OTHER							
Headquarters	$ -	$ -	$ -	$ -	$ 6,627	$ -	$ 6,627
Various Locations (Contractor-Held)	-	-	-	-	8,240	-	8,240
Total	$ -	$ -	$ -	$ -	$ 14,867	$ -	$ 14,867
Grand Total	$120,094	$1,383,481	$1,082,796	$985	$1,690,850	$206,932	$4,485,138

* 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 1971 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 which are funded from the Research and Program Management appropriation and are included in the NASA Headquarters budget presentation.

The Research and Program Management type costs are presented for 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 planetary exploration.

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

3. A continuing program of supporting research and technology.

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. 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, 1969, was $193,425,000.

SUMMARY OF RESOURCES REQUIREMENTS:

	(Dollars in Thousands)		
	1969	1970	1971
Authorized permanent positions, end of year	3,990	4,200	4,100
Research and Program Management type costs	$74,468	$84,649	$88,855

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1971 ESTIMATES

CONSOLIDATED SUMMARY

FOR AVIATION TECHNOLOGY

	(Dollars in millions)		
	1969	1970	1971
OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY			
Research and development:			
Aeronautical vehicles	$74.7	$75.9	$87.1
Electronics systems	11.1	10.5	5.8
Human factor systems	3.0	3.6	2.1
Basic research	5.9	6.2	6.6
Space power and electric propulsion systems	---	.2	.4
Subtotal	94.7	96.4	102.0
Research and program management:			
Support of aeronautical vehicles program	73.4	85.1	83.5
Construction of facilities	---	4.8	---
Total	$168.1	$186.3	$185.5
Number of direct positions associated with Aviation Technology budget activity	3,140	3,286	3,197

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1971 ESTIMATES

SUPPORTING RESEARCH AND TECHNOLOGY
(In thousands of dollars)

	1969	1970	1971
OFFICE OF SPACE SCIENCE AND APPLICATIONS	$73,968	$75,550	$73,200
Physics and astronomy	22,497	17,500	17,500
Lunar and planetary exploration	18,571	17,980	17,400
Bioscience	8,900	11,170	9,400
Space applications	19,600	24,900	25,900
Launch vehicle procurement	4,400	4,000	3,000
OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY	$215,662	$223,937	$206,715
Basic research	20,220	18,902	17,600
Space vehicle systems	30,149	29,470	28,800
Electronics systems	34,060	33,200	22,400
Human factor systems	17,329	19,605	16,300
*Space power and electric propulsion systems	37,287	33,950	30,625
Nuclear rockets	6,002	8,000	5,000
Chemical propulsion	25,752	20,480	20,300
Aeronautical vehicles	44,863	60,330	65,690
OFFICE OF TRACKING AND DATA ACQUISITION	$11,156	$12,400	$12,900
GRAND TOTAL	$300,786	$311,887	$292,815

*Includes SNAP-8 technology.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1971 ESTIMATES

Automatic Data Processing Equipment

Table of Contents

	Page No.
General Statement	SA 11
Figures	
1. Total Category A Computer Capacity and Requirements	SA 14
2. Category A Computer Requirements by Type of Use	SA 15
3. Total Category B Growth	SA 16
4. Category B Growth by Application Areas	SA 17
5. Percentage Distribution of Computers and Capital Values by Size	SA 18
6. Capital Value of ADP Equipment	SA 19
7. ADP Personnel Average Employment	SA 20
8. ADP Contractor Identification	SA 21
9. End of Fiscal Year ADPE Inventory	SA 25
10. Summary of ADPE Funding	SA 26
Summary of Requirements by NASA Installation	SA 27

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Automatic Data Processing Equipment

General Statement

NASA requirements for ADP resources are still increasing, but these increases have slowed considerably from the early build-up stages within NASA. We can foresee no great change in this growth rate. We believe there are several major factors that dictate this continuing increase in requirements. First, NASA has built up a very large data base of information concerning space and aeronautical research in the process of achieving the successes we have had. This basic data must be retrieved, manipulated, processed, and combined in order to be used for our future research and development. Only computers can economically manipulate these vast amounts of data. Second, our scientists and engineers are beginning to prove out their analytical techniques and are continually extending their boundaries for predicting and designing our future spacecraft missions. As a result, they are using these techniques much more than in previous planning stages and in the process are using very large blocks of computer time. Next, we have pioneered in the use of computers to automate our laboratories and test facilities in order to make better use of these facilities and have been successful in accomplishing this task. The advent of very low cost, small, fairly powerful computers has accelerated this trend by making it more economical to use the small computer than a separately designed controller, so that such devices are increasingly showing up in our system acquisitions. This process generated digital data in large quantities that must be carefully assessed, analyzed, and evaluated. Because of this our tests are more valid, our facilities are more heavily used, and our designs much more accurate. Finally, we have improved our techniques for using a digital computer and as a result there are more people who are now able and willing to utilize this device.

The uses of computers by NASA are divided into two categories. The Category A, general purpose use, includes all equipments that can service multiple users. Continuous improvements in management and programming techniques, coupled with the higher speed of third generation computers, have allowed us to reduce the number of computers in this category while taking care of the increasing requirements for data processing services. Figure 1 shows the small but steady increase in NASA's Category A computing requirements through FY 1971. 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) Mission control, which includes not only the active mission control computations but also the mission analysis and simulation necessary for effective control.

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

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

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 computers, by size, and their respective capital values as of June 30, 1969. As shown, large computers account for eight percent of the inventory and 49 percent of the capital value which leaves the large preponderance of computers in the smaller monetary range. Inventory accounting of these smaller computers has been of increasing concern to us since they are treated as one item and cannot be easily compared to one very large, sophisticated computer.

Although these small computers are relatively inexpensive and serve a very useful purpose in the space program, a general misconception can result if only the gross number of computers is looked at. To prevent this misconception, we have added mini-computers (value up to $50,000) to Figure 5 to show that 11 percent of the inventory falls in this category but represents less than one percent of the total NASA ADPE value. It is apparent that the number of mini-computers will continue to increase since they are relatively inexpensive and can be easily programmed to accomplish a particular task in an economical fashion. In addition,

many aerospace contractors bidding on various systems and projects incorporate these small computers with their equipment bids to serve as a controlling or monitoring device in lieu of building a more expensive separate device.

Figure 6 reflects the capital value of the ADP equipment which was installed as of June 30, 1969. 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 table at the bottom of Figure 9 reflects the breakdown of equipment between general purpose and special purpose.

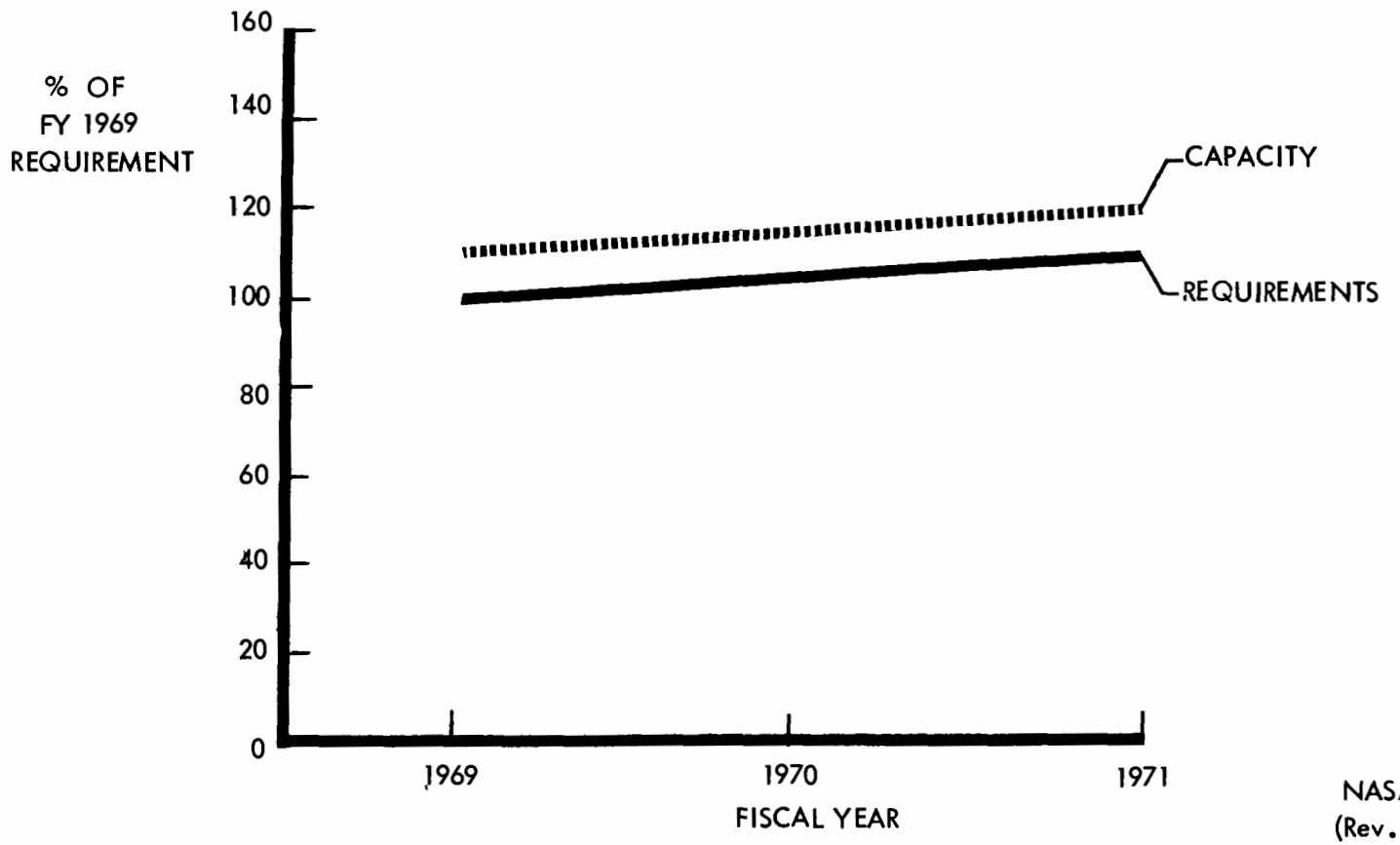
The financing of ADP equipment by installation is shown in Figure 10. The overall decrease from 1970 to 1971 is due to the anticipated purchase in FY 1970 of the IBM 360/75's already on hand at MSC. Studies have shown these equipments will readily serve the immediate known future requirements of the Real-Time Computation Center and present an economical benefit to the government if purchased. NASA is continually exploring the most economical use of our computers. 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.

375-328 C - 70 - 12

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

TOTAL CATEGORY A COMPUTER CAPACITY AND REQUIREMENTS BY FISCAL YEAR

(FY 1969 REQUIREMENTS EQUAL 91 PERCENT OF CAPACITY)



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(Rev. 1) 1-21-70

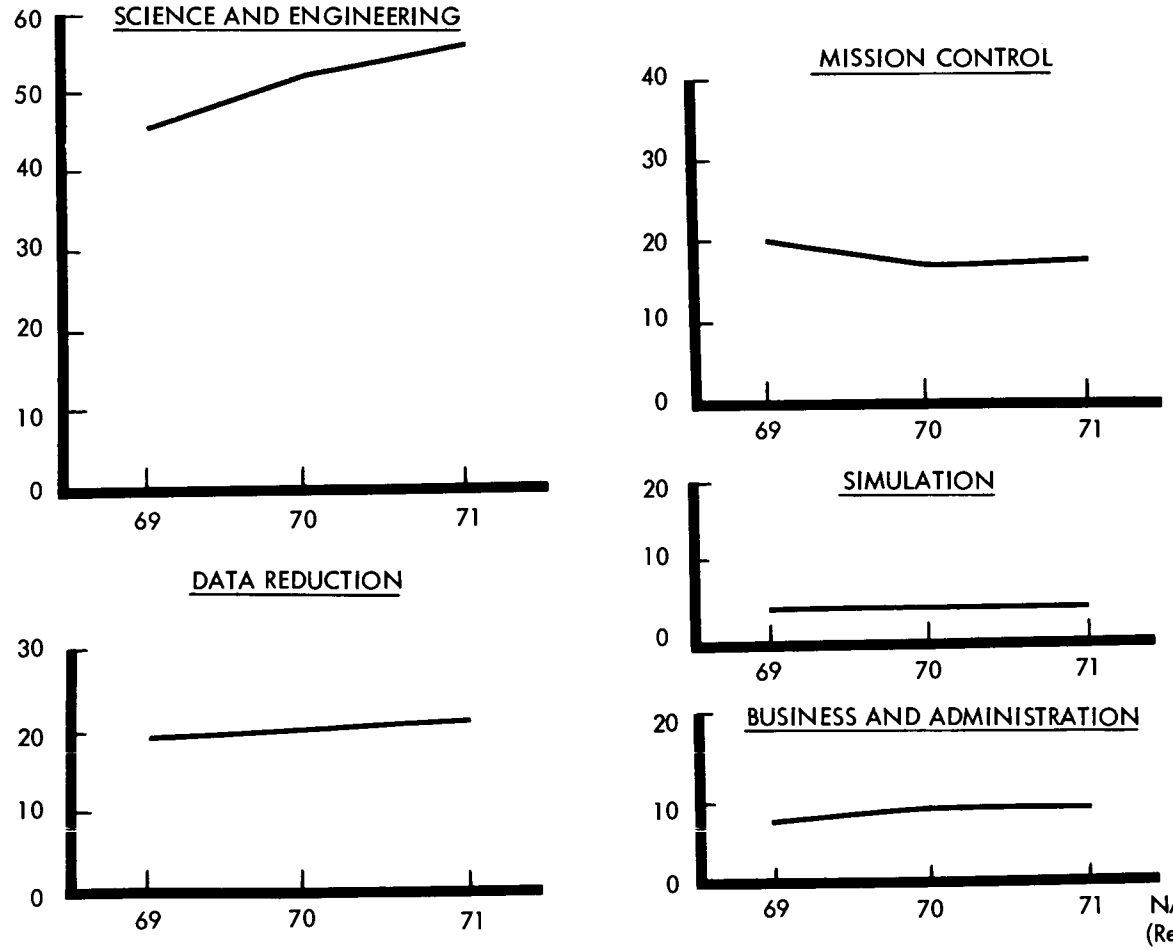
Figure 1

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CATEGORY A COMPUTER REQUIREMENTS BY TYPE OF USE

FY 1969 TOTAL REQUIREMENTS EQUAL 100 %

(ALL SCALES IN PERCENT)



NASA BT69-132
(Rev. 1) 1-21-70

Figure 2

SA 15

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)

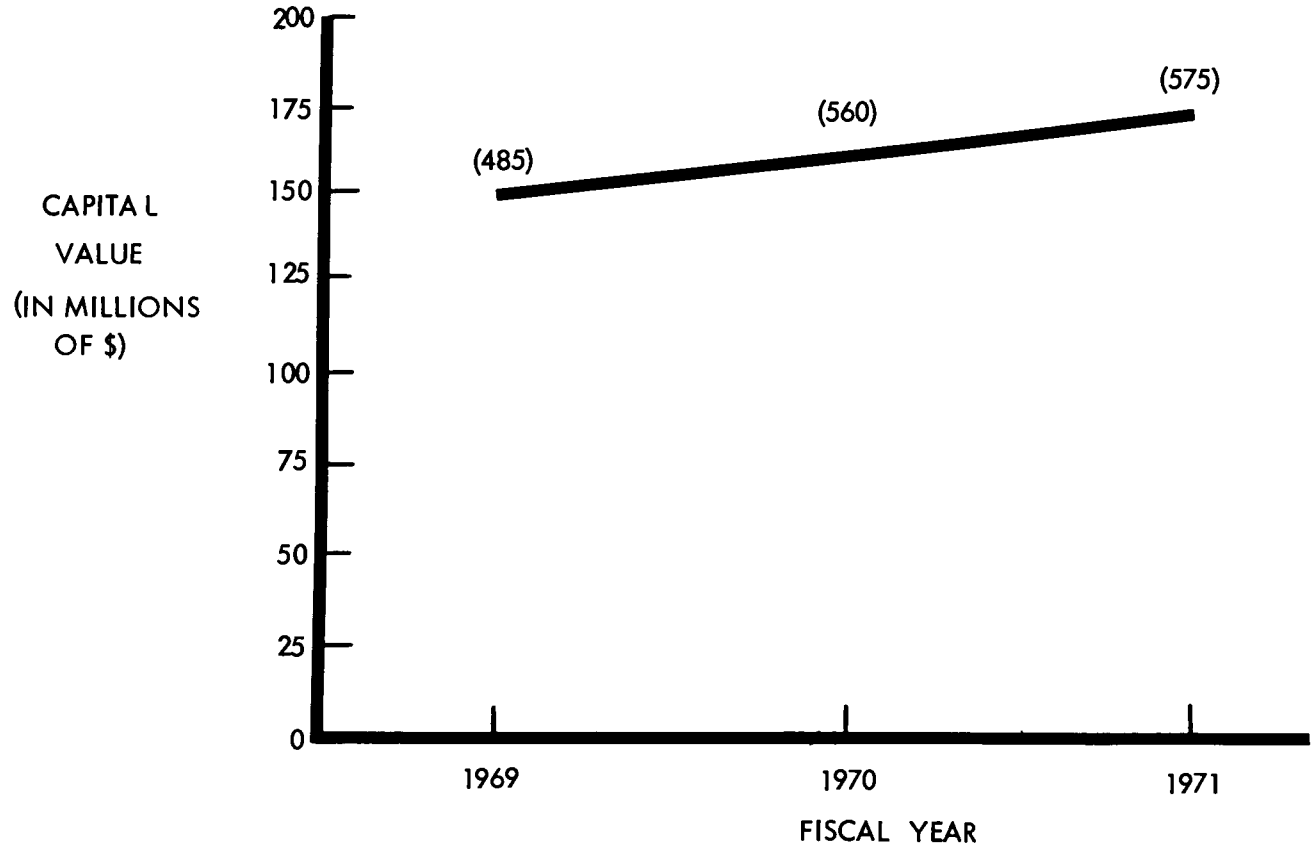


Figure 3

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(Rev. 1) 1-21-70

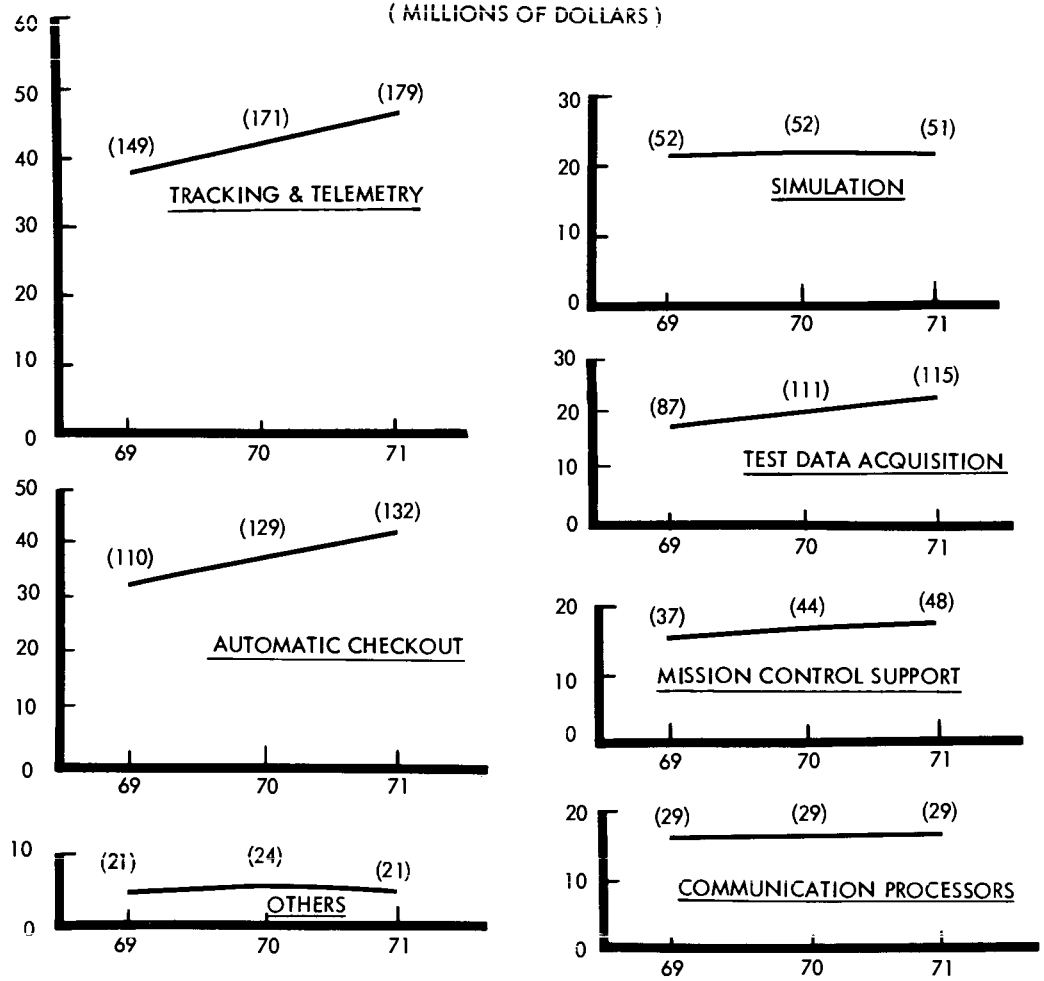
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CATEGORY B GROWTH BY APPLICATION AREAS

CAPITAL VALUE OF INSTALLED COMPUTERS

(FIGURES IN PARENTHESES REPRESENT END OF FISCAL YEAR INVENTORY)

(MILLIONS OF DOLLARS)



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(Rev. 1) 1-21-70

Figure 4

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PERCENTAGE DISTRIBUTION OF COMPUTERS AND CAPITAL VALUES BY SIZE

AS OF JUNE 30, 1969

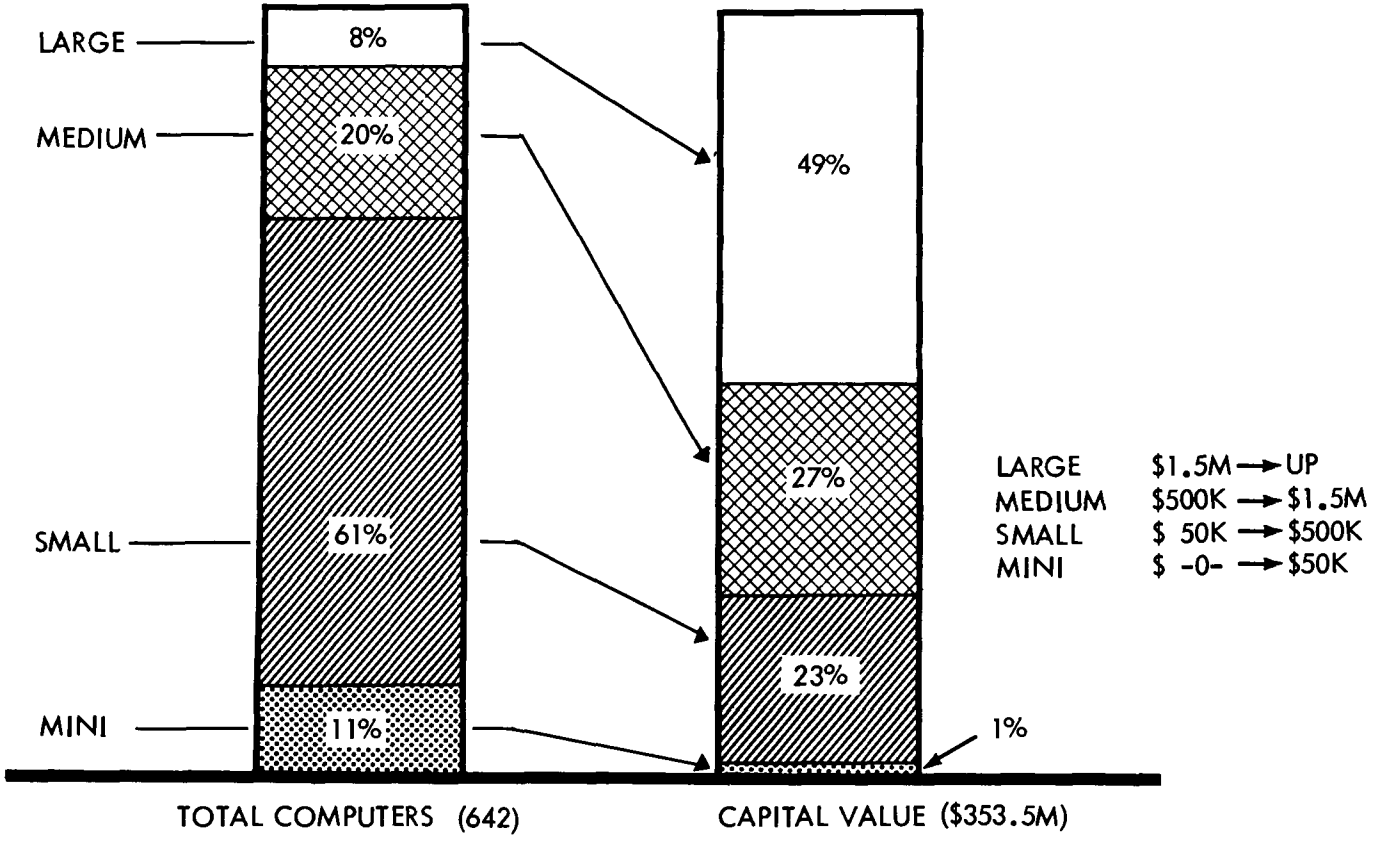

Figure 5

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(Rev. 1) 1-21-70

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Capital Value of Owned and Leased ADP Equipment
on Hand June 30, 1969

(In thousands of dollars)

	NASA-Owned Equipment	Leased Equipment	Total Capital Value
Office of Manned Space Flight....	$89,896	$60,288	$150,184
Kennedy Space Center.....	13,842	1,960	15,802
Manned Spacecraft Center.....	59,670	32,616	92,286
Marshall Space Flight Center...	16,384	25,712	42,096
Office of Space Science and Applications.....	$129,255	$24,164	$153,419
Goddard Space Flight Center....	96,958	14,387	111,345
Jet Propulsion Laboratory.....	29,899	9,698	39,597
Wallops Station.....	2,398	79	2,477
Office of Advanced Research and Technology.....	$39,480	$6,560	$46,040
Ames Research Center.....	5,659	2,737	8,396
Electronics Research Center....	3,159	1,443	4,602
Flight Research Center.....	2,309	333	2,642
Langley Research Center.....	16,765	1,016	17,781
Lewis Research Center.....	11,588	131	11,719
Space Nuclear Propulsion Office	---	900	900
Headquarters.....	$2,100	$1,796	$3,896
TOTAL.....	$260,731	$92,808	$353,539

Figure 6

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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

	FY 1969		FY 1970		FY 1971	
	Civil Service	Contractor	Civil Service	Contractor	Civil Service	Contractor
Office of Manned Space Flight.....	387	2,748	386	2,379	386	2,258
Kennedy Space Center.....	67	439	68	399	68	370
Manned Spacecraft Center.....	159	1,636	164	1,381	164	1,287
Marshall Space Flight Center....	161	673	154	599	154	601
Office of Space Science and Applications.....	735	1,211	753	1,265	784	1,314
Goddard Space Flight Center.....	493	932	507	978	507	999
Jet Propulsion Laboratory.....	216 a/	245	220 a/	247	251 a/	276
Wallops Station.....	26	34	26	40	26	39
Office of Advanced Research and Technology.....	369	317	376	382	360	366
Ames Research Center.....	59	86	58	95	58	110
Electronics Research Center.....	22	90	25	117	---	---
Flight Research Center.....	18	25	18	20	18	20
Langley Research Center.....	135	105	140	129	146	217
Lewis Research Center.....	135	4	135	16	138	17
Space Nuclear Propulsion Office.	---	7	---	5	---	2
Headquarters.....	15	119	17	135	18	121
Total.....	1,506	4,395	1,532	4,161	1,548	4,059

a/ Employees of JPL.

Figure 7

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 Company	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 Services Performed
Goddard Space Flight Center	Computer Applications, Inc.	Programming, Analysis, and Operations
	Computing and Software, Inc.	Programming, Analysis, and Operations
	Computer Sciences Corp.	Programming and Analysis
	General Electric	Programming
	IBM	Programming, Analysis, Operations, and Maintenance
	UNIVAC	Programming, Analysis, and Maintenance
	D. Brown Associates, Inc.	Programming and Analysis
	Wolf Research and Development Corp.	Programming and Analysis
	System Development Corp.	Data Scheduling System 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.	Programming and Analysis
	RCA	Operations and Maintenance
	UNIVAC	Software Maintenance and Operations Support

Installation	Name of Firm	ADP Service Performed
Jet Propulsion Laboratory	Programatics	Programming
	Mauchly-Wood Software Company	Programming
Wallops Station	Philco-Ford	Programming and Data Analysis
	Technitrol Engineering Corp.	Operations and Key-punching
	Wolf Research and Development Corp.	Programming and Data Analysis
Ames Research Center	Computer Sciences Corp.	Scientific Programming Analysis, Administrative Applications, Key-punching
	IBM, Federal Systems Div.	Scientific Programming
	Electronic Associates	Programming
	Informatics	Scientific Programming
	Computer Applications, Inc.	Operations
	System Development Corp.	Programming
	Information Systems Corp.	Programming
Flight Research Center	General Electric	Operations, Data Preparation, Keypunching
	Computing and Software, Inc.	Biomedical Programming and Analysis

Installation	Name of Firm	ADP Service Performed
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
Space Nuclear Propulsion Office	Pan American World Airways, Inc.	Programming, Analysis, and Operations
Headquarters	Leasco	Programming and Operations
	Informatics (TISCO)	Programming, Analysis and Operations, Keypunching

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

End of Fiscal Year Inventory of Computers

	FY 1969	FY 1970	FY 1971
Office of Manned Space Flight.....	269	252	256
Kennedy Space Center.....	22	22	22
Manned Spacecraft Center.....	147	145	156
Marshall Space Flight Center.....	100	85	78
Office of Space Science and Applications	299	353	362
Goddard Space Flight Center.....	202	231	241
Jet Propulsion Laboratory.....	94	116	114
Wallops Station.....	3	6	7
Office of Advanced Research and Technology	70	91	82
Ames Research Center.....	27	31	29
Electronics Research Center.....	11	11	---
Flight Research Center.....	7	9	9
Langley Research Center.....	10	16	20
Lewis Research Center.....	14	24	24
Space Nuclear Propulsion Office.....	1	---	---
Headquarters.....	4	4	4
Total.....	642	700	704
Breakdown by Category of Equipment:			
Category A (General Purpose).....	157	140	129
Category B (Special Purpose).....	485	560	575

Figure 9

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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

	FY 1969				FY 1970				FY 1971			
	Lease	Maint.	Purch.	Total	Lease	Maint.	Purch.	Total	Lease	Maint.	Purch.	Total
Office of Manned Space Flight....	$20,733	$3,389	$3,327	$27,449	$14,578	$4,217	$18,895	$37,690	$14,721	$4,144	$695	$19,560
Kennedy Space Center.....	1,267	491	154	1,912	1,023	585	165	1,773	1,005	640	200	1,845
Manned Spacecraft Center.....	15,722	2,611	3,035	21,368	6,250	3,205	18,705	28,160	6,606	3,185	495	10,286
Marshall Space Flight Center...	3,744	287	138	4,169	7,305	427	25	7,757	7,110	319	---	7,429
Office of Space Science and Applications.....	8,900	4,812	7,888	21,600	9,918	4,888	10,281	25,087	10,630	5,200	9,774	25,604
Goddard Space Flight Center....	5,654	3,807	6,655	16,116	5,518	3,853	8,163	17,534	6,244	4,003	7,939	18,186
Jet Propulsion Laboratory.....	3,197	940	920	5,057	4,316	941	1,830	7,087	4,283	1,049	1,440	6,772
Wallops Station.....	49	65	313	427	84	94	288	466	103	148	395	646
Office of Advanced Research and Technology.....	3,038	1,399	6,348	10,785	2,942	1,919	14,638	19,499	2,241	1,998	13,226	17,465
Ames Research Center.....	1,352	349	518	2,219	954	546	6,550	8,050	520	568	210	1,298
Electronics Research Center....	410	153	862	1,425	679	161	2,108	2,948	---	---	---	---
Flight Research Center.....	29	51	20	100	345	69	273	687	517	69	---	586
Langley Research Center.....	896	648	3,744	5,288	840	921	4,148	5,909	1,148	1,115	7,416	9,679
Lewis Research Center.....	97	198	1,204	1,499	54	222	1,559	1,835	56	246	5,600	5,902
Space Nuclear Propulsion Office	254	---	---	254	70	---	---	70	---	---	---	---
Headquarters.....	174	44	1,251	1,469	501	65	---	566	502	65	---	567
Total.....	32,845	9,644	18,814	61,303	27,939	11,089	43,814	82,842	28,094	11,407	23,695	63,196
Breakdown by Appropriation:												
R&D.....	20,239	7,554	16,567	44,360	15,585	9,744	43,739	69,068	15,077	10,057	23,695	48,829
R&PM.....	12,606	2,090	2,178	16,874	12,354	1,345	25	13,724	13,017	1,350	---	14,367
CoF.....			69	69			50	50				
Breakdown by Category of Equipment:												
Category A.....	29,893	4,730	7,355	41,978	25,192	5,879	28,444	59,515	25,129	6,021	18,477	49,627
Category B.....	2,952	4,914	11,459	19,325	2,747	5,210	15,370	23,327	2,965	5,386	5,218	13,569

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, an IBM 360/50, and an IBM 360/40. 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, computational services are being increasingly provided to the aerospace contractors in the Cape Kennedy area.

Although there has been a substantial decline in data reduction and general scientific computations at KSC during the first half of FY 1970, this has been largely offset by an increase in engineering and administrative data processing resulting in a relatively stable overall workload. The decline in data reduction is due to the reduced level of launch and test activity while the increase in administrative data processing is accounted for by the transfer of some functions from the contractors to KSC, general growth in ADP, and improved services provided to the end user.

Additional computer resources do not appear necessary in the FY 1970-71 time frame. Changes in future launch schedules will have a sharp impact on the ADP workload at KSC but the only changes which are anticipated are those minor reconfigurations which may be necessary to adapt the computation complex to the data reduction requirements of the experimenters.

Manned Spacecraft Center

At the Manned Spacecraft Center 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.

All categories of CAD work are expected to remain fairly level during the 1970-71 time frame with the exception of mission planning and Apollo guidance and control which have dropped sharply following the Apollo 11 flight. The reduced level of mission planning activity allowed the release of one IBM 7094 and one 360/30 early in FY 1970. Studies are currently under way to determine optimum configurations and mode of operation of the primary CAD computer systems (UNIVAC 1108's). If these systems were to be consolidated into multiprocessors, additional core storage modules would be required.

However, preliminary experience indicates front-end processors may be more efficient. In the administrative applications area it may be advantageous to replace the older second generation systems as a result of increased application, sophistication, and deteriorating equipment reliability.

Mission Control computation requirements declined sharply following the Apollo 11 flight and the revision of launch schedules. Although requirements have declined sharply in this area a relatively large amount of equipment must be retained supporting the Real-Time Computation Center through the end of the Apollo program. Between missions the equipment is utilized in program test and development, simulation, and training functions.

A large number of projects are in the planning stage which may result in a need for several small and medium Category B computers in FY 1971. An effort is being made to satisfy this requirement largely through re-utilization of installed systems.

Marshall Space Flight Center

Most Marshall Space Flight Center 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.

At Huntsville new requirements have developed faster than expected. Substantial work previously done by contractors must now be done in-house and commercial applications are using much more computer time largely as a result of system deficiencies. A far higher percentage of the central computation capacity is now devoted to the commercial jobs in an effort to complete the conversion of all such work and allow release of the IBM 7010 and 7740 systems currently leasing for over one-half million dollars per year.

Much launch azimuth, operational trajectory, and lunar targeting computation previously done by Boeing is now done in-house or at the GSA Service Center using IBM 7094's previously installed at the Computation Laboratory. New scientific computations are required to support the development and test of the Lunar Roving Vehicle; simulation requirements continue to expand slowly; and in the data reduction area requirements are expected to increase very rapidly with the return of stage contractor data reduction and AAP telemetry processing.

The Slidell Computer Operations Office provides computation support to the Michoud Assembly Facility (MAF), the Mississippi Test Facility, and associated contractors. Workload is divided almost equally between scientific computation, engineering data processing, and commercial applications with a smaller volume of data reduction derived from static firing and launch support.

Engineering and commercial data processing includes tasks associated with manufacture, quality assurance, and configuration control of the stages manufactured at MAF. Scientific computations include engineering analysis in such areas as structures, trajectories, and vehicle dynamic control. Workload size depends on the number of stages in process at Michoud, problems associated with development of stages, and overflow work or functions transferred from Huntsville.

During FY 1970 and 1971 the majority of the decentralized small and medium systems will be released at Huntsville and Slidell, provided the capacity of the central computer complexes can be sufficiently enhanced through improved efficiencies or re-utilization of excess government-owned systems. Since many of the excess systems at MSFC are purchased they are expected to be shifted to requirements which would otherwise call for new acquisitions.

Goddard Space Flight Center

At the Goddard Space Flight Center the Category A equipment funds required for FY 1970 will be directed primarily towards augmenting the existing computers of the main third generation computer complex. This augmentation will provide greater project support capability and an increase in system output capacity. The greater capability is needed to support the continuing rise in the science and engineering applications requirement, whereas the increased output capacity will provide the added support required in such areas as the reduction of satellite telemetry data. Some small systems will be acquired during this fiscal year to serve as terminals to the large third generation computer complex. Programs to be supported by these terminals include the sounding rocket effort and the Manned Space Flight Network development.

Again, in FY 1971 the major Category A equipment funds requirement will be for the continuation of the central computing facility augmentation effort now under way. A significant action during this fiscal year will be the establishment of a third generation computing capability to the business and administrative computer facility. However, the major components needed for this conversion will be acquired through the re-utilization of existing equipment from another center.

During FY 1970 Category B equipment procurements will be directed towards providing support to the increased requirements of the Small Astronomy Satellite and the Small Scientific Satellite programs. Funds will also be used to provide a high speed data switching capability to the computers that serve as the heart of the NASA communications switching network.

375-328 C - 70 - 13

The largest Category B equipment acquisition effort for FY 1971 will be the acquisition of the computer support for the Earth Resources Technology Satellite. Additional equipment will be acquired to provide a special capability at certain of the Satellite Tracking and Data Acquisition Network (STADAN) sites to support the forthcoming launches of two Advanced Technology Satellites (ATS). Finally, some additional equipment will be needed for improved support techniques for future Orbiting Solar Observatory (OSO) launches.

Jet Propulsion Laboratory

During FY 1970 the Jet Propulsion Laboratory's Scientific Computing Facility (SCF) will lease a second UNIVAC 1108, thus giving it a multiprocessing capability. This multiprocessor plus the acquisition of the appropriate terminals will provide the SCF with the increased capability to meet its growing workload requirement. This increase in workload is attributed to greater complexity of the advanced missions planned for the early 1970's and the attendant increase in the level of support required during the planning and development stage of these missions. Also during FY 1970 the Space Flight Operations Facility (SFOF) will install third generation equipment. This conversion is again attributed to the more complex missions of the 1970's, in particular the need for simultaneous coverage of multiple missions and the higher data rates employed in these more sophisticated missions.

In FY 1971 the additional funds sought will be used to purchase miscellaneous peripherals for the previously acquired third generation Category A computers of the SCF and the SFOF.

During FY 1970 new Category B systems will be acquired for the Deep Space Instrumentation Facility and the Tracking and Data Acquisition Advanced Engineering Sections. These computers will support the development and implementation of the advanced spacecraft tracking and data acquisition functions needed to support the more complex deep space missions of the future. The largest equipment acquisitions planned for this fiscal year are aimed at expanding the spacecraft checkout facility associated with the Mariner Mars '71 program.

Some additional equipment is being sought for FY 1971 to support two of the development efforts associated with the deep space missions. The programs requiring support are the Research and Advanced Development Vehicle Motion Control Program and the Gamma Ray Spectrometer Development effort.

Wallops Station

During FY 1970 at the Wallops Station the Category A computer of the station's Central Computing System will be augmented with additional core memory and by a mass storage device to be added during FY 1971. These

additional system elements are necessary to provide the system capability required to meet the steady growth in the scientific, engineering, and data reduction workloads at this facility.

Three Category B computers will be acquired during FY 1970. Two of these systems will become part of the Mobile Range Facility with the third to be incorporated in the Pulse Code Modulation (PCM) Telemetry Systems supporting the Center's rocket vehicle launching activity.

Ames Research Center

Ames Research Center's general purpose computation requirements are primarily for theoretical research, analysis of experimental data, and math modeling of spacecraft and aeronautical systems. Major programs requiring ADP support are aeronautics, flight projects, and life sciences. A significant increase in ADP requirements is expected as a result of new emphasis on aeronautics research. The Center has installed a large scale IBM Duplex 360/67 system and plans to expand their remote computation facilities to provide for improved on-line ADP support to their wind tunnels.

A major new requirement will result from plans for the development of math modeling to augment the exploratory aerodynamic work that has previously been done in the wind tunnel facilities. A particular need is in the study of dynamic aerodynamic phenomena and testing of aeroelastic configurations where analysis of time varying data is a prime concern.

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.

Their requirements for simulation applications continue to increase, primarily in conjunction with flight and guidance control for advanced aircraft and spacecraft design. Applications of this type involve electromechanical systems for piloted simulation studies and require the use of computers for closed-loop computer control functions.

The Ames life sciences research program has a continuing requirement for digital-analog hybrid configurations for studies of effects of various degrees of environment stress on the human operation. In some selected types of applications, direct digital control will be used for studies to evaluate human response and decision-making capabilities.

Electronics Research Center

In 1971, the Electronics Research Center, Cambridge, Massachusetts, will be closed. The Center has recently installed a large scale IBM

360/75 computer system to meet expected increased general purpose ADP requirements. In addition, small scale computers have been installed for special applications in conjunction with their research laboratory equipment. The NASA-owned ADP equipment released as a result of closing of this Center will be carefully screened for relocation to meet requirements at other NASA centers in lieu of acquiring new systems. Equipment which cannot meet the ADP requirements of other centers will be released through the government-wide re-utilization/sharing exchange administered by GSA.

Flight Research Center

Computer requirements at the Flight Research Center are primarily for data reduction, however, there is a rapidly increasing demand for scientific and engineering computation. New requirements include data analysis and theoretical computations in connection with F-8 supercritical wing research and stability/control research; YF-12 propulsion, performance, and structures; and new research in the high temperature loads calibration facilities. Existing major programs requiring continued emphasis include F-111 propulsion and performance research, general aircraft handling qualities studies, Bio-Medical Data Analysis, and Lifting Body Research.

Flight Research Center uses small scale computers for special applications including on-line data acquisition and analog-digital configurations for digital computation support in vehicle simulation. Additional computer installations will provide on-line data collection from tracking range telemetry stations and for control of test parameters in the high temperature loads calibration facilities.

The Center is planning to replace their general purpose computer equipment with a large scale computer system and to provide a direct interconnection with some of their special applications equipment. They are planning to install an IBM 360/50 on an interim basis pending implementation of the general purpose ADP replacement configuration.

Langley Research Center

Langley Research Center utilizes ADP equipment for analytical research, digital simulation, data reduction, and mission analysis. Analytical research includes analysis of complex unsymmetrical structures of aerospace vehicles and integrated analysis of several interdependent processes in aerodynamic flow. New applications include studies in the fields of oceanography, ground transport, and operations research. A new requirement for data reduction and analysis is expected as a result of plans for modernization of their wind tunnel instrumentation and control facilities.

An additional increased ADP workload will result from the Viking Mars Lander project and the space station and space shuttle development effort. These studies make use of complex computer programs to define earth, lunar, and interplanetary trajectories requiring use of optimization and statistical analysis techniques. Langley also provides inter-agency support to FAA for glide-slope studies and flight handling procedures for large multispeed aircraft and support to DOD maneuverability qualities of advanced fighter aircraft.

Langley is expanding its third generation equipment to meet these requirements and is developing new digital simulation techniques. Small scale computer equipment is used primarily in real-time data collection systems and is directly interconnected to the test data sensing equipment. Additional new computers are scheduled for installation to provide on-line data collection from their wind tunnels and to include interconnection with their central ADP facilities for remote/on-line computation support. They are planning additional expansion to include computer control and data acquisition of selected wind tunnel parameters.

Lewis Research Center

Lewis Research Center ADP requirements are primarily for data reduction of all raw data from their research and test facilities, for analytical studies, and for digital simulation studies.

Scientific and engineering computation requirements relate directly to the needs for solving problems that limit the development of engines for supersonic flight. Applications include heat transfer calculations, trajectory calculations, and other elements related to engine systems and performance during all flight phases. Mathematical modeling is employed for materials research covering a wide temperature range from cryogenic temperatures of liquid gases to the high temperatures encountered in rocket nozzles.

The major Lewis programs and projects requiring ADP are aeronautics, space power and propulsion systems, and rockets and vehicles. Their research program encompasses the entire spectrum of activities from basic research to applied research and development. The scope ranges from work on individual components through complete systems.

Lewis Research Center is planning to improve their centralized data collection system to provide for a more efficient data flow from the testing facilities to their IBM 360/67 central data processing facilities. In addition, they are planning to expand their conversational-mode remote terminal system to provide remote computation service to all of their research and testing facilities. Additional new equipment includes small scale computers in special applications requiring real-time data acquisition

as a part of the nuclear electric engine research, the cyclotron, the solar cell and Brayton Cycle Research Facilities, and components environment test chambers. In addition to on-line monitoring and data collection, they plan to include some experiment control applications. Additional special purpose computers are installed at Cape Kennedy and at contractor plants to provide for automatic checkout and launch control of the Centaur Inertial Guidance System and for the actual launch of the Centaur.

Space Nuclear Propulsion Office

The Space Nuclear Propulsion Office utilizes ADP equipment at the Nuclear Rocket Development Station (NRDS) to support the full scale static testing of nuclear reactors, engines and stages being developed under the ROVER program, a program of research and development for a nuclear rocket engine system to be integrated into nuclear powered space vehicles. Computer applications include monitoring test progress, and display of critical test parameters based on quick analysis; test data conversion; engineering studies; and administrative support applications. Scientific and engineering work includes computations in fluid dynamics, reactor decay heat, fuel element weight loss, and radiation dose predictions.

The Space Nuclear Propulsion Office plans to transfer the ADP workload over to an AEC-owned IBM 7094 computer scheduled for installation during FY 1970. SNPO plans to release their CDC 3200 computer shortly after installation of the 7094. They plan to retain five CDC magnetic tape units which are used for data collection at the engine test locations.

Headquarters

General data processing services at Headquarters are provided by an IBM 360/40 and an IBM 1410 managed by the Management Systems Division within the Office of Technology Utilization. Primary applications include Financial Accounting, Status of Contracts and Grants, Personnel Accounting, and Payroll. The Scientific and Technical Information Facility (STIF), also under Technology Utilization, operates an IBM 360/50 at College Park, Maryland, in support of an information retrieval function. Both the general data processing and the information retrieval functions have steadily increased in recent years and this trend is expected to continue.

During FY 1970 the STIF information retrieval function will be expanded to provide remote CRT terminals at most NASA centers. In addition, there are plans for a magnetic tape-to-tape communications system to link all centers with Headquarters within the next two years. No other major equipment changes are planned for the FY 1970-71 period although there may be some minor augmentations of peripherals to balance the configurations as applications are modified.

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