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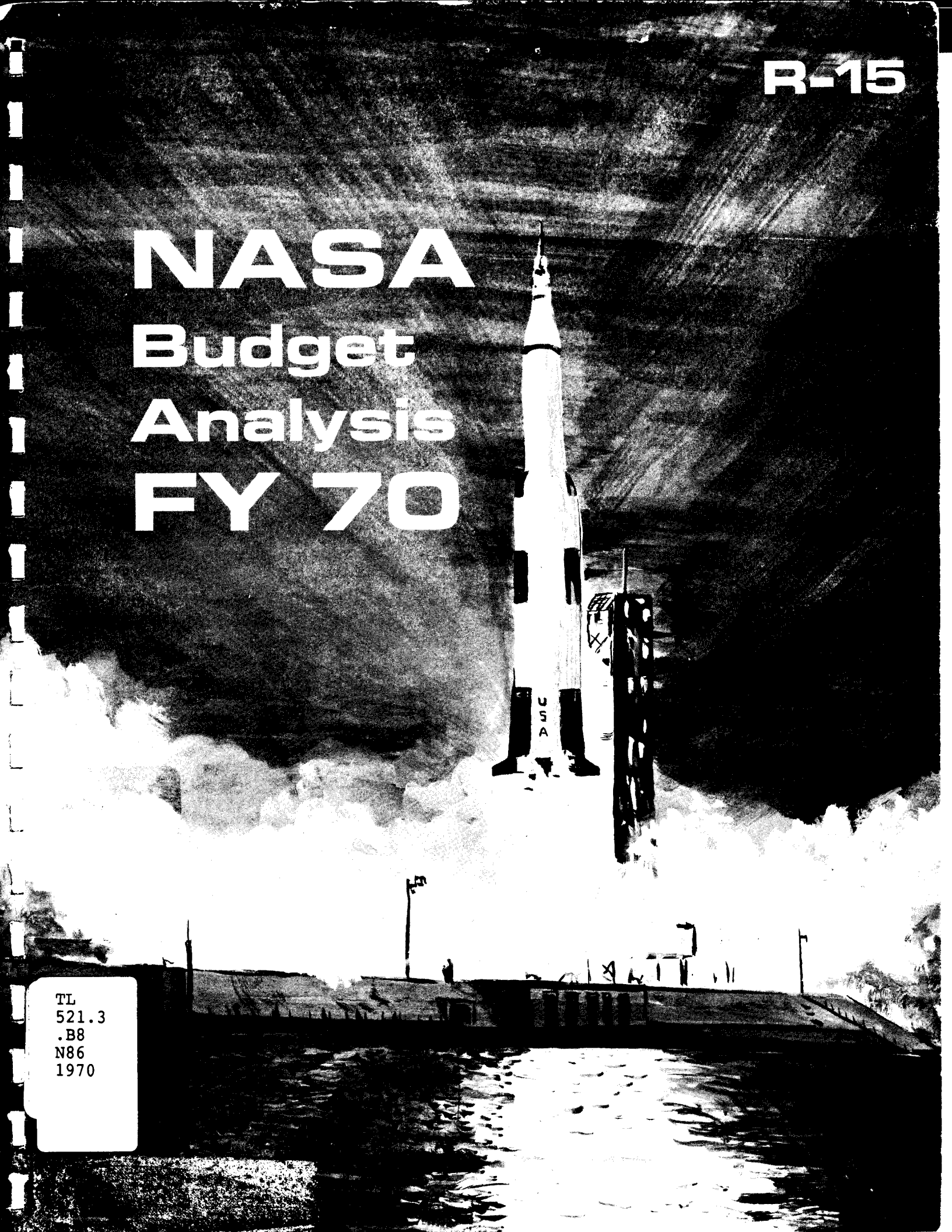
NASA Budget Analysis FY 70



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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
FISCAL YEAR 1970 BUDGET REQUEST

OUTLOOK

The NASA FY 1970 Budget arrests the steady downward trend of NASA budgets in the past several years and is designed to provide NASA with the same total program level in FY 1970 as it was allowed in its reduced FY 1969 operating plans, even though the authorization request before Congress shows an apparent decrease.

For FY 1969, the total appropriated by Congress was $3,995 million. Under the requirements of the Revenue and Expenditure Control Act last year, the President withheld $117 million, leaving NASA with a FY 1969 operating plan of $3,878 billion, including provision for the civil service pay increases becoming effective during the year.

For FY 1970, President Johnson's decision was to provide NASA the same program level as in the final FY 1969 operating plan -- $3,878 million. The $117 million withheld in FY 1969 is "no-year funds" which can be applied to NASA's FY 1970 requirements without further Congressional action. Thus, the FY 1970 authorization and appropriation requests now before Congress total only $3,761 million, $117 million less than the $3,878 million program level the Budget recommends. This then is $3,168,900,000 for Research and Development (including the $117,473,000 of the FY 1969 appropriation); $58,200,000 for Construction of Facilities, and $650,900,000 for Research and Program Management.

Dr. Thomas O. Paine, head of NASA, has characterized the FY 1970 Budget as a "holding" budget that provides for progress, but defers critical and program funding decisions to the Nixon

Administration.

NASA's FY 1969 Operating Budget was $762 million below FY 1968 and over one billion dollars below FY 1967. During this same period total nationwide employment on NASA work decreased from an earlier peak of approximately 420,000 to 270,000 at the end of FY 1968, to about 215,000 at the end of FY 1969, and, under the FY 1970 Budget to about 190,000. The reduction of the NASA civil service during the same period placed a difficult burden on its program management, coming during the period of intense preparations to support the heavy schedule for manned space flight.

It has not been easy to maintain a strong forward-thrusting program under these conditions and the problem has been compounded by the uncertainties on the funding level and future goals of the program.

In recent years, the budgets submitted by the President and the funding levels finally approved have required deferral wherever possible of programs pointed at major new objectives. To maintain some momentum and preserve important options, NASA had to take uneconomical actions to defer programs, curtail scope and value of projects, stretch-out schedules, and reduce planning and preliminary design and development work on future programs.

Virtually all of the $3,878 million requested for FY 1970 is required for the necessary costs of continuing in FY 1970 projects and programs approved and begun in previous years. These include the Apollo program, the limited Apollo Applications program which NASA finally was able to undertake within its reduced FY 1969 operating plan, the Titan-Mars 1973 program - now called "Viking" - which was also approved last year, and other lesser programs.

NEW RESEARCH AND DEVELOPMENT PROGRAMS AND PROJECTS

To carry forward previously approved programs in FY 1970 will require about $3.8 billion. The remainder of NASA's request, about $70 million, is for previously anticipated extensions of some of its continuing space science and applications programs, such as a Mariner-Mercury 1973 mission and the synchronous meteorological satellite, and for starting three principal new programs or major developments. They are:

1. The Earth Resources Technology Satellite Program - NASA has secured approval in this budget to move ahead with the actual development of experimental Earth Resources Technology Satellites now designated ERTS A and B. If this budget recommendation is approved by the Congress, NASA will be able to begin satellite testing of multi-spectral television systems which will enable experimenters in the several government agencies and universities cooperating in our program to assess experimentally the value of space-collected data in the study and understanding of a variety of earth resources. For many years NASA and the Departments of Interior, Agriculture, Commerce and other agencies have been enthusiastic about the great potential value of data that can be collected from space.

Hitherto, NASA has been limited by budgetary constraints to experimentation on the ground and from aircraft, sensor development, and studies of satellite systems. This work has progressed to the point where NASA is now ready, if this budget recommendation is approved, to carry out work from space which will enable it and the cooperating "user" agencies to assess with hard experimental evidence the utility of earth resource data collected by satellites and begin to develop plans and systems for utilizing such data in their operations. ERTS A and B correspond to the

first experimental meteorological satellites and should have the same revolutionary impact on the many disciplines in the earth resource field as the original TIROS experiments had in the field of meteorology and weather forecasting.

2. NERVA Flight Weight Engine Development - A reduced budget level for FY 1969 prevented NASA from beginning development of the NERVA flight weight nuclear engine. Initiation of this development has now been approved in the FY 1970 Budget. By the end of FY 1969, Paine says NASA will have reached the point beyond which it would be impractical, from a technical or program standpoint, to proceed with further preliminary development and test work on the NERVA engine without a clear decision to proceed with actual development of the flight weight engine. This is NASA's longest-term future major technological development effort.

3. Planetary Explorers - The third new program in the FY 1970 Budget calls for the start of a series of small "planetary explorers." On flights to Venus starting in 1972 and later to Mars, they will supplement the more detailed and comprehensive data gathered by NASA's larger and more costly Mariner-class missions. NASA feels that in the field of planetary exploration, as in the scientific exploration of space around the earth, the greatest progress can be made at the least cost through a balance of small relatively unsophisticated satellites and larger more expensive spacecraft with sensors and instruments embodying the most advanced technology available.

In all other respects, the FY 1970 Budget must be regarded as a "holding" budget which does not set and support new goals for the nation's space program to replace those achieved or which the nation is now close to achieving in the first decade

of space.

This is especially true in the area of manned space flight. NASA has felt and expressed the need for several years now for clear decisions and support for future manned space flight objectives, believing that it is clear that the future goals in a balanced manned space flight program lie in two directions: One, continued exploration of the moon; and two, in the development and utilization of a permanent manned space station in earth orbit.

In his decisions on the NASA FY 1970 Budget, President Johnson specifically deferred to President Nixon's Administration decisions on both of these goals and on the initiation of new programs to work toward them. Under the FY 1970 Budget before Congress, it will be NASA's task to proceed with studies of possible future programs and to do everything it can to preserve until FY 1971 effective options to proceed in either or both of these directions.

In manned space flight the FY 1970 Budget provides for continuing the Apollo program at a decreasing level and for continuing work toward the single set of flights of the Saturn I Workshop and Apollo telescope mount now scheduled for 1971 and 1972. Beyond that, it provides only funds for study - $11 million for studies of equipment required for future exploration of the moon and $9 million for studies and related preliminary work in the earth-orbital space station field.

NASA feels that it is now abundantly clear that the Soviets are proceeding in manned space flight programs directed both at sending men to the moon and at substantially enlarged and extended manned operations in earth orbit. In their planetary program, the Soviets have launched two spacecraft to Venus which they say are intended to soft-land instruments on Venus much im-

proved over those they landed with Venera 4 last year. In other categories of space and aeronautics, their program continues to be active and their entire effort apparently is receiving a continuing high level of support.

As indications of future Soviet direction and pace become clearer and as this nation approaches the first manned Apollo lunar landing, NASA feels it is clearly appropriate for the new Administration and the Congress to take a fresh look at long-term U.S. goals in space.

President Nixon has asked Paine, the new Administrator of NASA, the Secretary of Defense, and the President's Science Adviser, each to develop proposed plans on the direction the U.S. space program should take in the post-Apollo period and to meet together as a Task Group under the Chairmanship of the Vice President, to prepare for the President a coordinated program proposal. From this process could come firm decisions for a future long-range program in space and aeronautics.

NASA's Paine feels major program goals for the next ten years should include:

TEN YEAR GOALS

First - We should do all we can to understand and put to early use the promise of space for people here on earth. We should increase our scientific knowledge of the earth-sun relationship and study the earth itself from space. We should develop and experiment with new and improved practical applications of satellites, particularly in earth resources. We should continue to foster prompt introduction into the economy of space applications and technology.

Second - We should follow up the first Apollo landing with a sound program of manned lunar exploration.

Third - We should proceed with the development and experi-

mental operation of a permanent U.S. space station in earth orbit.

Fourth - We should move out steadily in the exploration of deeper space, exploring the planets with unmanned probes and the sun, stars, and galaxies from orbital observatories outside the atmosphere.

Fifth - We should provide the technology for developing the full potential of U.S. civil and military aeronautics, and

Sixth - We should maintain a strong momentum of broad technological advance in all aerospace disciplines.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1970 BUDGET REQUEST

SUMMARY OF APPROPRIATIONS

(In thousands of dollars)

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

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1970 BUDGET REQUEST

SUMMARY OF APPROPRIATIONS (ADJUSTED)

(In thousands of dollars)

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

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1970 BUDGET REQUEST

SUMMARY OF BUDGET PLAN BY APPROPRIATION BY BUDGET ACTIVITY

(In thousands of dollars)

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

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

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1970 BUDGET REQUEST

SUMMARY OF BUDGET PLAN

OFFICE OF MANNED SPACE FLIGHT PROGRAMS

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

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1970 BUDGET REQUEST

SUMMARY OF BUDGET PLAN

OFFICE OF SPACE SCIENCE AND APPLICATIONS PROGRAMS

OFFICE OF UNIVERSITY AFFAIRS PROGRAM

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

(UNIVERSITY AFFAIRS PROGRAM)

Research and Development			
Sustaining University program	$ 10,000	$ 9,000	$ 9,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1970 BUDGET REQUEST

SUMMARY OF BUDGET PLAN

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY PROGRAMS

OFFICE OF TRACKING AND DATA ACQUISITION PROGRAMS

OFFICE OF TECHNOLOGY UTILIZATION PROGRAM

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

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

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1970 BUDGET REQUEST

NUMBER OF PERSONNEL POSITIONS

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

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Research and Development

PROGRAM AND FINANCING

(In thousands of dollars)

	Budget plan (amounts for research and development actions programmed)			Costs and obligations		
	1968 actual	1969 est.	1970 est.	1968 act.	1969 est.	1970 est.
PROGRAM BY ACTIVITIES:						
Direct program:						
1. Manned space flight:						
(a) Gemini	---	---	---	4,808	---	---
(b) Apollo	2,556,030	2,025,000	1,651,000	2,489,182	2,310,000	1,675,000
(c) Apollo applications.	253,200	150,000	345,100	127,551	216,000	369,000
(d) Advanced manned mission studies	---	2,500	11,500	3,933	4,000	10,000
2. Scientific investigations in space:						
(a) Physics and astronomy.	155,981	144,191	134,958	177,902	158,800	135,200
(b) Lunar and planetary exploration	156,874	97,770	166,151	169,177	113,000	152,500
(c) Bioscience	42,800	34,300	34,000	43,812	37,000	34,000
(d) Launch vehicle development and support.	82,797	53,722	74,440	99,627	60,000	70,050
3. Space applications	110,332	105,039	148,601	107,628	107,000	141,800
4. Space technology	237,688	193,665	190,350	245,096	217,200	203,950
5. Aircraft technology.	81,400	94,900	100,700	70,694	87,000	96,400
6. Supporting activities:						
(a) Tracking and data acquisition.	275,850	279,672	298,000	285,002	295,000	321,700
(b) Sustaining university program.	10,000	9,000	9,000	40,473	26,000	23,000
(c) Technology utilization	4,000	3,800	5,000	4,320	4,000	5,000
TOTAL, direct program costs, funded.	3,966,952	3,193,559	3,168,900	3,869,205	3,635,000	3,237,600

(cont.)

(cont.)

	Budget plan (amounts for research and development actions programmed)			Costs and obligations		
	1968 actual	1969 est.	1970 est.	1968 act.	1969 est.	1970 est.
Reimbursable program:						
1. Manned space flight:						
(a) Gemini	---	---	---	1	84	---
(b) Apollo	212	615	555	261	709	555
(c) Apollo applications.	371	306	---	12	665	---
2. Scientific investigations in space:						
(a) Physics and astronomy.	8,412	5,744	494	8,132	11,292	494
3. Space applications	21,215	32,656	34,601	35,386	65,257	34,601
4. Space technology	31,619	25,379	28,300	34,748	26,455	28,300
5. Aircraft technology.	5,368	2,800	2,550	3,234	7,423	2,550
6. Supporting activities:						
(a) Tracking and data acquisition.	598	500	500	243	678	500
(c) Technology utilization	---	---	---	42	4	---
TOTAL, reimbursable program costs	67,795	68,000	67,000	82,059	112,567	67,000
Total program costs, funded. .	4,034,747	3,261,559	3,235,900	3,951,264	3,747,567	3,304,600
Change in selected resources*	---	---	---	-69,980	-174,860	-68,700
TOTAL	4,034,747	3,261,559	3,235,900	3,881,284	3,572,707	3,235,900

(cont.)

(cont.)

	Budget plan (amounts for research and development actions programmed)			Costs and obligations		
	1968 actual	1969 est.	1970 est.	1968 act.	1969 est.	1970 est.
FINANCING:						
Receipts and reimbursements from:						
11 Federal funds	-63,233	-56,000	-59,200	-63,233	-56,000	-59,200
14 Non-Federal sources**	-1,535	-12,000	-7,800	-1,535	-12,000	-7,800
Adjustment to prior year reimbursable orders	-3,027	---	---	---	---	---
21 Unobligated balance available, start of year: For completion of prior year budget plans. . .	---	---	---	-160,362	-311,148	---
Available to finance new budget plans	---	---	-117,473	-56,352	---	-117,473
23 Unobligated balance transferred to other accounts	---	---	---	600	---	---
Reprograming from prior year budget plans.	-55,402	---	---	---	---	---
24 Unobligated balance available, end of year: For completion of prior year budget plans. . .	---	---	---	311,148	---	---
Available to finance new budget plans	---	117,473	---	---	117,473	---
BUDGET AUTHORITY.	3,911,550	3,311,032	3,051,427	3,911,550	3,311,032	3,051,427

(cont.)

	Budget plan (amounts for research and development actions programmed)			Costs and Obligations		
	1968 actual	1969 est.	1970 est.	1968 act.	1969 est.	1970 est.
Budget authority:						
40 Appropriation	3,925,000	3,370,300	3,051,427	3,925,000	3,370,300	3,051,427
41 Transferred to other accounts . .	-13,450	-59,268	---	-13,450	-59,268	---
43 APPROPRIATION (adjusted). . .	3,911,550	3,311,032	3,051,427	3,911,550	3,311,032	3,051,427
Relation of obligations to outlays:						
71 Obligations incurred, net				3,816,516	3,504,707	3,168,900
72 Obligated balance, start of year.				1,573,457	1,443,923	1,428,630
74 Obligated balance, end of year.				-1,443,923	-1,428,630	-1,362,530
90 Outlays				3,946,050	3,520,000	3,235,000

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

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

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

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1970 BUDGET REQUEST

SUMMARY OF RESEARCH AND DEVELOPMENT BUDGET PLAN

BY PROGRAM BY COGNIZANT OFFICE

(In thousands of dollars)

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

*Funds for the procurement of launch vehicles are statistically distributed to unmanned flight programs (e.g., Physics and Astronomy, Space Vehicle Systems).

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

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1970 BUDGET REQUEST

SUMMARY OF CONSTRUCTION OF FACILITIES BUDGET PLAN BY LOCATION

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

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND PROGRAM MANAGEMENT

PROGRAM AND FINANCING

(In thousands of dollars)

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

	1967	1968 adjustments	1968	1969	1970
*Selected resources as of June 30 are as follows:					
Unpaid undelivered orders	54,265	-2,751	35,806	36,367	35,267
Advances.	157	---	342	342	342
Total selected resources.	54,421	-2,751	36,148	36,709	35,609

(cont.)

(cont.)

	Budget plan			Costs and obligations		
	1968 act.	1969 est.	1970 est.	1968 act.	1969 est.	1970 est.
FINANCING:						
Receipts and reimbursements from:						
Federal funds				-2,494	-3,000	-3,200
Non-Federal Sources**				-208	-300	-300
Unobligated balance lapsing				130	---	---
BUDGET AUTHORITY				639,423	648,261	650,900
Budget authority:						
Appropriation				628,000	603,173	650,900
Transferred to other accounts				-127	-280	---
Transferred from other accounts				11,550	45,368	---
APPROPRIATION (adjusted)				639,423	648,261	650,900
Relation of obligations to outlays:						
Obligations incurred, net				639,293	648,261	650,900
Obligated balance, start of year				101,291	86,373	74,934
Obligated balance, end of year				-86,373	-74,934	-70,834
Adjustments in expired accounts				-2,685	---	---
Outlays				651,527	659,700	655,000

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

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1970 BUDGET REQUEST

RESEARCH AND PROGRAM MANAGEMENT

SUMMARY OF OBLIGATIONS BY INSTALLATION

(In thousands of dollars)

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

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
FISCAL YEAR 1970 BUDGET REQUEST

NEW RESEARCH AND DEVELOPMENT PROJECTS

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

Lunar and Planetary Exploration Program

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

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

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

Planetary Explorers $8,000,000

The Planetary Explorer spacecraft is a small, relatively

inexpensive, planetary orbiter which will complement the larger and more complex Mariner spacecraft series in exploring Mars and Venus and their space environments. It will carry 50 pounds of instruments to measure both planetary and interplanetary particle and field environments, as well as for planetary upper-atmosphere experiments. A block of five flights is planned to provide for exploration and near-continuous orbital monitoring of the planets Venus and Mars, with single launches to Venus in 1972, 1973, and 1975, and to Mars in 1973 and 1975

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

Space Applications Program

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

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

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

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

The objectives of the Earth Resources Technology Satellites are to: (1) assess the practical value of remote sensing of earth resources from space; (2) compare the capabilities in earth resources data acquisition of a space system versus aircraft; (3) determine whether, and in what configuration, an operational space-assisted user-oriented earth resources survey system should be pursued; (4) determine which remote sensors are most effective for earth resources surveying; (5) develop and improve data handling procedures; and (6) ensure full understanding of operational system requirements and costs. It is planned to design, develop, launch and test spacecraft capable of conducting a variety of selected experiments in the earth resources disciplines. A definition and preliminary design study is being conducted in FY 1969. Starting in FY 1970, effort will be initiated on procurement of two spacecraft and associated sensors for launch in 1971 and 1972. These missions will result in a major advancement in our understanding of the overall subject of earth resources survey from space.

Nuclear Rockets Program

NERVA development $27,500,000

The objective of this joint NASA-AEC project is to provide a rocket propulsion system for application to advanced orbital, lunar and planetary missions. System analysis, design, and development of this nuclear engine through pre-flight rating tests is planned. The engine will have a specific impulse of approximately 825 seconds, a thrust of approximately 75,000 pounds (1500 megawatts reactor power) and will include the capability for multiple cycles of operation, long duration operation, and

and high reliability. A nuclear stage using this type of engine would be capable of performing a wide variety of high energy and high payload space missions beyond the performance potential of chemical rockets.

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

OFFICE OF MANNED SPACE FLIGHT
APOLLO PROGRAM

From its inception, the Apollo program has focused on developing and demonstrating a basic national capability to conduct manned space operations around the earth and moon, and on the moon. The development of the Apollo spacecraft, the Saturn launch vehicles and the associated operations base, with the construction of the ground facilities required to achieve this, has brought together the largest and most varied scientific and engineering team ever assembled for a peaceful program. This partnership of industry, universities, and government has advanced the Apollo program to the point where the national goal of manned lunar landing and return during 1969 appears attainable. The accomplishment of this goal should be a decisive demonstration of the Nation's ability to conduct complex space operations, and should provide a sound foundation for a new and increasingly productive era in space flight.

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

Apollo 7, the first manned Apollo mission, was launched from Cape Kennedy on 11 October 1968 and added a number of "firsts"

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

The first Apollo Saturn V, an unmanned development test flight designated Apollo 4, was launched on 9 November 1967. During this Apollo 4 mission, the Saturn V vehicle launched an Apollo Command and Service Module into a high elliptical orbit to test the systems and to verify the heatshield's ability to withstand the intense heat of re-entry from lunar distances. The major test objectives were achieved, and the 6 million individual parts in the complex Saturn V performed reliably. The second unmanned flight test of the Saturn V occurred on 4 April 1968. During this Apollo 6 mission, the "POGO" phenomenon (longitudinal oscillations) developed, causing unacceptably high stresses in the space vehicle. Additionally, igniter fuel lines in the upper stages ruptured, resulting in a premature shutdown of two engines on the second stage, and the failure of the third stage engine to restart. Despite these difficulties, the Saturn V placed the Apollo spacecraft into orbit around the earth. The resolution of anomalies that occurred in Apollo 6 by a government and industry task team under the direction of the Marshall Space Flight Center is considered an outstanding technical achievement. The POGO and fuel line rupture problems were resolved through an extensive program of flight data analysis, mathematical modeling

using computers, and ground testing, and the Saturn V launch vehicle was determined to be ready for manned flight.

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

On Apollo 9, the fourth Saturn V launched an Apollo Command and Service Module and Lunar Module into orbit around the earth to perform the rendezvous and docking maneuvers that will be required for a landing mission. For the first time, the Command and Service Module docked with the Lunar Module, and two of the three Apollo

crew members transferred to the Lunar Module. The reliability and performance of this module was evaluated during these manned simulations of lunar operations.

The following mission, Apollo 10, is planned as the last major step before a manned lunar landing may be attempted. This mission is to be an operational checkout of the complete Apollo spacecraft in orbit around the moon, including rendezvous and docking. The success of Apollo 9 and 10 will provide the experience to attempt the initial lunar landing.

RESOURCES REQUIRED:

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

WHY FUNDS REQUIRED:

Spacecraft ($653,800,000)

The Apollo spacecraft consists of three modules: the Command Module, the Service Module, and the Lunar Module. The Command Module is a double-shelled, conical shaped spacecraft containing systems for communications; environmental control; guidance and navigation, stabilization and control for inflight and re-entry maneuvering; thermal protection against the heat of re-entry; and earth landing systems. Providing the living and crew station quarters, it is the only hardware used during a mission that is recovered. The Service Module is a cylindrical structure storing most of the spacecraft consumables such as oxygen, hydrogen, and

propulsion fuels. The Service Module contains the main spacecraft propulsion system providing 20,500 pounds of thrust; the reaction control system for secondary propulsion and maneuvering; the electrical power system; and elements of the communication and environmental control systems. The Lunar Module is a self-contained vehicle consisting of a descent stage and an ascent stage with a two-man cabin. The module serves as a base of operations on the surface of the moon. Each stage is equipped with its own engine - the descent stage engine provides the decelerating force necessary for a soft landing; the ascent stage engine launches the two astronauts up from the surface of the moon to the orbiting Command and Service Module. Eleven Command and Service Modules will be in various stages of production and factory checkout during FY 1970.

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

Saturn V ($496,700,000)

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

Saturn V problems encountered in the flight missions, and for engineering support activity required for flight evaluation. Five Saturn V launches are planned for the budget year.

Lunar Exploration ($11,000,000)

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

Operations ($489,600,000)

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

The two principal centers for launch, flight control and recovery activities are the Kennedy Space Center, Florida and the Manned Spacecraft Center, Texas. The Kennedy Space Center is responsible for checkout of both the launch vehicles and the spacecraft; maintenance and operation of the launch facilities; final integration and integrated checkout of the space vehicle which

includes the launch vehicle payload; the operation and coordination of supporting facilities, ground support equipment and logistics support; and the conducting of the launch. The Manned Spacecraft Center (MSC) in Houston is the headquarters for all crew, flight, and recovery operations. The astronauts are based at this Center along with most of their essential training equipment. Also at MSC is the Mission Control Center with its highly sophisticated computer complex and extensive communications links to the tracking network and other worldwide data sources.

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

OFFICE OF MANNED SPACE FLIGHT
SPACE FLIGHT OPERATIONS PROGRAM

The Space Flight Operations program is directed toward increasing the scientific, technical, and economic return on this nation's investment in technology; launch, production, and operations facilities; the scientific, engineering and management skills and expertise; operational techniques; and hardware equipment developed in the Gemini and Apollo programs. The present focus for the Space Flight Operations program is the development and operation of a manned space station that can be launched in the mid-1970's.

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

RESOURCES REQUIRED:

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

WHY FUNDS REQUIRED:

Apollo Applications ($308,800,000)

Apollo Applications consists of three basic missions and relies primarily on hardware developed and produced for the Apollo program. They are:

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

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

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

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

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

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

The third mission, planned for early 1972, uses the Workshop as a base of operations for a manned solar observatory. A Saturn IB will launch a three-man Apollo Command and Service Module configured for a 56-day mission. After the Command and Service Module rendezvous and docks with the Workshop, the crew enters and reactivates the Workshop and prepares for the operational phase of the mission. Later, a second Saturn IB launches the unmanned Apollo Telescope Mount (ATM) which will rendezvous and

dock with the Workshop. The ATM incorporates high resolution solar telescopes and spectrographs for observing dynamic phenomena on the surface and in the corona of the sun.

Backup hardware will be provided for both the Workshop (with Docking Adapter and Airlock) and the Apollo Telescope Mount, including a second set of experiments for the Workshop and Solar Astronomy missions.

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

Space Station ($9,000,000)

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

Operations ($36,300,000)

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

OFFICE OF MANNED SPACE FLIGHT
ADVANCED MISSIONS PROGRAM

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

RESOURCES REQUIRED:

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

WHY FUNDS REQUIRED:

Advanced Missions Studies ($2,500,000)

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

FY 1970 funding will be used as follows:

a. Rescue and Escape - Studies will be undertaken to examine and identify methods and systems for astronaut escape and rescue on lunar orbit and lunar surface missions. Conceptual design of manned and unmanned earth based rescue systems will be studied for

low earth and geosynchronous orbit missions. The impact of the projected use of such systems on the design and operation of Space Stations and lunar surface shelters and vehicles will be assessed.

b. Advanced Lunar Studies - Studies will be conducted on advanced studies which have the potential for utilization in the latter half of the 1970's. The studies will be concerned with spacecraft systems required to transport personnel and cargo to the moon and systems to provide shelter and support for exploration activities. System synthesis studies will provide planning data applicable to development of an early lunar station using Apollo system derivatives.

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

OFFICE OF SPACE SCIENCE AND APPLICATIONS
PHYSICS AND ASTRONOMY PROGRAM

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

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

RESOURCES REQUIRED:

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

WHY FUNDS REQUIRED:

Supporting Research and Technology/
Advanced Studies ($19,600,000)

This project provides for advanced technological development of experiments and spacecraft components for future flight programs, the support of theoretical and laboratory research, and the conduct of scientific flight research using balloons and aircraft. The program is carried out by universities, nonprofit and industrial research centers, NASA centers and other Government agencies.

Data Analysis ($3,700,000)

This project exploits the data obtained from space science experiments on NASA spacecraft. Reduced data records are forwarded by each principal investigator to the National Space Science Data Center (NSSDC) located at the Goddard Space Flight Center. After processing and cataloging, the availability of the data is made known to the world scientific community through periodic announcements by the NSSDC.

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

Sounding Rockets ($20,100,000)

Sounding rockets conduct scientific studies at altitudes between 80 and 1,000 miles. These rockets are relatively small, inexpensive vehicles capable of carrying a wide variety of in-

strumentation to conduct studies in planetary atmospheres, ionospheric physics, energetic particles, astronomy, and solar physics. Sounding rocket flights are extremely useful in developing instrumentation for later use on satellites. The usefulness of sounding rockets for astronomical observations of the sun and stars in the X-ray and ultraviolet regions of the spectrum have been greatly increased by the development of accurate attitude control systems capable of spatial pointing accuracies of one arc second.

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

Solar Observatories ($14,800,000)

The Orbiting Solar Observatory (OSO) is a spin-stabilized satellite designed to continuously point at the sun and scan the celestial sphere. Observations of solar and astronomical events are recorded and transmitted to ground based stations for analysis and dissemination in appropriate scientific publications by the Principal Investigators.

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

Astronomical Observatories ($28,600,000)

The Orbiting Astronomical Observatory (OAO) project is designed to develop and use an accurately stabilized automated space observatory system for telescopic observations of celestial objects in the electromagnetic spectral range from the X-ray region through the ultraviolet into the visible region. The early experiments in the OAO project will provide exploratory sky mapping surveys in the ultraviolet, with later experiments providing high resolution studies of faint objects.

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

Geophysical Observatories ($6,800,000)

The Orbiting Geophysical Observatory (OGO) project has as a primary objective the accomplishment of a coordinated series of scientific studies of the earth's environment and the effect of solar activity on that environment. Five observatories have been launched at approximately one year intervals, starting with OGO-I in 1964. These missions and the planned OGO-F mission cover the period from minimum to maximum activity of the current sunspot cycle, and provide for widely spaced measurements throughout the earth's magnetosphere as well as the nearby interplanetary medium.

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

Explorers ($26,000,000)

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

The early Explorer satellites have been responsible for many of the discoveries made in the earth's environment during the past decade.

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

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

OFFICE OF SPACE SCIENCE AND APPLICATIONS
LUNAR AND PLANETARY EXPLORATION PROGRAM

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

The fundamental scientific objectives of the lunar exploration program are to understand the moon's origin, evolutionary history, relationship to the earth and the solar system, and processes of formation. Projects now completed have advanced considerably our knowledge of the moon and provided a wealth of data which aided and will continue to aid in unraveling the mysteries of our nearest neighbor. The Ranger project, the first step in this effort, provided the first close up picture of the moon's surface through the thousands of lunar photographs its spacecraft transmitted to earth. The subsequent Lunar Orbiter project provided the large scale detailed photographs of the moon required for the selection and certification of sites for the Apollo manned lunar landing missions. The Surveyor

project, by demonstrating the soft landing of a complex spacecraft verified the ability of Apollo to land on the lunar surface. In addition, Surveyor made valuable contributions to our knowledge of the moon by taking hundreds of high resolution photographs of the lunar terrain, measuring lunar surface bearing strength and by making the first rudimentary chemical analysis of lunar materials. The initial phase of lunar exploration came to a close with the successful completion of the Surveyor project.

The next phase of our exploration of the moon will be conducted by men in the Apollo program currently approaching fruition. The initial landings and the subsequent modifications to the systems necessary for comprehensive exploration of the moon are funded under the Manned Space Flight program. However, a manned exploration of this scope requires a very solid foundation of scientific research if it is to be an effective program. Funding requested under the Supporting Research and Technology and Data Analysis projects will provide the science planning which will serve as the base for conducting meaningful exploration of the moon.

The planetary and interplanetary programs have experienced a high degree of success beginning with the Mariner II flyby of Venus and continuing with the most recent successful launching of the Pioneer IX spacecraft into an orbit around the Sun. The Mariner II mission in 1962, the first flyby mission to Venus, provided new data on the magnetic and atmospheric characteristics of the planet. The Mariner IV mission to Mars in 1965 provided the first close up photography of the planet's cratered surface and showed that its atmospheric density was very low compared to the earth. Mariner V, launched in June 1967, made more precise measurements of Venus' ionosphere, magnetosphere, and atmosphere. Pioneer IX, launched in November 1968, is the

latest in the current series of spacecraft designed to measure the interplanetary medium. Earlier missions provided data enabling a better understanding of the mechanisms related to the propagation through space of solar disturbances, the effect of these disturbances on terrestrial phenomena, and the relationship between solar activity and solar and cosmic rays.

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

RESOURCES REQUIRED:

	(Thousands of Dollars)		
	1968	1969	1970
Supporting research and technology/advanced studies	$19,800	$20,600	$24,600
Data analysis	600	2,600	2,700
Pioneer	6,000	5,000	18,200
Mariner-Mars 1969	62,850	27,200	4,900
Mariner-Mars 1971	---	18,300	45,400
Mariner-Mercury 1973	---	---	3,000
Viking	---	8,100	40,000
Planetary explorers	---	---	8,000

	(Thousands of Dollars) 1968	1969	1970
Advanced planetary missions technology	$12,000	---	---
Surveyor	33,000	---	---
Lunar orbiter	9,500	---	---
Mariner-Venus 1967	3,400	---	---
Voyager	350	---	---
Total	$147,500	$81,800	$146,800

Supporting Research and Technology/ Advanced Studies ($24,600,000)

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

During FY 1970, effort in the lunar science area will largely

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

Data Analysis ($2,700,000)

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

In 1970, the Lunar Data Analysis project will support continuing Lunar Orbiter photographic analysis. This analysis will emphasize geographical areas outside the Apollo landing zone, primarily for scientific interest. The balance of the funds requested will support analysis of data obtained in early Apollo lunar orbital and landing missions. The purpose of these analyses will also focus on potential Lunar Exploration mission requirements. The Planetary Data Analysis project will continue to support the reduction of data from the Mariner IV, Mariner V, and Pioneer missions; and also from earth upper atmosphere ex-

periments. It will provide the results for the use of the scientific community in advancing the knowledge of mankind in general.

Pioneer ($18,200,000)

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

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

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

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

FY 1970 funds will be used for design and development work on the spacecraft and the selected experiments for Pioneer F and G.

Operational support for the five active Pioneer spacecraft and for data analysis will continue. U.S. experiments for Helios will be selected and begun.

Mariner

The objective of the Mariner program is to conduct the early exploration of the planets with automated spacecraft in the medium weight class, about 1000 pounds. The Mariner spacecraft represents the tool in the Planetary program for remote observations, from an attitude controlled spacecraft of the other planets in the solar system. Mariner II flew by Venus in December 1962 to provide the first direct temperature and magnetic field measurements from near the planet. This was followed by the Mariner IV flight past Mars on 14 July 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 19 October 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.

The next step in the scientific exploration of the planets consists of two Mariner spacecraft to flyby Mars in early August

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

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

A single modified Mariner spacecraft will be used to study both Venus and Mercury in 1973. Although the similarities between Mars, Venus, and Earth make the study of these planets

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

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

Viking ($40,000,000)

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

The objectives established for the Viking project are to obtain, through the use of two lander/orbiter missions to Mars

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

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

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

Planetary Explorers ($8,000,000)

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

The Planetary Explorers will team with the larger Mariner spacecraft to produce a highly efficient program to explore the near planets, just as the most efficient program to explore the earth and its environment proved to be a mix of small Explorer orbiters with larger satellites such as Nimbus and OGO. As part of its role on the team, the magnetically clean Planetary Explorers will make those sensitive readings of the particle and field environments around Venus and Mars which are difficult to make aboard the higher-powered Mariners with their strong internal magnetic fields. The Planetary Explorers will thus free the Mariners to concentrate on conducting those high priority experiments which require stable and precise pointing, high power, and high data rate. Effort during Fiscal Year 1970 will include completion of the detailed design, fabrication, and test of a structural test model and a thermal control model.

OFFICE OF SPACE SCIENCE AND APPLICATIONS

BIOSCIENCE PROGRAM

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

RESOURCES REQUIRED:

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

WHY FUNDS REQUIRED:

Supporting Research and Technology/ Advanced Studies ($11,400,000)

Research in environmental biology deals with the response and interaction of living earth systems with the variables of the space and planetary environments. Critical space environmental factors, e.g., altered gravity, are being studied to determine the manner in which each of these individually or in combination with others, influence normal function in biologic systems removed from their normal earth habitat. Knowledge of

this nature is required to establish expeditious and efficient means for using a variety of living organisms to assist in the biologic exploration of the unique space environment. The ground based research carried out under Supporting Research and Technology (SR&T) supports flight research on the Biosatellite and other flight projects.

Behavioral biology seeks fundamental knowledge concerning the behavior of organisms, their behavioral mechanisms of adaptation to artificial and extraterrestrial environments, and determining the biologic bases of such behavior, thus providing a broader understanding of the function of the total organism and its environmental interactions. Both ground based and in-flight studies are designed to investigate the effects of weightlessness and other conditions peculiar to the space environment.

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

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

physical condition and well being of astronauts during space flight missions.

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

The Bioscience Communications project was established to increase effective communication between NASA program scientists and administrators and scientists in universities, industry, and other government agencies. Through support of ad hoc and interdisciplinary conferences, synposia, scientific training programs,

research literature and reports, and the Space Science Board of the National Academy of Sciences, the project works toward a more complete exchange of information and ideas within the scientific community.

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

Planetary Quarantine ($3,000,000)

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

The Planetary Quarantine activity is shown as a separate line item because of its direct relationship to the planetary flight program. Continuing efforts are being made, before

initiation of space flights destined to land on the planets, to assure adequate technology development in the solution of the complex problems related to the planetary quarantine constraints. The funding increase requested is in direct support of the Viking mission

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

Biosatellite ($18,000,000)

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

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

Biosatellite D, Primate Mission, is to be flown early in 1969 and will carry a primate and subject the animal to a long-duration period of weightlessness (up to 30 days) and through extensive instrumentation, will determine the changes that occur to his central nervous system and physiology The primate's brain waves will be recorded and analyzed as will its cardiovascular system performance (through electrocardiograms), its alertness, memory, and coordination through the use of a behavioral task performance panel. Also, through the use of a unique automated and miniature wet-chemistry laboratory, measurements of calcium and other urine constituents will be made to determine the changes in body metabolism.

Funding for FY 1970 will provide for continued development of the primate experiment, the analyses of the Biosatellite D

flight results, the acceptance of the spacecraft, and preparations for launch of Biosatellite F.

OFFICE OF SPACE SCIENCE AND APPLICATIONS
SPACE APPLICATIONS PROGRAM

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

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

Through these efforts the knowledge and technology of space are applied to the solution of the practical problems of mankind. Examples of these applications are: (1) improved weather forecasting through more knowledge and better understanding of the atmosphere and its content and energy; (2) improvement of communication techniques through understanding and expansion of

the frequency spectrum, development of space antenna designs and pointing accuracies, and increasing multi-access capabilities; (3) increasing our knowledge of the size and shape of the earth through the acquisition of global datum; and (4) better understanding and assessment of the factors affecting the agriculture environment, water resources, and soil and terrain conditions.

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

RESOURCES REQUIRED:

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

WHY FUNDS REQUIRED:

Supporting Research and Technology ($22,400,000)

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

TIROS/TOS Improvements ($5,200,000)

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

Nine TIROS research and development spacecraft funded by NASA and nine operational spacecraft funded by ESSA have been successfully launched. Current development effort by NASA is to complete the TIROS M spacecraft for launch in second quarter

of calendar year 1969. Under TOS Improvements, effort will be continued in the development of advanced sensors and subsystems such as high resolution radiometers and attitude determination systems which will be incorporated into future operational spacecraft. FY 1970 funds are required for post launch support and data acquisition and handling for TIROS M, for continued sensor and subsystems development for TOS Improvements and for a systems definition study for a future spacecraft system (TIROS N).

Nimbus ($29,200,000)

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

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

E in 1972, and F in 1973.

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

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

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

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

Meteorological Soundings ($3,000,000)

The objectives of this project are to investigate the structure and characteristics of the atmosphere through the use of sounding rockets and to develop a small inexpensive meteorological sounding rocket system. Three areas of effort are involved: (1) large research sounding rockets to explore the characteristics and phenomena of the atmosphere between 30 and about 100 km which is otherwise inaccessible; (2) the development

of an inexpensive operational meteorological sounding rocket system capable of reliable launches amenable to the requirements for range support, research, and network operations; (3) sounding rocket field experiment support, which, through cooperation with other countries, provides for the establishment of self-sustaining capabilities for coordinated meteorological sounding rocket launches from sites that will contribute mutually valuable data. Approximately 50 large research rockets and about 125 small development rockets are launched each year. FY 1970 funds are required to procure additional large research and small developmental rockets, flight test various payload experiments, improve rocket performance and to continue field experiment projects with other cooperating countries to obtain additional atmospheric research data.

Cooperative Applications Satellite ($100,000)

This cooperative project between the United States and France in space meteorology consists of developing instrumented balloon techniques to be utilized in conjunction with an earth orbiting satellite for the purpose of obtaining the characteristics of air masses, particularly in-site measurements of speed and wind direction at various altitudes. The meteorological data obtained will be used by U.S. and French scientists to assist in understanding the structure of the atmosphere and extended weather forecasting capability. One spacecraft and one backup with instruments will be provided by France. The spacecraft will be launched by NASA in 1970 to gather data from approximately 500 balloons, developed and launched by France in the Southern Hemisphere. Satellite tracking and data acquisition, reduction and analysis will be provided by France, after initial tracking by NASA. The U.S. will provide the Scout launch vehicle, and

backup if required, launch services, initial satellite tracking, and analysis, along with France, of the reduced data.

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

Applications Technology Satellites ($44,200,000)

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

FY 1970 funds are required to complete development of the

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

Geodetic Satellites ($3,000,000)

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

Three geodetic satellites have been launched, PAGEOS I, 23 June 1966; GEOS I, 6 November 1965; and GEOS II, 11 January 1968. Data obtained from these launches are utilized in the establishment of a unified worldwide geodetic datum. Effort will be initiated in FY 1970 for an additional mission (GEOS-C) for launch in late CY 1970, to obtain the additional data required to meet the gravimetric objective of the National Geodetic Satellite Program, and to demonstrate the feasibility of employing a geodetic satellite radar altimeter to measure the mean sea level of the oceans. FY 1970 funds are required for continued data acquisition and analysis, and for preparations for the GEOS-C mission.

Earth Resources Survey ($25,100,000)

The objectives of this project are to: (1) assess the practical value of remote sensing of earth resources from space; (2) compare the capabilities in earth resources data acquisition of a space system versus aircraft; (3) determine whether, and in what configuration, an operational space-assisted user-oriented earth resources survey system should be pursued; (4) determine which remote sensors are most effective for earth resources survey-

ing; (5) develop and improve data handling procedures; and (6) ensure full understanding of operational system requirements and costs.

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

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

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

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

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

OFFICE OF SPACE SCIENCE AND APPLICATIONS
LAUNCH VEHICLE PROCUREMENT PROGRAM

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

RESOURCES REQUIRED:

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

WHY FUNDS REQUIRED:

Supporting Research and Technology/ Advanced Studies ($4,000,000)

Under this project launch vehicle requirements to support future missions are defined and new technology required for advanced missions is developed in a timely and orderly manner. In FY 1968 and FY 1969 advanced studies efforts have been directed toward the Centaur/Burner II integration, Saturn S-IVB/Centaur

integration, and solar-electric propulsion. In FY 1970 advanced studies are planned in the areas of chemical and electric high-energy upper stages. FY 1969 supporting research and technology efforts are being conducted in five disciplines of launch vehicle technology: Propulsion and energy conversion, guidance, control and navigation, instrumentation and electronics, structures and materials, and vehicle engineering. In FY 1970 efforts in these areas will be continued.

Scout ($15,700,000)

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

Delta ($33,700,000)

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

Agena ($7,300,000)

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

Centaur ($57,600,000)

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

Titan III C ($5,900,000)

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

OFFICE OF UNIVERSITY AFFAIRS
SUSTAINING UNIVERSITY PROGRAM

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

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

The program is designed to bring the universities into closer partnership with NASA. It helps increase the nation's technological resources by sharing with the universities the responsibility of determining, directing, and assessing research and training pursuits. This support is largely managed by the

universities, and thereby provides the distinct benefit of contributing to greater fiscal and academic strength in each university. The program also has the effect of providing greater geographic distribution of research support.

RESOURCES REQUIRED:

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

WHY FUNDS REQUIRED:

Research ($5,000,000)

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

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

Administration and Management ($1,500,000)

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

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

Engineering Systems Design ($1,000,000)

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

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

Special Training ($1,500,000)

As aerospace manpower deficiencies are identified, the Sustaining University program responds with special training

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

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

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY

BASIC RESEARCH PROGRAM

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

RESOURCES REQUIRED:

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

WHY FUNDS REQUIRED:

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

The Fluid Physics subprogram promotes basic research on aero-

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

The objective of the electrophysics subprogram is to obtain a better understanding of fundamental electron-atom-molecule behavior in an environment of acoustic, nuclear, electric, and magnetic forces. The research results are directly relevant to advancing communications technology, plasma propulsion technology, and the technology associated with several advanced space power supply systems.

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

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

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY
SPACE VEHICLE SYSTEMS PROGRAM

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

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

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

RESOURCES REQUIRED:

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

WHY FUNDS REQUIRED:

Research and Technology ($8,545,000)

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

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

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

Scout-launched reentry technology experiments, which deal with aerothermodynamic aspects of atmosphere entry flight, will continue. A planetary atmosphere experiment will investigate a

technique to use special measurements of vehicle motions and heating to determine the properties and composition of an unknown planetary atmosphere. A heat transfer and boundary layer transition experiment will measure heat transfer, map the transition region, and measure the acoustic environment.

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

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

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

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

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

The importance of meteoroid protection increases as space vehicles become larger and mission durations become longer. A flight experiment to investigate the effectiveness of meteoroid

bumpers will be undertaken to provide correlation with laboratory investigations. Flight experiments to obtain additional data on both the near-earth and interplanetary meteoroid environments may be included on missions conducted for other purposes.

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

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

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

Aerospace Safety Research ($1,800,000)

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

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY

ELECTRONICS SYSTEMS PROGRAM

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

RESOURCES REQUIRED:

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

WHY FUNDS REQUIRED:

Supporting Research and Technology ($35,000,000)

The requested FY 1970 funds are needed to support basic and applied research and advanced technical development efforts in the disciplines related to electronics and control. Avionic components are an integral part of all automatic and semiautomatic systems used in aircraft and manned and unmanned space vehicles. Key systems and components such as communications, flight control, navigation and guidance, computation and data processing, a myriad of sensors, reference and control systems, approach and landing, surveillance and identification, and hazard avoidance depend on electronic equipment. Specific objectives of the guidance program are advanced precision inertial and electromagnetic sensors and simplified techniques for navigation and guidance applicable to supersonic aircraft and future space vehicles. Increased emphasis on V/STOL aircraft guidance, control and display systems will help realize the promise which V/STOL vehicles have in relieving overloaded transportation systems in major population centers. Advanced research in avionics offers substantial support to various aspects of air traffic control such as communications, navigation, surveillance, and hazard avoidance. Research in communication at higher frequencies (centimeter to millimeter wave lengths) is expected to result in higher information transfer rates, smaller and lighter weight antennas, simpler power generation equipment. Continued advancements in the technology of computing and data processing are required to keep pace with the growing complexity, variety and volume of data attendant to the experimental development and operation of advanced aeronautical and space vehicles; the end objective is to facilitate the acquisition and extraction of useful information for human

users. Instrumentation research will be continued to advance measurement capabilities in the far ultraviolet and soft X-ray regions. Development of instrumentation systems will be carried on using laser technology for accurate measurement of gas parameters and flow field characteristics of test models at hypersonic speeds. Research in solid state technology with emphasis on integrated circuits in which many components are combined into one functional assembly of minute weight and size for aerospace application will be continued; integral to the program is the search for materials and techniques to provide longer useful lifetimes of components and a consequent reduction in cost of both system and component testing.

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY

HUMAN FACTOR SYSTEMS PROGRAM

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

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

RESOURCES REQUIRED:

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

WHY FUNDS REQUIRED:

Supporting Research and Technology ($21,600,000)

This is an integrated program effort directed toward fulfillment of the Human Factor Systems program objectives. In FY 1970, emphasis will be given to investigations to define and understand such phenomena as changes in man's cardiovascular function due to prolonged exposure to zero gravity and other space flight stressors, behavioral changes in small groups of men isolated and confined for extended periods, the unique design features necessary to ensure the highest reliability of life support and protective systems, and the psychological and physiological effects of aircraft noise. These and other problem areas require research in cardiovascular, respiratory, and vestibular physiology; in bioinstrumentation, to measure the effects of stresses on man and animals; in radiobiology, stress endocrinology, and microbiology; in water and waste management; in oxygen regeneration and air pollution control; in space suits; in extravehicular activities; in man-machine interactions, and in many more areas. The work is directed toward defining and solving known and anticipated problems in future aeronautical and space operations.

Biotechnology Flight Projects ($2,000,000)

The small flight experiments are designed to provide informa-

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

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

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

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

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

technology program are essential steps toward the goal of early application.

RESOURCES REQUIRED:

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

*Included in the Supporting Research and Technology.

WHY FUNDS REQUIRED:

Supporting Research and Technology ($39,400,000)

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

Emphasis in the FY 1970 solar power generation program will be placed on obtaining improved understanding of the structural dynamic characteristics of large area solar cell arrays. In addition, technological advances in the electromechanical drive

systems needed to turn the large solar cell arrays to track the sun will be pushed. Methods for compact stowage during launch, and reliable, automatic deployment once in space, will be pursued for these high power solar cell arrays. Major advances in the resistance of solar cells to degradation in the space environment will be sought in FY 1970.

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

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

The electric thruster technology program continues to make progress toward the goal of early mission application. During FY 1969, such systems have seen their first NASA operational flight in the Applications Technology Satellite (ATS) program where accurate production of very low thrust for accomplishing east-west station keeping was the principal advantage sought and

realized. During FY 1970 the electric propulsion program will focus on the high, specific impulse ion thruster system with electric thrust vectoring capability which shows to advantage in long duration missions for both auxiliary and prime propulsion applications. Work on the high temperature resistojet and the use of biowastes as propellants from the life support system for manned space stations will also continue.

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

Space Electric Rocket Test (SERT) ($500,000)

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

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY
NUCLEAR ROCKETS PROGRAM

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

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

RESOURCES REQUIRED:

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

WHY FUNDS REQUIRED:

Supporting Research and Technology ($8,000,000)

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

NERVA ($27,500,000)

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

NRDS Operations ($1,000,000)

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

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY

CHEMICAL PROPULSION PROGRAM

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

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

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

Propulsion processes, performance improvement, combustion

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

RESOURCES REQUIRED:

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

WHY FUNDS REQUIRED:

Supporting Research and Technology ($25,100,000)

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

vironment are being explored.

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

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

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY
AERONAUTICAL VEHICLES PROGRAM

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

RESOURCES REQUIRED:

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

Advanced Research ($21,785,000)

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

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

The primary goals of the Advanced Research air breathing propulsion program are to provide advanced technology through analytical and experimental investigations of engine components and propulsion concepts which either are not readily identified with a specific flight spectrum or else identified over a broad flight spectrum. Included are research studies of: basic

mechanism of fan and compressor noise generation and suppression, jet exhaust noise suppression, development of engine noise prediction techniques, technological assessment of nuclear power for aircraft use, and smoke suppression of jet engines. Basic studies will be continued on advanced bearing and lubrication systems, and on aircraft-propulsion system integration problems.

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

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

General Aviation Aircraft Technology ($500,000)

The general aviation industry continues to exhibit rapid growth, especially in the area of the scheduled air taxi operation (so-called third level carrier, mini-airlines, etc.) where the small airplane is providing air transportation links between

small communities and major air terminals. In order to assure a continuing increase in the level of operational safety and utility, the NASA is conducting research to provide the necessary technology base which the industry and FAA can use for constantly improving these aircraft. The program encompasses aerodynamics, structures, and flight dynamics technology which, coupled to the effort in the operating environment area, is already beginning to fill the technology gaps in the general aviation area.

V/STOL Aircraft Technology ($11,250,000)

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

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

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

of future production V/STOL aircraft.

Subsonic Aircraft Technology ($16,190,000)

Technology work on subsonic aircraft is oriented toward safety of flight, improvement of flight efficiency and the reduction of noise. In the disciplinary areas, aerodynamic technology will be conducted on advanced aircraft configurations with particular emphasis on seeking favorable flow interactions between airframes and high by-pass ratio turbofan engines. Structures research applicable to subsonic commercial aircraft will include studies of structural loads and environment, fatigue and the development of improved crack detection techniques. Propulsion technology will seek to improve the efficiency, utility and safety of present and advanced subsonic aircraft propulsion system concepts and to provide supporting in-house technology for the Quiet Engine Project. Included are analytical and experimental research studies of high performance, low noise fans, compressors, combustors and turbines and studies of problems related to the integration of the Quiet Engine with subsonic aircraft. Flight dynamics research will be concentrated on investigation of handling qualities and operational techniques of subsonic jet transports to provide a more rational foundation for certification criteria, studies of pilot-managed automatic flight control in terminal area operations, and tests of improved vertical situation displays for noise abatement steep approaches.

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

In continuing to provide the full research and technology support required by the Interagency Aircraft Noise Abatement Pro-

gram, the NASA will conclude the nacelle fan noise minimization program by conducting flight tests of choked inlet nacelles (final configurations of acoustically treated nacelles will have been completed in FY 1969) and fabricating and testing components for the Quiet Engine project.

Supersonic Aircraft Technology ($20,900,000)

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

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

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

Utilizing an F-111A aircraft, measurements of high-frequency

inlet airflow oscillations are continuing. In addition, flight tests of a boron composite horizontal tail and an investigation of aerodynamic buffet will be made.

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

Hypersonic Aircraft Technology ($8,275,000)

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

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

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

OFFICE OF TRACKING AND DATA ACQUISITION

TRACKING AND DATA ACQUISITION PROGRAM

The purpose of this program is to provide responsive and efficient tracking and data acquisition support to meet the requirements of all NASA flight projects. In addition, support is provided, as mutually agreed, for projects of the Department of Defense, other Government agencies, and other countries and international organizations engaged in space research endeavors.

Support is provided for manned and unmanned flights; for spacecraft, sounding rockets, and research aircraft; for earth orbital and suborbital missions; for lunar and planetary missions; and for space probes.

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

Tracking and data acquisition support is provided by a worldwide network of NASA ground stations supplemented by appropriate instrumentation ships, aircraft, and ground stations of the Depart-

ment of Defense. These facilities are interconnected by a network of ground communication lines, undersea cables, high frequency radio links, and communication satellite circuits, which provide the capability for instantaneous transmission of data and critical commands between spacecraft and the control centers in the United States from which the flights are directed. Facilities also are provided to process into meaningful form the large amounts of data which are collected from flight projects. In addition, instrumentation facilities are provided for support of sounding rocket launchings and flight testing of research aircraft.

RESOURCES REQUIRED:

	(Thousands of Dollars) 1968	1969	1970
Operations	$211,483	$226,950	$239,400
Equipment	51,567	41,222	46,100
Supporting research and technology	12,800	11,500	12,500
Total	$275,850	$279,672	$298,000

WHY FUNDS REQUIRED:

Operations ($239,400,000)

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

In the Deep Space Network, additional engineering effort is

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

Equipment ($46,100,000)

The tracking and data acquisition support requirements placed on the networks establish needs for equipments which are essential to provide the continual on-going support for approved and planned programs. Funds for equipment are required to replace obsolete and wornout items, to modify existing systems to maintain compatibility with changes in spacecraft instrumentation, to increase the support utilization and efficiency of existing systems, and to complete or provide new systems required to support specific flight missions of approved and planned programs. In FY 1970, emphasis will continue on sustaining the existing capability of the networks with only minor augmentations of equipment to meet the requirements of new programs such as the Earth Resources Technology Satellite (ERTS).

Supporting Research and Technology ($12,500,000)

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

OFFICE OF TECHNOLOGY UTILIZATION

TECHNOLOGY UTILIZATION PROGRAM

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

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

RESOURCES REQUIRED:

	(Thousands of Dollars) 1968	1969	1970
Identification and publication	$1,500	$1,600	$1,700
Evaluation	700	800	950
Dissemination	1,600	1,400	2,350
Analysis	200	---	---
Total	$4,000	$3,800	$5,000

WHY FUNDS REQUIRED:

Identification and Publication ($1,700,000)

Technology Utilization Officers at NASA field installations and specialists from universities, research institutes and private industry search through selected areas of scientific and technical endeavor, and identify and document those inventions, innovations, improvements, and discoveries that have potential utility to the nonaerospace sector of the economy. Continued increased emphasis is placed on the identification and reporting of new technology by NASA contractors.

Evaluation ($950,000)

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

Dissemination ($2,350,000)

This program element is accomplished by the employment of

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

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