National Aeronautics and Space Administration

BUDGET ESTIMATES

FISCAL YEAR 1969

Volume II

RESEARCH AND DEVELOPMENT

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1969 ESTIMATES

RESEARCH AND DEVELOPMENT

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT

GENERAL STATEMENT

The National Aeronautics and Space Administration program of research and development and supporting activities is directed toward maintaining the United States in a position of world leadership in aeronautics and space. The major programs for achieving this objective are:

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

SPACE SCIENCE AND APPLICATIONS: An unmanned space flight program directed toward scientific investigations of the earth, moon, sun, planets, stars and interplanetary space; and the development of technology and spacecraft systems which can be utilized for meteorology, communications and geodetic and earth resources observations.

ADVANCED RESEARCH AND TECHNOLOGY: An effort required to provide the fundamental knowledge and the technological base for future aeronautics and space programs.

TRACKING AND DATA ACQUISITION: The world wide activity required to support the NASA manned and unmanned flight programs.

MANNED SPACE FLIGHT

Manned Space Flight activities, continue to comprise the largest portion of the budget request. Included are the development and demonstration of a capability for manned space operations and exploration. The primary objective of landing men on the moon and returning them safely to earth within this decade remains unchanged and is still possible in 1969. Projects Mercury and Gemini have been completed. Apollo, slowed by the spacecraft flash fire last year, is regaining its momentum as evidenced by the highly successful "all up" flight test of the Saturn V launch vehicle. The first manned Apollo mission is scheduled in 1968. The Apollo Applications program has moved from the definition and design phase to actual hardware fabrication. The program is directed toward increasing the effectiveness of manned flight operations in the accomplishment of experiments and other in-flight activities, using capabilities developed in the Apollo program. Flight activity to begin in 1970 is designed to accomplish a limited but carefully selected spectrum of scientific, technological and biomedical investigations. The program is configured to maintain progress in manned space flight and to provide information required for future decisions concerning the follow-on space programs.

SPACE SCIENCE AND APPLICATIONS

The Space Science and Applications program is the second largest in the FY 1969 budget request. The scientific program includes studies of the solar system, stars, and space environment. Research on the earth and its local environment is conducted through the use of balloons, sounding rockets, explorers, and the Orbiting Geophysical Observatories. Studies of the sun are carried out using the Orbiting Solar Observatory. The Orbiting Astronomical Observatory, explorers, and sounding rockets support a program of research in astronomy. Planetary and interplanetary studies are accomplished through use of the Pioneer, Mariner, and advanced planetary spacecraft. The Biosatellite program continues investigation on the effects of the space environment on living organisms. The Applications program is made up of activities for adapting space technology to the direct benefit of mankind. TIROS and Nimbus continue to support requirements of the atmospheric sciences research community and continued improvements in operational weather satellite systems. Applications Technology Satellites are being used to develop information and test techniques for new applications in the areas of communications, navigation, and traffic control. Geodetic Satellites will continue to conduct measurements on a global basis and Meteorological Sounding Rocket launches will continue studies in the region of 20 to 60 miles above the earth. Efforts to develop remote sensing techniques for use in earth resources survey will be increased in FY 1969.

ADVANCED RESEARCH AND TECHNOLOGY

The Advanced Research and Technology effort is a continuing program aimed at providing the technological base for significant future aero-space missions. This effort covers the spectrum of activity from basic research to improve our fundamental scientific knowledge, through applied technology to improve our practical capability for developing advanced systems applicable to space and aeronautical activity. The specific areas of effort in the program are Basic Research, Biotechnology and Human Research, Electronics and Control, Nuclear Systems and Space Power, Chemical Propulsion, Space Vehicle Research and Technology, and Aeronautics.

TRACKING AND DATA ACQUISITION

The Tracking and Data Acquisition effort is directed toward providing the support required by the NASA space flight programs. As in the current year, the largest part of the FY 1969 request is for operating the world wide network of tracking and data acquisition facilities. This activity will increase in FY 1969 to meet the support requirements of the Apollo manned lunar landing program. Activity in support of the unmanned space flight programs will remain at approximately the same level as in the current year.

Funds in FY 1969 for replacement of equipment and maintaining the capability of the facilities remain at approximately the same sustaining level as in the current year with only minor augmentations of capability to meet requirements of new programs. The Supporting Research and Technology effort will continue at the same level as in the current year.

TECHNOLOGY UTILIZATION

The Technology Utilization program covers the dissemination of the scientific, technological and engineering information and concepts resulting from NASA programs so as to assist in the fullest use of this information for the benefit of the nation. In order to assure fulfillment of this objective, the program provides not only for the collection and dissemination of these data but also for: (a) establishing effective mechanisms and systems for assuring that all new knowledge is identified, collected and evaluated; and, (b) establishing effective mechanisms for announcing and disseminating this new knowledge in order to assure its wide application and utilization.

SUSTAINING UNIVERSITY PROGRAM

NASA depends upon universities to supply expertise and competence essential to the space effort, in areas available only in universities. University scientists contribute new knowledge, serve on space advisory groups, train scientists, engineers and managers for the space program. From their participation, universities gain new knowledge and experience necessary to their continued technical and academic growth. NASA needs universities to concentrate their research efforts on the greater complexities of space projects that may be undertaken in the future. NASA support to universities is mostly through the agency's Program Offices and Centers in conducting research and development for specific projects. Many needs are outside the scope of this project research, and require the flexibility, breadth, and long-range view of the Sustaining University Program in multidisciplinary research, training of graduate students in disciplines representing particular NASA needs, special studies and training in space research, administration of the space program and in engineering systems design.

FINANCING

The FY 1969 Research and Development program plan, discussed in this volume, requires $3,677,200,000, a reduction of $293,400,000 below the FY 1968 program of $3,970,600,000.

Research and Development expenditures for the current fiscal year are estimated at $4,004,500,000 and at $3,851,300,000 for FY 1969, a reduction of $153,300,000.

REIMBURSEMENT AT EASTERN TEST RANGE

The cost to NASA for use of the Air Force Eastern Test Range has been increased by $26.2 million in FY 1969. The Bureau of the Budget provided a new formula for the distribution of costs at the Range which increased the cost sharing requirement to NASA from $25.2 million to $51.4 million. This new arrangement for NASA reimbursement to the Air Force recognizes the impact of NASA activities on the Eastern Test Range Support functions. The DOD retains responsibility for range management and the funding associated therewith. NASA continues to pay for all additional directly identifiable costs and under the new provision will reimburse DOD for a share of the operational support costs based upon the estimated use ratio of operational facilities and equipment. Specific categories of technical support that have been added to the NASA reimbursement include range instrumentation ships and aircraft, mainland and down range instrumentation sites for tracking and communications, and data processing.

This additional funding requirement has been distributed to two line items in the present NASA FY 1969 budget. Network Operations under Tracking and Data Acquisition has been increased by $6.4 million to cover estimated costs of range instrumentation ships and aircraft and special communications requirements. Launch operations under Apollo has been increased by $19.8 million to cover the remainder of the new reimbursement cost including operational support to flight missions, and general support from technical shops and instrumentation sites. NASA anticipates that when refined cost data are available from the Air Force Eastern Test Range providing a more precise association of cost with specific categories of technical support, some realignment of funding among NASA programs may be indicated.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1969 ESTIMATES

SUMMARY OF RESEARCH AND DEVELOPMENT BUDGET PLAN BY BUDGET ACTIVITY AND RELATED FINANCING

	Fiscal Year 1967	Fiscal Year 1968	Fiscal Year 1969
Budget Activity:			
1. Manned Space Flight:			
(a) Gemini..........	$ 15,200,000	---	---
(b) Apollo..........	2,922,600,000	$2,556,000,000*	$2,038,800,000
(c) Apollo applications..	80,000,000	253,200,000	439,600,000
(d) Advanced mission studies.......	6,200,000	---	5,000,000
2. Scientific Investigations in Space:			
(a) Physics and astronomy.....	160,837,000	175,817,000	175,922,000
(b) Lunar and planetary exploration...	201,005,000	150,666,000	113,900,000
(c) Bioscience......	42,000,000	45,700,000	54,400,000
(d) Launch vehicle development...	77,452,000	61,340,000	61,300,000
3. Space Applications....	91,486,000	114,337,000	127,338,000
4. Space Technology......	235,570,000	256,890,000	265,240,000
5. Aircraft Technology...	35,900,000	66,800,000	76,900,000
6. Supporting Activities:			
(a) Tracking and data acquisition...	270,850,000	275,850,000	304,800,000
(b) Sustaining university program.......	31,000,000	10,000,000	10,000,000
(c) Technology utilization...	5,000,000	4,000,000	4,000,000
Total Budget Plan...	$4,175,100,000	$3,970,600,000*	$3,677,200,000

*Includes $60 million of prior year funds applied to FY 1968 budget plan.

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1969 ESTIMATES

SUMMARY OF RESEARCH AND DEVELOPMENT BUDGET PLAN BY BUDGET ACTIVITY AND RELATED FINANCING

	Fiscal Year 1967	Fiscal Year 1968	Fiscal Year 1969
Financing:			
Appropriation...............	$4,245,000,000	$3,925,000,000	$3,677,200,000
Transferred to other accounts.................	-9,900,000	-14,400,000	---
Appropriation (adjusted)............	4,235,100,000	3,910,600,000	3,677,200,000
Unobligated balance, start of year - available to finance new budget plans..	---	60,000,000	---
Unobligated balance, end of year - available to finance new budget plans..........	-60,000,000	---	---
Total financing of the budget plan...........	$4,175,100,000	$3,970,600,000	$3,677,200,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1969 ESTIMATES

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

BUDGET ACTIVITY	OFFICE/PROGRAM	Fiscal Year 1967	Fiscal Year 1968	Fiscal Year 1969
	MANNED SPACE FLIGHT.........	$3,024,000,000	$2,809,200,000	$2,483,400,000
1a	Gemini....................	15,200,000	---	---
1b	Apollo....................	2,922,600,000	2,556,000,000**	2,038,800,000
1c	Apollo applications.......	80,000,000	253,200,000	439,600,000
1d	Advanced mission studies..	6,200,000	---	5,000,000
	SPACE SCIENCE AND APPLICATIONS...............	576,100,000	552,850,000	538,200,000
2a	Physics and astronomy.....	129,800,000	142,950,000	141,900,000
2b	Lunar and planetary exploration.............	184,150,000	141,500,000	107,300,000
2d	Launch vehicle development	31,200,000	---	---
*	Launch vehicle procurement	117,650,000	127,100,000	128,300,000
2c	Bioscience................	42,000,000	41,800,000	48,500,000
3	Space applications........	71,300,000	99,500,000	112,200,000
	UNIVERSITY AFFAIRS			
6b	Sustaining university program.................	31,000,000	10,000,000	10,000,000
	ADVANCED RESEARCH AND TECHNOLOGY.................	268,150,000	318,700,000	336,800,000
4	Basic research............	21,401,000	21,465,000	22,000,000
4	Space vehicle systems.....	33,909,000	35,000,000	35,300,000
4	Electronics systems.......	33,597,000	39,200,000	39,400,000
4	Human factor systems......	16,265,000	20,985,000	21,700,000
4	Space power and electric propulsion systems......	40,440,000	44,000,000	44,800,000
4	Nuclear rockets...........	53,000,000	54,000,000	60,000,000
4	Chemical propulsion.......	33,638,000	37,250,000	36,700,000
5	Aeronautical vehicles.....	35,900,000	66,800,000	76,900,000
6a	TRACKING AND DATA ACQUISITION	270,850,000	275,850,000	304,800,000
6c	TECHNOLOGY UTILIZATION......	5,000,000	4,000,000	4,000,000
	TOTAL BUDGET PLAN.........	$4,175,100,000	$3,970,600,000**	3,677,200,000

*Funds for the procurement of launch vehicles are statistically distributed to unmanned flight programs (e.g., Physics and Astronomy, Space Vehicle Systems).
**Includes $60 million of prior year funds applied to FY 1968 budget plan.

PROGRAM OFFICE	TOTAL	J. F. KENNEDY SPACE CENTER, NASA	MANNED SPACECRAFT CENTER	MARSHALL SPACE FLIGHT CENTER	GODDARD SPACE FLIGHT CENTER	JET PROPULSION LABORATORY	WALLOPS STATION	AMES RESEARCH CENTER	ELECTRONICS RESEARCH CENTER	FLIGHT RESEARCH CENTER	LANGLEY RESEARCH CENTER	LEWIS RESEARCH CENTER	SPACE NU PROPUL OFFI
Office of Manned Space Flight													
1967	3,024,000	213,950	1,444,896	1,323,017	273	-	-	365	-	-	1,426	-	
1968	2,809,200	356,600	1,271,900	1,121,100	3,100	800	-	-	2,000	-	1,000	-	
1969	2,483,400	374,300	1,089,700	959,900	3,200	1,100	-	-	1,200	-	1,000	-	
Office of Space Science and Applications.													
1967	576,100	2,546	105	1,949	179,272	143,499	761	43,489	3,544	10	41,347	109,962	
1968	552,850	5,290	7,109	1,276	207,607	115,217	1,640	41,544	3,615	-	25,717	79,800	
1969	538,200	5,900	12,800	1,145	215,456	64,248	1,335	44,430	4,540	-	42,515	75,800	
Office of University Affairs													
1967	31,000	-	-	-	-	-	-	-	-	-	-	-	
1968	10,000	-	-	-	-	-	-	-	-	-	-	-	
1969	10,000	-	-	-	-	-	-	-	-	-	-	-	
Office of Advanced Research and Technology													
1967	268,150	49	2,770	17,327	10,960	20,019	-	20,932	12,824	8,346	46,336	52,652	47,
1968	318,700	175	4,420	17,090	9,006	23,502	535	23,502	20,655	21,668	56,774	59,263	49,
1969	336,800	150	4,850	18,140	9,568	28,720	500	26,150	21,199	16,740	59,838	70,766	54,
Office of Tracking and Data Acquisition													
1967	270,850	-	-	800	195,800	51,350	5,750	-	-	1,900	2,250	-	
1968	275,850	-	-	400	197,350	57,200	6,400	-	-	2,100	1,900	-	
1969	304,800	-	-	300	227,300	55,300	6,800	-	-	2,100	1,600	-	
Office of Technology Utilization													
1967	5,000	-	-	-	-	-	-	-	-	-	-	-	
1968	4,000	-	-	-	-	-	-	-	-	-	-	-	
1969	4,000	-	-	-	-	-	-	-	-	-	-	-	
Total Budget Plan													
1967	4,175,100	216,545	1,447,771	1,343,093	386,305	214,868	6,511	64,786	16,368	10,256	91,359	162,614	47,
1968	3,970,600	362,065	1,283,429	1,139,866	417,063	196,719	8,575	65,046	26,270	23,768	85,391	139,063	49,
1969	3,677,200	380,350	1,107,350	979,485	455,524	149,368	8,635	70,580	26,939	18,840	104,953	146,566	54,

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1969 ESTIMATES

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

(Thousands of dollars)

?ICE	TOTAL	J. F. KENNEDY SPACE CENTER, NASA	MANNED SPACECRAFT CENTER	MARSHALL SPACE FLIGHT CENTER	GODDARD SPACE FLIGHT CENTER	JET PROPULSION LABORATORY	WALLOPS STATION	AMES RESEARCH CENTER	ELECTRONICS RESEARCH CENTER	FLIGHT RESEARCH CENTER	LANGLEY RESEARCH CENTER	LEWIS RESEARCH CENTER	SPACE NUCLEAR PROPULSION OFFICE	NASA HEADQUARTERS	WESTERN SUPPORT OFFICE
ice Flight															
....	3,024,000	213,950	1,444,896	1,323,017	273	-	-	365	-	-	1,426	-	-	40,073	-
....	2,809,200	356,600	1,271,900	1,121,100	3,100	800	-	-	2,000	-	1,000	-	-	52,700	-
....	2,483,400	374,300	1,089,700	959,900	3,200	1,100	-	-	1,200	-	1,000	-	-	53,000	-
nce and															
....	576,100	2,546	105	1,949	179,272	143,499	761	43,489	3,544	10	41,347	109,962	-	41,385	8,231
....	552,850	5,290	7,109	1,276	207,607	115,217	1,640	41,544	3,615	-	25,717	79,800	-	52,235	11,800
....	538,200	5,900	12,800	1,145	215,456	64,248	1,335	44,430	4,540	-	42,515	75,800	-	70,031	-
Affairs															
....	31,000	-	-	-	-	-	-	-	-	-	-	-	-	31,000	-
....	10,000	-	-	-	-	-	-	-	-	-	-	-	-	10,000	-
....	10,000	-	-	-	-	-	-	-	-	-	-	-	-	10,000	-
esearch and															
....	268,150	49	2,770	17,327	10,960	20,019	-	20,932	12,824	8,346	46,336	52,652	47,835	19,198	8,902
....	318,700	175	4,420	17,090	9,006	23,502	535	23,502	20,655	21,668	56,774	59,263	49,700	25,904	6,506
....	336,800	150	4,850	18,140	9,568	28,720	500	26,150	21,199	16,740	59,838	70,766	54,600	25,579	-
nd Data															
....	270,850	-	-	800	195,800	51,350	5,750	-	-	1,900	2,250	-	-	13,000	-
....	275,850	-	-	400	197,350	57,200	6,400	-	-	2,100	1,900	-	-	10,500	-
....	304,800	-	-	300	227,300	55,300	6,800	-	-	2,100	1,600	-	-	11,400	-
Utilization															
....	5,000	-	-	-	-	-	-	-	-	-	-	-	-	5,000	-
....	4,000	-	-	-	-	-	-	-	-	-	-	-	-	4,000	-
....	4,000	-	-	-	-	-	-	-	-	-	-	-	-	4,000	-

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1969 ESTIMATES

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

(Thousands of dollars)

PROGRAM OFFICE	TOTAL	J. F. KENNEDY SPACE CENTER, NASA	MANNED SPACECRAFT CENTER	MARSHALL SPACE FLIGHT CENTER	GODDARD SPACE FLIGHT CENTER	JET PROPULSION LABORATORY	WALLOPS STATION	AMES RESEARCH CENTER	ELECTRONICS RESEARCH CENTER	FLIGHT RESEARCH CENTER	LANGLEY RESEARCH CENTER	LEWIS RESEARCH CENTER	SPACE NUCLE[illegible] PROPULSIO[illegible] OFFICE
Office of Manned Space Flight													
1967....................	3,024,000	213,950	1,444,896	1,323,017	273	-	-	365	-	-	1,426	-	
1968....................	2,809,200	356,600	1,271,900	1,121,100	3,100	800	-	-	2,000	-	1,000	-	
1969....................	2,483,400	374,300	1,089,700	959,900	3,200	1,100	-	-	1,200	-	1,000	-	
Office of Space Science and Applications.													
1967....................	576,100	2,546	105	1,949	179,272	143,499	761	43,489	3,544	10	41,347	109,962	
1968....................	552,850	5,290	7,109	1,276	207,607	115,217	1,640	41,544	3,615	-	25,717	79,800	
1969....................	538,200	5,900	12,800	1,145	215,456	64,248	1,335	44,430	4,540	-	42,515	75,800	
Office of University Affairs													
1967....................	31,000	-	-	-	-	-	-	-	-	-	-	-	
1968....................	10,000	-	-	-	-	-	-	-	-	-	-	-	
1969....................	10,000	-	-	-	-	-	-	-	-	-	-	-	
Office of Advanced Research and Technology													
1967....................	268,150	49	2,770	17,327	10,960	20,019	-	20,932	12,824	8,346	46,336	52,652	47,[illegible]
1968....................	318,700	175	4,420	17,090	9,006	23,502	535	23,502	20,655	21,668	56,774	59,263	49,[illegible]
1969....................	336,800	150	4,850	18,140	9,568	28,720	500	26,150	21,199	16,740	59,838	70,766	54,[illegible]
Office of Tracking and Data Acquisition													
1967....................	270,850	-	-	800	195,800	51,350	5,750	-	-	1,900	2,250	-	
1968....................	275,850	-	-	400	197,350	57,200	6,400	-	-	2,100	1,900	-	
1969....................	304,800	-	-	300	227,300	55,300	6,800	-	-	2,100	1,600	-	
Office of Technology Utilization													
1967....................	5,000	-	-	-	-	-	-	-	-	-	-	-	
1968....................	4,000	-	-	-	-	-	-	-	-	-	-	-	
1969....................	4,000	-	-	-	-	-	-	-	-	-	-	-	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	91,359	162,614	47,[illegible]

PROGRAM OFFICE	TOTAL	J. F. KENNEDY SPACE CENTER, NASA	MANNED SPACECRAFT CENTER	MARSHALL SPACE FLIGHT CENTER	GODDARD SPACE FLIGHT CENTER	JET PROPULSION LABORATORY	WALLOPS STATION	AMES RESEARCH CENTER	ELECTRONICS RESEARCH CENTER	FLIGHT RESEARCH CENTER	LANGLEY RESEARCH CENTER	LEWIS RESEARCH CENTER	SPACE PRO… O…
Office of Manned Space Flight													
1967.....................	3,024,000	213,950	1,444,896	1,323,017	273	-	-	365	-	-	1,426	-	
1968.....................	2,809,200	356,600	1,271,900	1,121,100	3,100	800	-	-	2,000	-	1,000	-	
1969.....................	2,483,400	374,300	1,089,700	959,900	3,200	1,100	-	-	1,200	-	1,000	-	
Office of Space Science and Applications.													
1967.....................	576,100	2,546	105	1,949	179,272	143,499	761	43,489	3,544	10	41,347	109,962	
1968.....................	552,850	5,290	7,109	1,276	207,607	115,217	1,640	41,544	3,615	-	25,717	79,800	
1969.....................	538,200	5,900	12,800	1,145	215,456	64,248	1,335	44,430	4,540	-	42,515	75,800	
Office of University Affairs													
1967.....................	31,000	-	-	-	-	-	-	-	-	-	-	-	
1968.....................	10,000	-	-	-	-	-	-	-	-	-	-	-	
1969.....................	10,000	-	-	-	-	-	-	-	-	-	-	-	
Office of Advanced Research and Technology													
1967.....................	268,150	49	2,770	17,327	10,960	20,019	-	20,932	12,824	8,346	46,336	52,652	4
1968.....................	318,700	175	4,420	17,090	9,006	23,502	535	23,502	20,655	21,668	56,774	59,263	4
1969.....................	336,800	150	4,850	18,140	9,568	28,720	500	26,150	21,199	16,740	59,838	70,766	5
Office of Tracking and Data Acquisition													
1967.....................	270,850	-	-	800	195,800	51,350	5,750	-	-	1,900	2,250	-	
1968.....................	275,850	-	-	400	197,350	57,200	6,400	-	-	2,100	1,900	-	
1969.....................	304,800	-	-	300	227,300	55,300	6,800	-	-	2,100	1,600	-	
Office of Technology Utilization													
1967.....................	5,000	-	-	-	-	-	-	-	-	-	-	-	
1968.....................	4,000	-	-	-	-	-	-	-	-	-	-	-	
1969.....................	4,000	-	-	-	-	-	-	-	-	-	-	-	
Total Budget Plan													
1967.....................	4,175,100	216,545	1,447,771	1,343,093	386,305	214,868	6,511	64,786	16,368	10,256	91,359	162,614	4
1968.....................	3,970,600	362,065	1,283,429	1,139,866	417,063	196,719	8,575	65,046	26,270	23,768	85,391	139,063	4
1969.....................	3,677,200	380,350	1,107,350	979,485	455,524	149,368	8,635	70,580	26,939	18,840	104,953	146,566	5

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OFFICE OF MANNED SPACE FLIGHT, TOTAL	1967	3,024,000	213,950	1,444,896	1,323,017	273	-	-	365	-	-	1,426	-	-
	1968	2,809,200	356,600	1,271,900	1,121,100	3,100	800	-	-	2,000	-	1,000	-	-
	1969	2,483,400	374,300	1,089,700	959,900	3,200	1,100	-	-	1,200	-	1,000	-	-
Gemini	1967	15,200	-	15,200	-	-	-	-	-	-	-	-	-	-
	1968	-	-	-	-	-	-	-	-	-	-	-	-	-
	1969	-	-	-	-	-	-	-	-	-	-	-	-	-
Apollo	1967	2,922,600	213,050	1,395,605	1,279,636	273	-	-	-	-	-	81	-	-
	1968	2,556,000	354,600	1,151,600	1,001,900	100	-	-	-	1,600	-	-	-	-
	1969	2,038,800	369,600	889,800	734,000	200	-	-	-	200	-	-	-	-
Apollo applications	1967	80,000	400	31,291	41,781	-	-	-	365	-	-	1,345	-	-
	1968	253,200	2,000	120,300	119,200	3,000	800	-	-	400	-	1,000	-	-
	1969	439,600	4,200	197,900	223,900	3,000	1,100	-	-	1,000	-	1,000	-	-
Advanced missions	1967	6,200	500	2,800	1,600	-	-	-	-	-	-	-	-	-
	1968	-	-	-	-	-	-	-	-	-	-	-	-	-
	1969	5,000	500	2,000	2,000	-	-	-	-	-	-	-	-	-
OFFICE OF SPACE SCIENCE AND APPLICATIONS, TOTAL	1967	576,100	2,546	105	1,949	179,272	143,499	761	43,489	3,544	10	41,347	109,962	-
	1968	552,850	5,290	7,109	1,276	207,607	115,217	1,640	41,544	3,615	-	25,717	79,800	-
	1969	538,200	5,900	12,800	1,145	215,456	64,248	1,335	44,430	4,540	-	42,515	75,800	-
Physics and astronomy	1967	129,800	-	40	158	97,020	339	496	9,828	60	10	1,607	-	-
	1968	142,950	-	359	36	109,881	196	1,200	9,383	140	-	1,532	-	-
	1969	141,900	-	300	40	105,500	400	950	9,100	140	-	2,930	-	-
Lunar and planetary exploration	1967	184,150	159	65	1,411	855	141,885	-	620	40	-	28,625	-	-
	1968	141,500	90	650	385	1,292	113,479	-	1,098	75	-	12,700	-	-
	1969	107,300	100	1,100	100	2,000	62,300	-	1,700	100	-	22,000	-	-
Launch vehicle development	1967	31,200	-	-	-	75	-	-	-	2,214	-	650	27,761	-
	1968	-	-	-	-	-	-	-	-	-	-	-	-	-
	1969	-	-	-	-	-	-	-	-	-	-	-	-	-
Launch vehicle procurement	1967	117,650	2,387	-	-	15,743	-	-	-	-	-	9,400	81,889	-
	1968	127,100	5,200	-	500	18,000	100	-	-	1,600	-	10,600	78,400	-
	1969	128,300	5,800	-	500	28,300	100	-	-	1,700	-	16,800	74,400	-
Bioscience	1967	42,000	-	-	100	369	954	25	32,941	-	-	160	-	-
	1968	41,800	-	-	55	134	1,342	40	30,963	-	-	85	-	-
	1969	48,500	-	-	105	156	1,448	185	33,530	-	-	85	-	-
Space applications	1967	71,300	-	-	280	65,210	321	240	100	1,230	-	905	312	-
	1968	99,500	-	6,100	300	78,300	100	400	100	1,800	-	800	1,400	-
	1969	112,200	-	11,400	400	79,500	-	200	100	2,600	-	700	1,400	-

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1969 ESTIMATES

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

(Thousands of dollars)

	TOTAL	J. F. KENNEDY SPACE CENTER, NASA	MANNED SPACECRAFT CENTER	MARSHALL SPACE FLIGHT CENTER	GODDARD SPACE FLIGHT CENTER	JET PROPULSION LABORATORY	WALLOPS STATION	AMES RESEARCH CENTER	ELECTRONICS RESEARCH CENTER	FLIGHT RESEARCH CENTER	LANGLEY RESEARCH CENTER	LEWIS RESEARCH CENTER	SPACE NUCLEAR PROPULSION OFFICE	NASA HEADQUARTERS	WESTERN SUPPORT OFFICE
:E															
1967	3,024,000	213,950	1,444,896	1,323,017	273	-	-	365	-	-	1,426	-	-	40,073	-
1968	2,809,200	356,600	1,271,900	1,121,100	3,100	800	-	-	2,000	-	1,000	-	-	52,700	-
1969	2,483,400	374,300	1,089,700	959,900	3,200	1,100	-	-	1,200	-	1,000	-	-	53,000	-
1967	15,200	-	15,200	-	-	-	-	-	-	-	-	-	-	-	-
1968	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1969	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1967	2,922,600	213,050	1,395,605	1,279,636	273	-	-	-	-	-	81	-	-	33,955	-
1968	2,556,000	354,600	1,151,600	1,001,900	100	-	-	-	1,600	-	-	-	-	46,200	-
1969	2,038,800	369,600	889,800	734,000	200	-	-	-	200	-	-	-	-	45,000	-
1967	80,000	400	31,291	41,781	-	-	-	365	-	-	1,345	-	-	4,818	-
1968	253,200	2,000	120,300	119,200	3,000	800	-	-	400	-	1,000	-	-	6,500	-
1969	439,600	4,200	197,900	223,900	3,000	1,100	-	-	1,000	-	1,000	-	-	7,500	-
1967	6,200	500	2,800	1,600	-	-	-	-	-	-	-	-	-	1,300	-
1968	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1969	5,000	500	2,000	2,000	-	-	-	-	-	-	-	-	-	500	-
CE															
1967	576,100	2,546	105	1,949	179,272	143,499	761	43,489	3,544	10	41,347	109,962	-	41,385	8,231
1968	552,850	5,290	7,109	1,276	207,607	115,217	1,640	41,544	3,615	-	25,717	79,800	-	52,235	11,800
1969	538,200	5,900	12,800	1,145	215,456	64,248	1,335	44,430	4,540	-	42,515	75,800	-	70,031	-
1967	129,800	-	40	158	97,020	339	496	9,828	60	10	1,607	-	-	20,242	-
1968	142,950	-	359	36	109,881	196	1,200	9,383	140	-	1,532	-	-	20,223	-
1969	141,900	-	300	40	105,500	400	950	9,100	140	-	2,930	-	-	22,540	-
1967	184,150	159	65	1,411	855	141,885	-	620	40	-	28,625	-	-	10,490	-
1968	141,500	90	650	385	1,292	113,479	-	1,098	75	-	12,700	-	-	11,731	-
1969	107,300	100	1,100	100	2,000	62,300	-	1,700	100	-	22,000	-	-	17,900	-
1967	31,200	-	-	-	75	-	-	-	2,214	-	650	27,761	-	500	-
1968	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1969	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1967	117,650	2,387	-	-	15,743	-	-	-	-	-	9,400	81,889	-	-	8,231
1968	127,100	5,200	-	500	18,000	100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1969 ESTIMATES

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

(Thousands of dollars)

PROGRAM		TOTAL	J. F. KENNEDY SPACE CENTER, NASA	MANNED SPACECRAFT CENTER	MARSHALL SPACE FLIGHT CENTER	GODDARD SPACE FLIGHT CENTER	JET PROPULSION LABORATORY	WALLOPS STATION	AMES RESEARCH CENTER	ELECTRONICS RESEARCH CENTER	FLIGHT RESEARCH CENTER	LANGLEY RESEARCH CENTER	LEWIS RESEARCH CENTER	SPACE NUCLEAR PROPULSION OFFICE	HEA
OFFICE OF MANNED SPACE FLIGHT, TOTAL	1967	3,024,000	213,950	1,444,896	1,323,017	273	-	-	365	-	-	1,426	-	-	
	1968	2,809,200	356,600	1,271,900	1,121,100	3,100	800	-	-	2,000	-	1,000	-	-	
	1969	2,483,400	374,300	1,089,700	959,900	3,200	1,100	-	-	1,200	-	1,000	-	-	
Gemini	1967	15,200	-	15,200	-	-	-	-	-	-	-	-	-	-	
	1968	-	-	-	-	-	-	-	-	-	-	-	-	-	
	1969	-	-	-	-	-	-	-	-	-	-	-	-	-	
Apollo	1967	2,922,600	213,050	1,395,605	1,279,636	273	-	-	-	-	-	81	-	-	
	1968	2,556,000	354,600	1,151,600	1,001,900	100	-	-	-	1,600	-	-	-	-	
	1969	2,038,800	369,600	889,800	734,000	200	-	-	-	200	-	-	-	-	
Apollo applications	1967	80,000	400	31,291	41,781	-	-	-	365	-	-	1,345	-	-	
	1968	253,200	2,000	120,300	119,200	3,000	800	-	-	400	-	1,000	-	-	
	1969	439,600	4,200	197,900	223,900	3,000	1,100	-	-	1,000	-	1,000	-	-	
Advanced missions	1967	6,200	500	2,800	1,600	-	-	-	-	-	-	-	-	-	
	1968	-	-	-	-	-	-	-	-	-	-	-	-	-	
	1969	5,000	500	2,000	2,000	-	-	-	-	-	-	-	-	-	
OFFICE OF SPACE SCIENCE AND APPLICATIONS, TOTAL	1967	576,100	2,546	105	1,949	179,272	143,499	761	43,489	3,544	10	41,347	109,962	-	
	1968	552,850	5,290	7,109	1,276	207,607	115,217	1,640	41,544	3,615	-	25,717	79,800	-	
	1969	538,200	5,900	12,800	1,145	215,456	64,248	1,335	44,430	4,540	-	42,515	75,800	-	
Physics and astronomy	1967	129,800	-	40	158	97,020	339	496	9,828	60	10	1,607	-	-	
	1968	142,950	-	359	36	109,881	196	1,200	9,383	140	-	1,532	-	-	
	1969	141,900	-	300	40	105,500	400	950	9,100	140	-	2,930	-	-	
Lunar and planetary exploration	1967	184,150	159	65	1,411	855	141,885	-	620	40	-	28,625	-	-	
	1968	141,500	90	650	385	1,292	113,479	-	1,098	75	-	12,700	-	-	
	1969	107,300	100	1,100	100	2,000	62,300	-	1,700	100	-	22,000	-	-	
Launch vehicle development	1967	31,200	-	-	-	75	-	-	-	2,214	-	650	27,761	-	
	1968	-	-	-	-	-	-	-	-	-	-	-	-	-	
	1969	-	-	-	-	-	-	-	-	-	-	-	-	-	
Launch vehicle procurement	1967	117,650	2,387	-	-	15,743	-	-	-	-	-	9,400	81,889	-	
	[illegible]	[illegible]	5,200	-	500	18,000	100	-	-	1,600	-	10,600	78,400	-	
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	100	-	-	1,700	-	16,800	74,400	-	

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1969 ESTIMATES

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

(Thousands of dollars)

		TOTAL	J. F. KENNEDY SPACE CENTER, NASA	MANNED SPACECRAFT CENTER	MARSHALL SPACE FLIGHT CENTER	GODDARD SPACE FLIGHT CENTER	JET PROPULSION LABORATORY	WALLOPS STATION	AMES RESEARCH CENTER	ELECTRONICS RESEARCH CENTER	FLIGHT RESEARCH CENTER	LANGLEY RESEARCH CENTER	LEWIS RESEARCH CENTER	SPACE NUCLEAR PROPULSION OFFICE	NASA HEADQUARTERS	WESTERN SUPPORT OFFICE
CE																
	1967	3,024,000	213,950	1,444,896	1,323,017	273	-	-	365	-	-	1,426	-	-	40,073	-
	1968	2,809,200	356,600	1,271,900	1,121,100	3,100	800	-	-	2,000	-	1,000	-	-	52,700	-
	1969	2,483,400	374,300	1,089,700	959,900	3,200	1,100	-	-	1,200	-	1,000	-	-	53,000	-
	1967	15,200	-	15,200	-	-	-	-	-	-	-	-	-	-	-	-
	1968	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1969	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1967	2,922,600	213,050	1,395,605	1,279,636	273	-	-	-	-	-	81	-	-	33,955	-
	1968	2,556,000	354,600	1,151,600	1,001,900	100	-	-	-	1,600	-	-	-	-	46,200	-
	1969	2,038,800	369,600	889,800	734,000	200	-	-	-	200	-	-	-	-	45,000	-
	1967	80,000	400	31,291	41,781	-	-	-	365	-	-	1,345	-	-	4,818	-
	1968	253,200	2,000	120,300	119,200	3,000	800	-	-	400	-	1,000	-	-	6,500	-
	1969	439,600	4,200	197,900	223,900	3,000	1,100	-	-	1,000	-	1,000	-	-	7,500	-
	1967	6,200	500	2,800	1,600	-	-	-	-	-	-	-	-	-	1,300	-
	1968	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1969	5,000	500	2,000	2,000	-	-	-	-	-	-	-	-	-	500	-
NCE																
	1967	576,100	2,546	105	1,949	179,272	143,499	761	43,489	3,544	10	41,347	109,962	-	41,385	8,231
	1968	552,850	5,290	7,109	1,276	207,607	115,217	1,640	41,544	3,615	-	25,717	79,800	-	52,235	11,800
	1969	538,200	5,900	12,800	1,145	215,456	64,248	1,335	44,430	4,540	-	42,515	75,800	-	70,031	-
	1967	129,800	-	40	158	97,020	339	496	9,828	60	10	1,607	-	-	20,242	-
	1968	142,950	-	359	36	109,881	196	1,200	9,383	140	-	1,532	-	-	20,223	-
	1969	141,900	-	300	40	105,500	400	950	9,100	140	-	2,930	-	-	22,540	-
	1967	184,150	159	65	1,411	855	141,885	-	620	40	-	28,625	-	-	10,490	-
	1968	141,500	90	650	385	1,292	113,479	-	1,098	75	-	12,700	-	-	11,731	-
	1969	107,300	100	1,100	100	2,000	62,300	-	1,700	100	-	22,000	-	-	17,900	-
	1967	31,200	-	-	-	75	-	-	-	2,214	-	650	27,761	-	500	-
	1968	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1969	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1967	117,650	2,387	-	-	15,743	-	-	-	-	-	9,400	81,889	-	-	8,231
	1968	127,100	5,200	-	500	18,000	100	-	-	1,600	-	10,600	78,400	[illegible]	[illegible]	11,800

	1968	10,000	-	-	-	-	-	-	-	-	-	-	-	-
	1969	10,000	-	-	-	-	-	-	-	-	-	-	-	-
OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY, TOTAL	1967	268,150	49	2,770	17,327	10,960	20,019	-	20,932	12,824	8,346	46,336	52,652	47,835
	1968	318,700	175	4,420	17,090	9,006	23,502	535	23,502	20,655	21,668	56,774	59,263	49,700
	1969	336,800	150	4,850	18,140	9,568	28,720	500	26,150	21,199	16,740	59,838	70,766	54,600
Basic research	1967	21,401	-	-	888	145	4,757	-	2,126	1,231	-	2,360	2,775	-
	1968	21,465	-	-	824	161	4,089	-	2,006	1,805	-	2,793	2,677	-
	1969	22,000	-	-	840	160	4,000	-	2,050	1,900	-	2,900	2,930	-
Space vehicle systems	1967	33,909	-	537	3,692	1,935	2,426	-	3,198	320	1,010	16,145	2,288	-
	1968	35,000	-	650	3,981	2,215	2,125	-	2,984	385	1,350	15,661	3,115	-
	1969	35,300	-	600	3,950	2,325	1,825	-	3,250	400	1,500	15,905	3,225	-
Electronics systems	1967	33,597	-	292	4,049	3,306	2,282	-	3,735	9,716	845	7,156	450	-
	1968	39,200	-	150	2,655	2,660	3,305	-	3,815	15,935	890	5,320	400	-
	1969	39,400	-	150	2,600	2,700	3,300	-	3,815	16,100	890	5,500	400	-
Human factor systems	1967	16,265	-	1,160	100	-	-	-	5,498	610	1,300	4,516	66	-
	1968	20,985	-	2,300	300	-	50	535	6,225	980	1,000	5,955	150	-
	1969	21,700	-	2,600	300	-	-	500	6,250	1,250	1,100	6,850	150	-
Space power and electric propulsion systems	1967	40,440	-	267	1,748	5,078	6,579	-	145	853	-	970	21,559	-
	1968	44,000	-	200	960	3,430	9,159	-	270	1,550	-	745	24,855	-
	1969	44,800	-	600	1,200	3,933	9,950	-	265	1,549	-	850	24,186	-
Nuclear rockets	1967	53,000	-	-	1,650	-	-	-	-	-	-	-	3,515	47,835
	1968	54,000	-	-	2,100	-	-	-	-	-	-	-	2,200	49,700
	1969	60,000	-	-	3,000	-	-	-	-	-	-	-	2,400	54,600
Chemical propulsion	1967	33,638	49	514	5,200	496	3,923	-	-	-	-	2,316	11,890	-
	1968	37,250	175	1,120	5,890	540	4,774	-	-	-	-	2,553	12,597	-
	1969	36,700	150	900	5,800	450	9,645	-	-	-	-	2,658	14,040	-
Aeronautical vehicles	1967	35,900	-	-	-	-	52	-	6,230	94	5,191	12,873	10,109	-
	1968	66,800	-	-	380	-	-	-	8,202	-	18,428	23,747	13,269	-
	1969	76,900	-	-	450	-	-	-	10,520	-	13,250	25,175	23,435	-
OFFICE OF TRACKING AND DATA ACQUISITION	1967	270,850	-	-	800	195,800	51,350	5,750	-	-	1,900	2,250	-	-
	1968	275,850	-	-	400	197,350	57,200	6,400	-	-	2,100	1,900	-	-
	1969	304,800	-	-	300	227,300	55,300	6,800	-	-	2,100	1,600	-	-
OFFICE OF TECHNOLOGY UTILIZATION														
	1967	5,000	-	-	-	-	-	-	-	-	-	-	-	-
	1968	4,000	-	-	-	-	-	-	-	-	-	-	-	-
	1969	4,000	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL BUDGET PLAN	1967	4,175,100	216,545	1,447,771	1,343,093	386,305	214,868	6,511	64,786	16,368	10,256	91,359	162,614	47,835
	1968	3,970,600	362,065	1,283,429	1,139,866	417,063	196,719	8,575	65,046	26,270	23,768	85,391	139,063	49,700
	1969	3,677,200	380,350	1,107,350	979,485	455,524	149,368	8,635	70,580	26,939	18,840	104,953	146,566	54,600

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1969 ESTIMATES

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

(Thousands of dollars)

	TOTAL	J. F. KENNEDY SPACE CENTER, NASA	MANNED SPACECRAFT CENTER	MARSHALL SPACE FLIGHT CENTER	GODDARD SPACE FLIGHT CENTER	JET PROPULSION LABORATORY	WALLOPS STATION	AMES RESEARCH CENTER	ELECTRONICS RESEARCH CENTER	FLIGHT RESEARCH CENTER	LANGLEY RESEARCH CENTER	LEWIS RESEARCH CENTER	SPACE NUCLEAR PROPULSION OFFICE	NASA HEADQUARTERS	WESTERN SUPPORT OFFICE
1967	31,000	-	-	-	-	-	-	-	-	-	-	-	-	31,000	-
1968	10,000	-	-	-	-	-	-	-	-	-	-	-	-	10,000	-
1969	10,000	-	-	-	-	-	-	-	-	-	-	-	-	10,000	-
1967	268,150	49	2,770	17,327	10,960	20,019	-	20,932	12,824	8,346	46,336	52,652	47,835	19,198	8,902
1968	318,700	175	4,420	17,090	9,006	23,502	535	23,502	20,655	21,668	56,774	59,263	49,700	25,904	6,506
1969	336,800	150	4,850	18,140	9,568	28,720	500	26,150	21,199	16,740	59,838	70,766	54,600	25,579	-
1967	21,401	-	-	888	145	4,757	-	2,126	1,231	-	2,360	2,775	-	6,584	535
1968	21,465	-	-	824	161	4,089	-	2,006	1,805	-	2,793	2,677	-	6,884	226
1969	22,000	-	-	840	160	4,000	-	2,050	1,900	-	2,900	2,930	-	7,220	-
1967	33,909	-	537	3,692	1,935	2,426	-	3,198	320	1,010	16,145	2,288	-	1,899	459
1968	35,000	-	650	3,981	2,215	2,125	-	2,984	385	1,350	15,661	3,115	-	2,434	100
1969	35,300	-	600	3,950	2,325	1,825	-	3,250	400	1,500	15,905	3,225	-	2,320	-
1967	33,597	-	292	4,049	3,306	2,282	-	3,735	9,716	845	7,156	450	-	1,761	5
1968	39,200	-	150	2,655	2,660	3,305	-	3,815	15,935	890	5,320	400	-	4,070	-
1969	39,400	-	150	2,600	2,700	3,300	-	3,815	16,100	890	5,500	400	-	3,945	-
1967	16,265	-	1,160	100	-	-	-	5,498	610	1,300	4,516	66	-	2,979	36
1968	20,985	-	2,300	300	-	50	535	6,225	980	1,000	5,955	150	-	3,390	100
1969	21,700	-	2,600	300	-	-	500	6,250	1,250	1,100	6,850	150	-	2,700	-
ric															
1967	40,440	-	267	1,748	5,078	6,579	-	145	853	-	970	21,559	-	1,808	1,433
1968	44,000	-	200	960	3,430	9,159	-	270	1,550	-	745	24,655	-	2,270	561
1969	44,800	-	600	1,200	3,933	9,950	-	265	1,549	-	850	24,186	-	2,267	-
1967	53,000	-	-	1,650	-	-	-	-	-	-	-	3,515	47,835	-	-
1968	54,000	-	-	2,100	-	-	-	-	-	-	-	2,200	49,700	-	-
1969	60,000	-	-	3,000	-	-	-	-	-	-	-	2,400	54,600	-	
1967	33,638	49	514	5,200	496	3,923	-	-	-	-	2,316	11,890	-	2,816	6,434
1968	37,250	175	1,120	5,890	540	4,774	-	-	-	-	2,553	12,597	-	4,082	5,519
1969	36,700	150	900	5,800	450	9,645	-	-	-	-	2,658	14,040	-	3,057	-
1967	35,900	-	-	-	-	52	-	6,230	94	5,191	12,873	10,109	-	1,351	-
1968	66,800	-	-	380	-	-	-	8,202	-	18,428	23,747	13,269	-	2,774	-
1969	76,900	-	-	450	-	-	-	10,520	-	13,250	25,175	23,435	-	4,070	-
D															
1967	270,850	-	-	800	195,800	51,350	5,750	-	-	1,900	2,250	-	-	13,000	-
1968	275,850	-	-	400	197,350	57,200	6,400	-	-	2,100	1,900	-	-	10,500	-
1969	304,800	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

1968	10,000	-	-	-	-	-	-	-	-	-	-	-	-	10,000	
1969	10,000	-	-	-	-	-	-	-	-	-	-	-	-	10,000	-
1967	268,150	49	2,770	17,327	10,960	20,019	-	20,932	12,824	8,346	46,336	52,652	47,835	19,198	8,902
1968	318,700	175	4,420	17,090	9,006	23,502	535	23,502	20,655	21,668	56,774	59,263	49,700	25,904	6,506
1969	336,800	150	4,850	18,140	9,568	28,720	500	26,150	21,199	16,740	59,838	70,766	54,600	25,579	-
1967	21,401	-	-	888	145	4,757	-	2,126	1,231	-	2,360	2,775	-	6,584	535
1968	21,465	-	-	824	161	4,089	-	2,006	1,805	-	2,793	2,677	-	6,884	226
1969	22,000	-	-	840	160	4,000	-	2,050	1,900	-	2,900	2,930	-	7,220	-
1967	33,909	-	537	3,692	1,935	2,426	-	3,198	320	1,010	16,145	2,288	-	1,899	459
1968	35,000	-	650	3,981	2,215	2,125	-	2,984	385	1,350	15,661	3,115	-	2,434	100
1969	35,300	-	600	3,950	2,325	1,825	-	3,250	400	1,500	15,905	3,225	-	2,320	-
1967	33,597	-	292	4,049	3,306	2,282	-	3,735	9,716	845	7,156	450	-	1,761	5
1968	39,200	-	150	2,655	2,660	3,305	-	3,815	15,935	890	5,320	400	-	4,070	-
1969	39,400	-	150	2,600	2,700	3,300	-	3,815	16,100	890	5,500	400	-	3,945	-
1967	16,265	-	1,160	100	-	-	-	5,498	610	1,300	4,516	66	-	2,979	36
1968	20,985	-	2,300	300	-	50	535	6,225	980	1,000	5,955	150	-	3,390	100
1969	21,700	-	2,600	300	-	-	500	6,250	1,250	1,100	6,850	150	-	2,700	-
c															
1967	40,440	-	267	1,748	5,078	6,579	-	145	853	-	970	21,559	-	1,808	1,433
1968	44,000	-	200	960	3,430	9,159	-	270	1,550	-	745	24,855	-	2,270	561
1969	44,800	-	600	1,200	3,933	9,950	-	265	1,549	-	850	24,186	-	2,267	-
1967	53,000	-	-	1,650	-	-	-	-	-	-	-	3,515	47,835	-	-
1968	54,000	-	-	2,100	-	-	-	-	-	-	-	2,200	49,700	-	-
1969	60,000	-	-	3,000	-	-	-	-	-	-	-	2,400	54,600	-	
1967	33,638	49	514	5,200	496	3,923	-	-	-	-	2,316	11,890	-	2,816	6,434
1968	37,250	175	1,120	5,890	540	4,774	-	-	-	-	2,553	12,597	-	4,082	5,519
1969	36,700	150	900	5,800	450	9,645	-	-	-	-	2,658	14,040	-	3,057	-
1967	35,900	-	-	-	-	52	-	6,230	94	5,191	12,873	10,109	-	1,351	-
1968	66,800	-	-	380	-	-	-	8,202	-	18,428	23,747	13,269	-	2,774	-
1969	76,900	-	-	450	-	-	-	10,520	-	13,250	25,175	23,435	-	4,070	-
1967	270,850	-	-	800	195,800	51,350	5,750	-	-	1,900	2,250	-	-	13,000	-
1968	275,850	-	-	400	197,350	57,200	6,400	-	-	2,100	1,900	-	-	10,500	-
1969	304,800	-	-	300	227,300	55,300	6,800	-	-	2,100	1,600	-	-	11,400	-
1967	5,000	-	-	-	-	-	-	-	-	-	-	-	-	5,000	-
1968	4,000	-	-	-	-	-	-	-	-	-	-	-	-	4,000	-
1969	4,000	-	-	-	-	-	-	-	-	-	-	-	-	4,000	-
1967	4,175,100	216,545	1,447,771	1,343,093	386,305	214,868	6,511	64,786	16,368	10,256	91,359	162,614	47,835	149,656	17,133
1968	3,970,600	362,065	1,283,429	1,139,866	417,063	196,719	8,575	65,046	26,270	23,768	85,391	139,063	49,700	155,339	18,306
1969	3,677,200	380,350	1,107,350	979,485	455,524	149,368	8,635	70,580	26,939	18,840	104,953	146,566	54,600	174,010	-

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1969 ESTIMATES

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

(Thousands of dollars)

	TOTAL	J. F. KENNEDY SPACE CENTER, NASA	MANNED SPACECRAFT CENTER	MARSHALL SPACE FLIGHT CENTER	GODDARD SPACE FLIGHT CENTER	JET PROPULSION LABORATORY	WALLOPS STATION	AMES RESEARCH CENTER	ELECTRONICS RESEARCH CENTER	FLIGHT RESEARCH CENTER	LANGLEY RESEARCH CENTER	LEWIS RESEARCH CENTER	SPACE NUCLEAR PROPULSION OFFICE	NASA HEADQUARTERS	WESTERN SUPPORT OFFICE
1967	31,000	-	-	-	-	-	-	-	-	-	-	-	-	31,000	-
1968	10,000	-	-	-	-	-	-	-	-	-	-	-	-	10,000	-
1969	10,000	-	-	-	-	-	-	-	-	-	-	-	-	10,000	-
1967	268,150	49	2,770	17,327	10,960	20,019	-	20,932	12,824	8,346	46,336	52,652	47,835	19,198	8,902
1968	318,700	175	4,420	17,090	9,006	23,502	535	23,502	20,655	21,668	56,774	59,263	49,700	25,904	6,506
1969	336,800	150	4,850	18,140	9,568	28,720	500	26,150	21,199	16,740	59,838	70,766	54,600	25,579	-
1967	21,401	-	-	888	145	4,757	-	2,126	1,231	-	2,360	2,775	-	6,584	535
1968	21,465	-	-	824	161	4,089	-	2,006	1,805	-	2,793	2,677	-	6,884	226
1969	22,000	-	-	840	160	4,000	-	2,050	1,900	-	2,900	2,930	-	7,220	-
1967	33,909	-	537	3,692	1,935	2,426	-	3,198	320	1,010	16,145	2,288	-	1,899	459
1968	35,000	-	650	3,981	2,215	2,125	-	2,984	385	1,350	15,661	3,115	-	2,434	100
1969	35,300	-	600	3,950	2,325	1,825	-	3,250	400	1,500	15,905	3,225	-	2,320	-
1967	33,597	-	292	4,049	3,306	2,282	-	3,735	9,716	845	7,156	450	-	1,761	5
1968	39,200	-	150	2,655	2,660	3,305	-	3,815	15,935	890	5,320	400	-	4,070	-
1969	39,400	-	150	2,600	2,700	3,300	-	3,815	16,100	890	5,500	400	-	3,945	-
1967	16,265	-	1,160	100	-	-	-	5,498	610	1,300	4,516	66	-	2,979	36
1968	20,985	-	2,300	300	-	50	535	6,225	980	1,000	5,955	150	-	3,390	100
1969	21,700	-	2,600	300	-	-	500	6,250	1,250	1,100	6,850	150	-	2,700	-
1967	40,440	-	267	1,748	5,078	6,579	-	145	853	-	970	21,559	-	1,808	1,433
1968	44,000	-	200	960	3,430	9,159	-	270	1,550	-	745	24,855	-	2,270	561
1969	44,800	-	600	1,200	3,933	9,950	-	265	1,549	-	850	24,186	-	2,267	-
1967	53,000	-	-	1,650	-	-	-	-	-	-	-	3,515	47,835	-	-
1968	54,000	-	-	2,100	-	-	-	-	-	-	-	2,200	49,700	-	-
1969	60,000	-	-	3,000	-	-	-	-	-	-	-	2,400	54,600	-	
1967	33,638	49	514	5,200	496	3,923	-	-	-	-	2,316	11,890	-	2,816	6,434
1968	37,250	175	1,120	5,890	540	4,774	-	-	-	-	2,553	12,597	-	4,082	5,519
1969	36,700	150	900	5,800	450	9,645	-	-	-	-	2,658	14,040	-	3,057	-
1967	35,900	-	-	-	-	52	-	6,230	94	5,191	12,873	10,109	-	1,351	-
1968	66,800	-	-	380	-	-	-	8,202	-	18,428	23,747	13,269	-	2,774	-
1969	76,900	-	-	450	-	-	-	10,520	-	13,250	25,175	23,435	-	4,070	-
1967	270,850	-	-	800	195,800	51,350	5,750	-	-	1,900	2,250	-	-	13,000	-
1968	275,850	-	-	400	197,350	57,200	6,400	-	-	2,100	1,900	-	-	10,500	-
1969	304,800	-	-	300	227,300	55,300	6,800								

ERRATA SHEET

Attached herewith are revised pages for the Apollo Applications Program. These revised pages should replace the same page numbers currently in the justification books as follows:

1. Volume I, Apollo Applications Program Summary, page numbers RD 14 through RD 18.
2. Volume II, Apollo Applications Program Detail, page numbers RD 2-1 through RD 2-12.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1969 ESTIMATES

OFFICE OF MANNED SPACE FLIGHT — APOLLO APPLICATIONS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Apollo Applications program is directed toward increasing the effectiveness of manned space flight operations in the accomplishment of experiments and other inflight activities. The program presented herein uses the capabilities developed for the Apollo Program and is designed to accomplish a limited but carefully selected spectrum of scientific, technological and medical investigations. The program is configured to maintain progress in manned space flight and provide the information required to permit knowledgeable decisions concerning potential follow-on space programs while operating within a severely limited budget.

Missions are built upon a strong base of flight experience, ground facilities, and trained manpower developed in the Gemini and Apollo Programs. Maximum economy is achieved through the use, modification, and expansion of present Apollo systems capabilities rather than moving toward wholely new developments. Further, any Apollo spacecraft and launch vehicles not required to meet Apollo objectives will be used for Apollo Applications missions.

The Apollo Applications mission objectives include:

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

2. The achievement of 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. The conduct of scientific, technical, and applications tasks with the aims of assessing, experimenting with, and increasing man's capabilities for performing these tasks; as well as the acquisition of useful data and results.

Because these activities are still exploratory in nature, and in many respects will establish the base for more extensive follow-on systems, the information will be obtained as early as possible within fiscal constraints by using to a large extent already developed Apollo hardware, and by employing revisit and reuse techniques in the flight missions.

Funding of Space Vehicle requirements in support of the Apollo Applications program through fiscal year 1969 is limited to the procurement of Saturn IB and Saturn V launch vehicles and to the design, development production and installation of Apollo spacecraft systems that require modifications to meet the long duration objectives established for Apollo Applications missions.

To minimize expenditures, delivery of Saturn IB launch vehicles for use in the Apollo Applications program has been re-scheduled to two per year beginning in calendar year 1970. Funding of the production activities to support the delivery requirements began in fiscal year 1966 when funds were used to procure long leadtime components for the H-1 engines used in the first stage of the Saturn IB. Component fabrication was started in fiscal year 1967, and by the end of fiscal year 1968, vehicles 213 and 214 will be in manufacturing.

Funding in fiscal year 1969 provides for the continuation of production of vehicles 213 and 214 and long lead time procurement on subsequent vehicles. We will have to place orders late in 1968 in order to continue production beyond IB #216.

Production of Saturn V launch vehicles for Apollo Applications is also scheduled at two per year with the first delivery of a post-Apollo vehicle planned for 1971. Funding in fiscal year 1967 and fiscal year 1968 is related to long lead procurement for engines. The very low rate of funding in these years is directly related to the stretch out of Apollo production which has deferred any substantial funding of follow-on Saturn V's until fiscal year 1969. Although there is a sharp increase in AAP funding for Saturn V procurement in FY 69, this is offset by a reduction in Apollo Saturn V funding and the total shows a steady downward trend.

FY 1969 funds provide for initial production efforts on all three stages of launch vehicle 516 and on the S-II stage of vehicle 517.

The long-duration characteristics of the Apollo Applications missions require that spacecraft systems be modified to support these extensions in flight time. The Apollo spacecraft has been designed and producted to provide a 14 day operational capability and must be modified to accommodate the 56 day missions that are incorporated in the Apollo Applications program. The capability of the lunar module will be extended to permit a three day stay time on the lunar surface.

Major modifications to the command and service module include increasing the capacity of the reaction control system to support flight maneuvering during long duration missions. The life time and reliability of the fuel cells will be improved to assure performance for 56 days. Cryogenic tankage will be increased to provide the additional hydrogen and oxygen for powering the fuel cells and life support during extended duration flights. The communications and electrical systems will also be modified to accommodate an increase in voice and data recording units and to provide power regulation, current transfer, and interface controls between the command module and the space vehicle coupled to it. Display and control systems for the crew must be changed to reflect the increased capacity and performance of the spacecraft. The command and service modules used for Apollo Applications missions will provide an oxygen/nitrogen atmosphere as the environment to avoid the possible deleterious effects of a pure oxygen atmosphere during long-term spaceflight. This change requires modification of the environmental control unit and the associated plumbing, heating units and tankage. A waste liquid retention system will also be installed so that the discharge of unneeded liquids can be made at controlled times so as not to interfere with experiment activities.

Changes will be made to the software elements of the guidance and navigation system to accommodate the workshop and ATM missions requirements.

Major definition analyses of the modifications to the spacecraft were undertaken in FY 1967. Design and development of the major modification kits will begin in FY 1968 with component and material testing of prototypes of the modified subsystems commencing during this year. Procurement of the propellant and cryogenic tankage has been initiated.

Funding during FY 1969 provides primarily for the detailed engineering, fabrication, checkout, and test of the modified subsystems prior to their installation in Block II command and service modules. It is planned that all manufacturing of the modifcation kits for the first command and service module will be completed during FY 1969. The modification kits include those for the environmental control systems, electrical systems, electronics, fluid systems, crew systems, reaction control systems, communication systems and the service propulsion system. Start of installation of the modifications in spacecraft will be deferred to as late as feasible and will not begin until early in calendar year 1969.

The Apollo Applications program will include extended duration missions on the lunar surface greater than the one day stay times of the Apollo program.

Feasibility studies directed toward modifying the lunar module to operate for a stay time of three days were performed during FY 1967, with preliminary design of the modified spacecraft being conducted during FY 1968.

FY 1969 funding provides for the preparation of vehicle and test specifications and the initial procurement of long lead hardware. Test programs for the additional cryogenic tankage and the solar cell array for electrical power will be started.

Experiments

	1967	1968	1969
Definition................	$10,974,000	$21,000,000	$25,000,000
Development...............	26,626,000	118,000,000	165,300,000
Total....................	$37,600,000	$139,000,000	$190,300,000

Apollo Applications experiments cover a wide range of objectives in the fields of space medicine, science, applications, technology, and engineering. The definition and development of experiment payloads to meet these objectives will include activity by elements of NASA, other government agencies and the scientific and industrial communities.

Definition

Unlike preceding manned space flight projects, in which the successful demonstration of the basic systems capability was the principal objective, Apollo Applications must achieve its objectives primarily through the judicious selection and carefully planned accomplishment of specific experiments. Therefore, the early and accurate definition of the experiments and experimental systems in this program is absolutely vital to eventual mission success and the achievement of program objectives.

Before an experiment can be committed to an on-going flight program it must be determined to be feasible for missions in the program and be assessed in terms of its specific contribution to the program objectives. In addition, it must be well-defined in terms of requirements for funding, schedule, power, temperature, volume, and other mission constraints. Formal approval for inclusion in a flight program is given by the Manned Space Flight Experiments Board which bases its decisions on the facts developed in the definition process. The program manager must be assured not only that the experiment is suitable but that it can be smoothly incorporated in the program and managed effectively.

In FY 1969 the funds requested for experiment definition will be used principally to clarify and define candidate experiments for the Saturn V workshop and to determine what experiments and equipment can provide the most effective post-Apollo exploration of the moon. Lead times are such that this definition work must begin now along with the preliminary design studies.

A major portion of the 1969 definition funds will be required to translate the experiment portion of potential payload capability of the Saturn V workshop into specific experiments which utilize man's capability to perform effectively in space for an extended period of time.

A continuing program of experiment definition will be required in FY 1969 in order to support the goals identified for lunar exploration. To do this, definition funds are required in 1969 which will enable us to select mobility devices for the lunar surface. In addition, experiment definition will continue in support of the scientific disciplines which are required to carry out an effective program of scientific exploration. Definition studies will also be conducted which will lead to the grouping of related experiments into mutually supporting experiments packages both for lunar surface and lunar orbital investigations.

Development

The measure of success in the Apollo Applications Program will be the degree to which the planned experiments meet the overall objectives of investigating, demonstrating, and utilizing man's effectiveness in space, extending his useful staytime, and contributing to the basic store of human knowledge. Each of the experiments currently included in the program will contribute substantially to one or more of these objectives.

Development of the Saturn I workshop has been started. The basic piece of hardware involved in this system is an S-IVB stage modified to be suitable for human habitation. Included in this payload section will be: 1) an airlock which will permit crew transfer from the command and service module to the workshop without extra-vehicular activity; 2) a multiple docking adapter which will permit more than one space vehicle to rendezvous and dock with the workshop simultaneously; and 3) systems which will make the workshop a habitable and effective space vehicle for a long period of time.

The concept of the orbital workshop is particularily promising for long duration flights in earth orbit. In 1969 we plan to initiate a substantial extension of this capability by beginning work on the Saturn V workshop, which will provide a much greater capability than the present generation workshop. This concept provides for inserting the workshop into orbit with a 1st and 2nd stage Saturn V vehicle and provides a potential payload increase of 200,000 lbs. The internal systems, experiments and equipment composing this payload will be installed and ready for use prior to launch.

The other major piece of experiment hardware initiated in prior years is the Apollo Telescope Mount (ATM). Whereas the basic purpose of the Saturn I Workshop is to provide a suitable platform for a large number of multi-disciplinary experiments including the study of man's effectiveness in space, the ATM is devoted entirely to astronomy. The focus of the project will be on the scientific study of the sun. The surface of the sun, the sun-spot cycle observable there, and the nature and pattern of the solar flare activity erupting from the sun hold the key to understanding the basic forces and elements which control the solar system. The orbiting solar observatory

(OSO) unmanned spacecraft provided the first opportunity to study the sun without hindrance from the earth's atmosphere. The ATM will provide a significant increase in the quality and depth of our knowledge of the sun by providing 1) greater pointing accuracy than was possible with the smaller OSO, 2) the capability of film return which can provide better quality pictures than were previously possible, and 3) most importantly, the selective discrmination capabilities of a man can be used to concentrate on phenomena of the greatest scientific interest.

The basic ATM system will be derived from the lunar module being developed for Apollo. The ascent stage of the lunar module will be modified and will serve as a command post for two astronauts conducting the experiments. The descent stage is replaced by a structural rack with associated power and pointing equipment which contains the various experiments to be flown.

Major contractor development effort is currently in process on the systems and components required for most of the major experiments described above. The basic pieces of hardware required for the workshop are well into their development phase at present. The modification of the basic S-IVB, which will convert the spent stage into the workshop, is being done by the McDonnell-Douglas Corporation, Huntington Beach, California. An extensive testing program utilizing boilerplates and special test hardware is currently in process and will continue through FY 1969.

The airlock module is currently under development by the McDonnell-Douglas Corporation in St. Louis, Mo. A test article is being fabricated and a test program utilizing this article will begin in 1968 and extend through 1969. Initial fabrication has begun on the first flight article, which will be ready for delivery to Cape Kennedy in late 1969.

The multiple docking adapter is being developed and fabricated in-house by NASA at the Marshall Space Flight Center, Huntsville, Alabama. Design of this unit has been in process for a year. An engineering mock-up has been built and the fabrication of a structural test unit is currently in process. Structural and vibration testing of this unit is scheduled to begin before the end of FY 1968 and extend into FY 1969. Manufacture of the initial flight unit will begin in 1969 and will be completed early in FY 1970.

Work is also in process on the ATM at the Marshall Space Flight Center, with major subsystem development having been underway for a year. Fabrication and assembly of a complete mock-up was initially completed in early 1967 and the article was recently updated to incorporate results of the continuing design work. A neutral buoyancy test article has been built and will be tested shortly. Fabrication of a structural test unit is currently in process with testing scheduled to begin before the end of FY 1968. Five specific experiments comprised of 13 major instruments have been selected for the ATM and are currently in the process of fabrication. These include

White Light Coronagraph, being developed by the High Altitude Observatory, Boulder, Colorado, an Ultra/Violet Spectro-Heliograph being developed by the Naval Research Laboratory, Washington, D.C.; an X-ray spectrographic telescope being developed by American Science and Engineering Company, Cambridge, Massachusetts; an X-ray telescope being developed at the Goddard Space Flight Center in Greenbelt, Maryland; and an Ultraviolet Scanning Spectrometer being developed by the Harvard College Observatory, Cambridge, Massachusetts.

Mission Support

	1967	1968	1969
Payload integration...........	$3,900,000	$21,000,000	$31,000,000
Operations....................	800,000	7,200,000	17,000,000
Total.........................	$4,700,000	$28,200,000	$48,000,000

Payload Integration includes mission payload analysis and systems engineering, design, development, fabrication, test, and program management support for the integration of experiment and resupply payloads into Apollo Applications space vehicles. It provides requirements, plans and program data for the integration of payloads; performance and interface specifications; design, test, and check-out plans and procedures; and ground and in-flight support equipment. Overall program coordination, engineering analysis and design of the integration of spacecraft and payloads into a coordinated space system qualified for flight is provided. Fiscal year 1967 efforts were concerned with preliminary definition of the payload integration requirements. Fiscal year 1968 funds support final definition and the implementation of design and development efforts. Fiscal year 1969 funding will support continued efforts in such areas as experiment grouping, payload carrier design development and integration, experiment support requirements, and feasibility, compatability and systems interface analyses for all near term Apollo Applications Missions. The Martin Company, Denver, Colorado is the prime contractor for payload integration.

Operations include efforts at the Kennedy Space Center and the Manned Spacecraft Center that are directly concerned with pre-launch, launch, flight, crew and recovery activity. In fiscal year 1967 operations efforts were related to accomplishing definition of Apollo Applications requirements peculiar to pre-launch, launch, mission planning and mission control. Fiscal year 1968 funding is supporting activities associated with crew training, flight operations, mission analysis, landing and recovery, launch operations and launch support.

Fiscal year 1969 funds are required for continuation of current year efforts, procurement and/or modification of flight simulators and associated maintenance and operation and flight crew training and related equipment procurements in preparation for Apollo Applications flights scheduled in early 1970.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1969 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR

MANNED SPACE FLIGHT PROGRAMS

Program	Fiscal Year 1967	Fiscal Year 1968	Fiscal Year 1969
Gemini.................	$15,200,000	---	---
Apollo.................	2,922,600,000	$2,556,000,000*	$2,038,800,000
Apollo applications...	80,000,000	253,200,000	439,600,000
Advanced missions.....	6,200,000	---	5,000,000
Total............	$3,024,000,000	$2,809,200,000	$2,483,400,000

*Includes $60 million of prior year funds applied to FY 1968 budget plan.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1969 ESTIMATES

OFFICE OF MANNED SPACE FLIGHT — APOLLO PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objective of the Apollo program is the creation of a viable manned space flight capability to achieve a position of leadership in space for the United States. The program, while focused on the accomplishment of manned lunar landing and return, is not solely directed toward this goal. Apollo represents the development of an extensive operational capability, including lunar exploration, to assure this country's preeminence in manned space flight. Directing itself toward achieving this position of leadership, the program is developing a spacecraft that is capable of supporting men in space for periods up to two weeks, operating at lunar distances, and conducting operations on the lunar surface. Leadership is also attained through the program's development of the Saturn IB and Saturn V vehicles, which are presently this country's two most powerful launch vehicles. The Saturn IB is capable of inserting a 20 ton payload into low-earth orbit. The Saturn V can launch nearly a 140 ton payload into earth orbit, and up to 50 tons to lunar distances.

The technology that forms the basis of this capability results from the melding of a large complex of development, manufacturing, test, and launch facilities with the knowledge and experience of a unified team of people brought together from the government, industry, and universities. The skills, resources, and technology created, assembled, and developed for Apollo are a versatile and powerful national asset.

The Apollo program is divided into unmanned flights, manned earth orbital flights, and manned lunar flights. Three unmanned flights conducted during 1966 qualified the Saturn IB for manned missions. These flights demonstrated the structural integrity and the compatibility of the spacecraft and adapter with the launch vehicles; the firing and restarting of the spacecraft engines; the ability of the command module heatshield to withstand high speed re-entry; and the operational readiness of the ground support and recovery crews.

The problems and progress of the Apollo program during the past year are mirrored in two events. On January 27, 1967, during a countdown simulation at Cape Kennedy, a flash fire occurred in the Apollo spacecraft, causing the deaths of the astronaut crew. The accident restrained progress toward accomplishing Apollo's objective of a successful manned lunar landing and return before the end of the decade, and forcefully focused full national attention on the ever-present realities of the hazards inherent in the exploration of space. The command module fire has delayed the first manned flight by over one year as design changes and modifications are made to the spacecraft. These modifications represent a concentrated effort to eliminate the possibility of a fire or to preclude its propagation.

Momentum was re-established on November 9, 1967, with the successful "all-up" unmanned test of the first Saturn V launch vehicle. This "all-up" test produced a substantial number of "firsts" for the Apollo program and this country. It represented the first launch of the S-IC and S-II stages of the vehicle, the first flight of the powerful F-1 engine which produces over 1.5 million pounds of thrust, the heaviest weight (nearly 140 tons) ever placed into orbit, the initial qualification of the Apollo heatshield to withstand the 25,000 mph speed and 4,500°F temperature of re-entry from lunar distances, and the recovery of a payload from the greatest distance in space--over 11,000 miles. The test also demonstrated the ability of the S-IVB stage to restart in earth orbit. Each is an essential part of the manned lunar landing mission.

The Saturn IB vehicle that was to launch the first manned Apollo spacecraft will now be used for the initial flight test of the lunar module. This unmanned test is scheduled for early in 1968. A second Saturn IB launch of an unmanned lunar module is also planned for 1968. The third Saturn IB launch planned for 1968 will be the first manned flight of the Apollo command and service module.

Two more unmanned flights of the Saturn V vehicle are scheduled for 1968, to qualify the Saturn V for manned flight. This first manned test is presently planned for the fourth Saturn V vehicle and will demonstrate the operational reliability and compatibility of the various modules in space. The missions will include lunar mission flight simulations, and docking and crew transfer between the command module and lunar module.

While the major portion of lunar mission simulation and training is planned to be conducted on Saturn V vehicles, the Apollo mission planning provides for alternative action. If technical difficulties develop in qualifying the Saturn V for manned Command and Service Module and Lunar Module flight, such operations will be conducted with dual launches of Saturn IB vehicles. During these paired launches, one vehicle will orbit the LM, while the other will orbit the manned CSM which will rendezvous and dock with the LM.

During 1969, five manned Saturn V launches are scheduled and represent progressive steps toward the manned lunar landings. The fiscal year 1969 funding to support the Apollo program is contained in the following tables:

SUMMARY OF RESOURCES REQUIREMENTS:

	1967	1968	1969
Spacecraft	$1,310,600,000	$1,095,000,000	$820,100,000
Saturn IB	225,626,000	146,600,000	69,100,000
Saturn V	1,098,154,000	998,900,000	818,200,000
Engine development	49,800,000	18,700,000	---
Mission support	238,420,000	296,800,000	331,400,000
Total	$2,922,600,000	$2,556,000,000	$2,038,800,000

Distribution of Program Amount by Installation:

	1967	1968	1969
John F. Kennedy Space Center, NASA	$213,050,000	$354,600,000	$369,600,000
Manned Spacecraft Center	1,395,605,000	1,151,600,000	889,800,000
Marshall Space Flight Center	1,279,636,000	1,001,900,000	734,000,000
Goddard Space Flight Center	273,000	100,000	200,000
Langley Research Center	81,000	---	---
NASA Headquarters	33,955,000	46,200,000	45,000,000
Electronics Research Center	---	1,600,000	200,000

BASIS OF FUND REQUIREMENTS:

Spacecraft

	1967	1968	1969
Command and service modules	$532,815,000	$455,300,000	$340,200,000
Lunar module	539,272,000	399,600,000	278,200,000
Spacecraft support	119,937,000	113,000,000	102,500,000
Guidance and navigation	82,977,000	66,600,000	44,000,000
Integration, reliability, and checkout	35,599,000	60,500,000	55,200,000
Total	$1,310,600,000	$1,095,000,000	$820,100,000

The Apollo spacecraft is composed of three modules: the command module, the service module, and the lunar module. The command module, which is the recoverable portion of the Apollo spacecraft, houses the three astronauts in a controlled environment. The cone-shaped command module contains life support and communication systems, as well as control systems for in-flight and re-entry maneuvering. The service module contains the propulsion system used for making trajectory corrections and electrical and other utility systems supporting the command module. The service propulsion system engine provides 22,000 lbs. of thrust and can be restarted up to 50 times. The lunar module is a self-contained vehicle consisting of a descent stage with landing legs and an ascent stage with a habitable two-man cabin. Each stage is equipped with its own engine. During the launch phase, the lunar module is enclosed by an adapter, which also provides structural support when the spacecraft is joined to the launch vehicle.

An Apollo spacecraft, launched by a Saturn V, will accomplish the national goal of a manned lunar landing and return. On this mission, the spacecraft, with the Saturn V 3rd (S-IVB) stage still attached, will be inserted into a 100 nautical mile earth-packing orbit. As the spacecraft orbits the earth, a thorough checkout will be conducted by the crew and the world-wide ground support network to verify that all the equipment is operating safely and reliably, and is ready for the commitment to the lunar mission. When the crew and systems readiness has been fully confirmed, the Saturn V 3rd Stage will be restarted to accelerate the spacecraft to the velocity necessary to escape the earth's gravity and to move into a translunar trajectory. After detailed checkout, the Apollo astronauts will separate the command and service module from the combination of the lunar module, S-IVB, and instrument unit, turn the craft around, and dock with the lunar module. The adapter section, S-IVB, and instrument unit will be jettisoned after this docking maneuver is successfully completed. Necessary mid-course corrections, using the service module propulsion system, will keep the spacecraft on the correct path to the moon. As the Apollo spacecraft nears the moon, the service module propulsion system will again be fired to slow down the spacecraft and inject it into lunar orbit. After a checkout of all systems to assure that the landing sequence requirements have been successfully met, two of the three astronauts will transfer from the command module to the lunar module, separate from the command craft, which will remain in lunar orbit, and prepare to land on the moon. The lunar module's descent engine will be fired to slow the vehicle down for a soft landing on the surface of the moon. After a stay of up to one day, during which the two astronauts will conduct observations, implant experiment equipment and instrumentation, and collect lunar samples, the astronauts will return to the lunar module and prepare for the critical take-off operation. The descent stage will serve as a launching pad for the ascent stage and the cabin. The two astronauts will maneuver their craft to rendezvous and dock with the orbiting command module and re-enter it. The ascent stage will be jettisoned, and left in lunar orbit to relay additional information on systems lifetime and operation back to earth. On-board guidance and navigation data, reinforced by tracking data transmitted from the world-wide network, will provide the crew with the reference points necessary to determine the return trajectory before they restart the service module propulsion system to escape from lunar orbit. After a coasting period, the service module propulsion system can be restarted for the final time to perform any mid-course corrections required to place the command module into the re-entry corridor. The service module will then be jettisoned. The command module will re-enter the earth's atmosphere, aiming at a narrow re-entry corridor about 26 miles wide. This brief description of the manned lunar mission outlines the basic profile, and emphasizes the painstaking procedures taken to assure crew safety and mission success.

Command and Service Module (CSM)

Command and service modules are produced at the Downey, California plant of the Space Division of the North American Rockwell Corporation. Three Block I CSM's have been successfully flight tested. One of these was used for unmanned flight qualification testing to assess the re-entry capability at high-speed, lunar-return velocities. The last spacecraft in this series will be launched by the second Saturn V vehicle early in 1968.

All manned missions will be flown in Block II spacecraft. These spacecraft are configured for lunar missions and incorporate technological changes, including the capability for rendezvous and docking. All Block II spacecraft are being modified to incorporate changes resulting from the Apollo accident. Principal modifications include the replacement of the previous two-piece command module hatch with a single unified hatch. This change will substantially reduce crew egress time under emergency conditions and simplify extravehicular procedures. Major substitutions are being made in spacecraft materials. Metallic cabin materials will, wherever possible, replace non-metallic ones. Where non-metallic materials remain, stringent non-flammability and non-propagation standards have been established. Potentially flammable materials required in the spacecraft are sealed in fire-resistant coverings. Metal covers encase all exposed plumbing and electrical equipment. Additional protective measures were taken to strengthen the plumbing by placing armored collars around joints.

Fiscal year 1967 was marked by extensive ground and flight qualification testing. On August 25, 1966, a second Block I spacecraft was successfully launched, orbited three-quarters of the way around the world, and recovered after withstanding high-speed re-entry. Plans for additional hardware deliveries and flight testing were delayed as a result of the accident.

During FY 1968, intensive qualification of Block II spacecraft systems is being conducted. A boilerplate command module is being subjected to full-scale flammability tests to minimize the possibility of ignition or propagation of fire. A flight-configured command and service module will

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undergo thorough acoustic and vibration testing, under simulated mission environments, to verify the operational safety, reliability, and integrity of the spacecraft. Testing of the command module in the thermal vacuum test chambers at the Manned Spacecraft Center will be conducted to qualify the spacecraft before the first manned flight. The two command and service modules to be used for the first manned flights will be delivered in FY 1968.

Funding during FY 1969 provides for continued production and test of the command and service modules, launch support, and post-flight analysis. Six command and service modules are scheduled for delivery, and integration and checkout will proceed on eleven others. A total of nineteen Block II flight command and service modules are included in the Apollo program.

Lunar Module (LM)

Study and design effort on the lunar module was initiated by Grumman Aircraft Engineering Corporation, Bethpage, New York, in early 1963. The first flight article, designated LM-1, was delivered to the Kennedy Space Center in the fall of 1967 for launch preparations leading to the Apollo 5 mission. This lunar module, launched by a Saturn IB, is scheduled for an unmanned development mission early in 1968 to verify the operational reliability of the systems. The mission will be one of the most significant undertaken to date. In addition to verifying the reliability of the equipment, the LM propulsion systems will be ignited to demonstrate its re-start capabilities during flight. A LM test article, which was flown on the first Apollo Saturn V mission as part of the unmanned flight qualification test program, provided data on vibration, acoustics and structural integrity under a launch environment. Flammability tests were conducted in December 1967 when the lunar module successfully completed a series of tests involving over 40 ignition sources and met the standards for non-propagation of fire. In FY 1968, three additional flight lunar modules are scheduled for delivery to the Kennedy Space Center.

Funding in FY 1969 provides for continued manufacturing and test of lunar modules, launch preparations, post-flight analysis, and associated hardware for experiments to be conducted on the lunar surface. Six flight articles will be delivered in FY 1969. The five remaining articles will be in the process of assembly, systems integration, and checkout at Grumman.

Spacecraft Support

Spacecraft support funds provide for test operations, crew equipment, including space suits, logistics, instrumentation, and scientific equipment.

Funds for test operations are required to conduct spacecraft development tests at the Manned Spacecraft Center and other government test laboratories.

Testing at the Manned Spacecraft Center facilities includes unmanned and manned thermal-vacuum testing in the environmental test laboratory, docking simulation tests, component and subsystem qualification, reliability and verification testing, and electronic systems compatibility tests. Service module propulsion system testing and lunar module ascent and descent engine testing were emphasized at White Sands during FY 1966, 1967, and 1968. The lunar module propulsion system and reaction control system testing is conducted in special test cells at the Arnold Engineering Development Center, Tullahoma, Tennessee. Spacecraft testing is being conducted during FY 1968 to re-qualify the re-entry parachute system to support the increased weight of the command module.

Spacecraft support funding also provides for development and procurement of spacesuits and related crew equipment, survival equipment, food, extra-vehicular activity umbilicals, personal hygiene systems, and bioinstrumentation. Major effort in FY 1969 is focused on manufacturing and testing a spacesuit and portable life support system, required for operating on the lunar surface, as well as manufacturing and testing the recently designed non-flammable crew spacesuit.

Logistic funding for FY 1969 is required for transportation of spacecraft between installations; reimbursement to the Department of Defense for inspection services; and procurement of spacecraft fuels and propellants used in the test programs at NASA facilities and contractor sites.

Instrumentation and scientific equipment funding for FY 1969 provides for development and procurement of specialized flight research and test instrumentation. Typical equipment includes signal conditioners, sensors, transmitters, antennas, ground support equipment, cameras, and radiation measuring devices.

Guidance and Navigation (G&N)

The guidance and navigation system units for the Apollo spacecraft were designed by the Massachusetts Institute of Technology. The General Motors/ A. C. Electronics Division in Milwaukee, Wisconsin, is the prime contractor for fabricating the inertial guidance, including the associated electronics and ground support, and checkout systems, and for assembling and testing all components of the system. The onboard navigational computer is manufactured by the Raytheon Company, Waltham, Massachusetts; the optical subsystem is built by the Kollsman Instrument Corporation, Elmhurst, New York.

Deliveries of the first flight G&N units for the Block II command module and the lunar module were made in FY 1967. In FY 1968, eight Block II command module and eight lunar module G&N units will be delivered. FY 1969 funds support delivery of six command module and six lunar module units, and effort on the last remaining unit which will be delivered in FY 1970.

Integration, Reliability, and Checkout

The integration, reliability, and checkout funding provides for automatic checkout equipment (ACE) stations and engineering support. The spacecraft ACE is used at the contractor plants and at NASA test and launch sites for separate and combined checkout of the spacecraft systems. The basic design of ACE ground stations for each of the major elements of the program was completed in FY 1964; 12 ACE stations are now operational, and the requirement for additional stations is being assessed.

In FY 1968 and 1969, funding provides for operation of the checkout stations, as well as related engineering changes and spare parts to maintain the operational equipment.

Integration and reliability funding provides for the engineering support required for spacecraft specification maintenance and review; systems performance analysis; reliability and quality assurance; trend analysis of failure reports; critical parameter studies and technical problem analysis; mission planning and analysis; post-flight data processing and documentation; simulation and training; and interface control. Emphasis has shifted to support of hardware verification, mission accomplishment and analysis of flight results.

Saturn IB

	1967	1968	1969
1st stage (S-IB).........	$39,111,000	$33,800,000	$20,000,000
2nd stage (S-IVB)........	51,175,000	25,700,000	12,500,000
Instrument unit..........	42,214,000	28,300,000	11,000,000
Vehicle support..........	63,696,000	43,800,000	18,300,000
Ground support equipment.	14,329,000	9,000,000	4,900,000
H-1 engine...............	8,535,000	5,200,000	2,000,000
J-2 engine...............	6,566,000	800,000	400,000
Total.................	$225,626,000	$146,600,000	$69,100,000

The Saturn IB is a two-stage launch vehicle with a capability of placing approximately 20 tons of payload into a low earth orbit, and is used to demonstrate the initial operational capability of the Apollo spacecraft. The 1st stage, powered by eight H-1 engines, produces about 1.6 million pounds of thrust.

The Apollo program includes 12 Saturn IB vehicles. The vehicle was qualified for manned flight in 1966 after three successful development flights. A Saturn IB was scheduled to launch the first Apollo manned spacecraft in early 1967, but the Apollo accident and the subsequent requirements for significant spacecraft modifications delayed this flight until mid-1968. The current plan schedules the next Saturn IB launch, an unmanned, earth-orbital test of the lunar module, early in 1968. Another launch is scheduled in 1968 if a second unmanned test of the lunar module is necessary. Use of the remaining six Saturn IB vehicles in the Apollo program is contingent on the qualification of the Saturn V for manned flight. If the Saturn V encounters difficulties, manned flights of the command and service and lunar modules can be conducted with dual launches of the Saturn IB vehicles. In the first phase of a dual-launch mission, a manned Apollo command and service module will be orbited by a Saturn IB. Approximately one day later, an unmanned lunar module will be orbited by another Saturn IB to provide experience in rendezvous and docking manuevers. Three dual launch missions can be conducted with the available Apollo Saturn IB vehicles. To the extent that these vehicles are not required for support of the Apollo program, they will be available for Apollo Applications missions.

1st Stage (S-IB)

The Chrysler Corporation/Space Division produces the S-IB stages at the government-owned Michoud Assembly Facility near New Orleans, Louisiana. The stage is barged to the Marshall Space Flight Center, Huntsville, Alabama, for static test. The stages are then returned to Michoud for post-static checkout and subsequent delivery to Cape Kennedy.

By the end of FY 1967, four flight stages had been delivered to Cape Kennedy, and three additional stages were completed.

In FY 1968, the remaining five stages for Apollo Saturn IB vehicles will be completed at Michoud and available for support of program requirements. If required for Apollo, the first of these stages will be checked out late in FY 1968, modified if necessary, and prepared for shipment to Cape Kennedy.

FY 1969 funds provide for checkout and pre-shipment activities at Michoud, as well as delivery to Cape Kennedy and pre-launch preparations. The budget year requirements also cover stage support activities, which include engineering analysis and operation and maintenance of electrical, data-measurement, and test equipment. A significant level of field support must be maintained for launch services and for proper evaluation of ground and flight data.

2nd Stage (S-IVB)

Basic development costs for the 2nd stage (S-IVB) were primarily funded in the Saturn V project. The S-IVB, which is produced by the McDonnell Douglas Corporation, uses a single J-2 engine developing over 200,000 pounds of thrust.

The first four flights stages for the Saturn IB have been delivered to Kennedy and three have been launched. Five additional stages were completed in FY 1967. Four of these have been static tested and remain at the Sacramento Test Operations site for use in future missions. The other stage has completed manufacturing and assembly at Huntington Beach, and will undergo static firing at a later date. The remaining three stages for the Apollo program were completed during the current fiscal year.

Fiscal year 1969 funding supports required stage activities, such as static testing at the Sacramento Test Operations site, post-static checkout, and pre-shipment verification. The funds provide a significant level of field support services, which are necessary for pre-launch and checkout activities at Cape Kennedy and for the evaluation of ground and flight data on S-IVB operations.

Instrument Unit (IU)

The instrument unit contains the primary guidance, control, measuring, and telemetry systems which govern the engine gimballing, in-flight sequencing of the engine propulsion system, staging operations, and primary timing signals. These units are being assembled and tested by the International Business Machines Corporation in Huntsville, Alabama. The components and configuration are essentially the same as those used for the Saturn V. Three units were completed by the end of fiscal year 1966.

Fiscal year 1967 and 1968 effort has concentrated on the completion of the nine remaining flight units. In FY 1967, five additional units were completed, one of which was delivered to Cape Kennedy and the other four were placed in storage at Huntsville, Alabama. The remaining four of the total of 12 flight units will be assembled and placed in storage in FY 1968.

Fiscal year 1969 funds support verification of the reliability of the completed units to meet the Apollo requirements. In addition, the funding provides for the IBM support at Cape Kennedy, necessary for pre-launch, checkout, and flight evaluation activities.

Vehicle Support

Vehicle support includes funds for studies, services, and equipment common to more than one stage of the Saturn IB. Funding provides for engineering services; reliability tests; fabrication services; transportation; propellants; expendable supplies and equipment; launch pad refurbishment; and contract administration, audit, quality assurance and inspection services performed by the Department of Defense.

Fiscal year 1969 funding is required to provide pre-launch and launch support at Cape Kennedy for dual launches from Complexes 34 and 37. Activities include component and subsystem testing, analysis and correction of pre-launch problems, incorporation of flight data into reliability assessments, and development of an integrated reliability report for each mission. Guidance and control systems studies will be conducted. In addition, the requirements cover refurbishment of the launch pad in preparation for the next mission. The FY 1969 vehicle support funds also include transportation of the flight stages and instrument units.

Ground Support Equipment (GSE)

The automatic ground support equipment includes electrical support equipment, which was built by the General Electric Company, and mechanical support equipment, which was produced by the Chrysler Corporation Space Division. Automatic ground checkout stations reduce the length of time and the cost of manual checkout. In addition to these checkout stations, a GSE development system or breadboard, using the RCA 110A computer, is operated at the Marshall Space Flight Center to provide the capability to validate the computer programs used at the Kennedy Space Center.

Funding in FY 1967 was geared primarily to activation of electrical and mechanical support equipment installed at Launch Complexes 34 and 37. Fiscal year 1968 and fiscal year 1969 funds will support the operation and updating of stage and vehicle ground support equipment used to meet specific mission requirements for Saturn IB launches. This activity includes the checkout operations for the stages, instrument units, and assembled launch vehicles used for the earth orbital missions planned during these periods.

H-1 Engines

The H-1, a liquid oxygen/kerosene engine, was developed and is now being produced by the Rocketdyne Division of North American Rockwell Corporation. Eight H-1 engines are used in a cluster to power the S-IB stage.

In FY 1967, the final set of H-1 engines for use in Apollo was delivered. A total of 123 engines were delivered to meet test and flight requirements.

Funding for FY 1968 and FY 1969 provides for support of the flight program and for evaluation of flight data and rapid response to problems encountered in flight missions.

J-2 Engines

The J-2 engine, developed and produced by the Rocketdyne Division of the North American Rockwell Corporation, is used in the upper stages of both the Saturn IB and Saturn V launch vehicles. A single J-2 is used in the 2nd stage of the Saturn IB, utilizes liquid hydrogen and liquid oxygen as propellants, and delivers over 200,000 pounds of thrust.

The flight rating tests of a 200,000 pound thrust engine were completed in July, 1965. In 1966, the engine completed the qualification test program, which was a prerequisite to certifying the configuration for manned flight.

All J-2 engines required for the Apollo Saturn IB series were delivered by the end of FY 1967.

In FY 1968 and again in FY 1969 funding is necessary to cover J-2 field support, which provides for evaluation of flight data and rapid response to any problems encountered in the flight series.

Saturn V

	1967	1968	1969
1st stage (S-IC).........	$158,866,000	$156,600,000	$137,600,000
2nd stage (S-II).........	249,000,000	203,000,000	174,000,000
3rd stage (S-IVB)........	142,114,000	130,000,000	117,100,000
Instrument unit..........	72,008,000	77,900,000	67,600,000
Vehicle support..........	267,147,000	233,800,000	208,000,000
Ground support equipment.	44,854,000	44,400,000	29,300,000
F-1 engine...............	77,434,000	83,200,000	42,700,000
J-2 engine...............	86,731,000	70,000,000	41,900,000
Total..................	$1,098,154,000	$998,900,000	$818,200,000

The Saturn V, the most powerful member of the Saturn family of launch vehicle, is composed of three propulsion stages and an instrument unit. The vehicle is designed to boost payloads up to 140 tons into low-earth orbit and to send payloads up to 50 tons on lunar missions.

The Saturn V schedule provides for fifteen launch vehicles for unmanned qualification flights, manned lunar mission simulations, and manned lunar missions. Nine of these vehicles are scheduled to be launched before the end of the decade. Two vehicles were delivered in FY 1967, the first of which was used on November 9, 1967 in the highly successful demonstration of the "all up" concept of space vehicle development. This unmanned orbital flight tested the vehicle dynamic characteristics, the reliability of the propulsion systems, and the accuracy of the guidance and control sequencing system, as well as a spacecraft heat shield. Two additional unmanned qualification tests and the first manned flight are scheduled for 1968. For 1969, the Apollo schedule includes five manned Saturn V flights, moving toward a manned lunar landing and return by the end of the decade. Major production activity continued over the last year, with the undelivered vehicles in the process of manufacturing, checkout or test.

1st Stage (S-1C)

The Saturn V 1st Stage (S-1C) is produced by the Boeing Company at the Michoud Assembly Facility near New Orleans, Louisiana. The stages are now acceptance tested at the Mississippi Test Facility in Hancock County, Mississippi, before shipment to the Kennedy Space Center. The 1st Stage is powered by five liquid oxygen-kerosene F-1 engines and has a total thrust of 7.5 million pounds. Stage development began in 1962. The Marshall Space Flight Center, with Boeing assistance, manufactured the first ground test stage and the first two flight stages. The first flight stage was delivered to Kennedy in 1967 and was used in the successful first Saturn V launch.

Fiscal year 1968 activity concentrates on manufacturing, checkout, and test activities. The second flight stage, which was delivered to KSC and integrated into the AS-502 launch vehicle, is undergoing checkout in preparation for a launch early in 1968. The third flight stage arrived at Kennedy Space Center in 1967 for use in the AS-503 vehicle, and two others are scheduled for delivery by the end of the fiscal year. Two additional stages will also complete acceptance testing.

In FY 1969, five stages, including the two completed in FY 1968, will be delivered to the Kennedy Space Center. Two other stages will be completed at Michoud and available by the end of the year. The last three of the fifteen flight stage program will be through manufacturing and in acceptance testing or post test refurbishment.

2nd Stage (S-II)

The 2nd Stage of the Saturn V uses a cluster of five liquid-oxygen, liquid-hydrogen J-2 engines. The stage generates a total thrust of about one million pounds. Development of this stage also began in 1962 and its maiden flight test was highly successful. The development, production, and test of the stage is the responsibility of the Space Division of the North American Rockwell Corporation. Manufacturing, assembly and factory checkout of the stage is performed at Seal Beach, California, in government-owned facilities. Acceptance testing of the flight stages is conducted at the Mississippi Test Facility before delivery to the Kennedy Space Center.

Three of the fifteen flight stages included in the S-II program have been delivered to the Kennedy Space Center. Two additional stages will arrive at Kennedy Space Center by the end of FY 1968. The remaining ten Apollo flight stages will be in fabrication, assembly, systems installation, factory checkout or acceptance testing by the end of the year.

Fiscal year 1969 funding provides for the completion and delivery of five stages, the continued manufacturing, factory checkout, and test of the remaining five stages. The funds cover extensive pre-launch checkout at the Kennedy Space Center in readiness for launch.

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3rd Stage (S-IVB)

The 3rd Stage of the Saturn V (S-IVB), was developed and is produced by the McDonnell Douglas Corporation at Huntington Beach, California. The stage is powered by a single J-2 engine and generates a thrust of over 200,000 pounds. The stage is used on both the Saturn IB and the Saturn V, but basic development costs were funded from this line item. McDonnell Douglas performs stage acceptance testing at the Sacramento Test Operations Site. Fabrication of the first Saturn V flight stage began in 1964 and this stage was delivered to the Kennedy Space Center in 1967. The S-IVB achieved a significant milestone during the first Saturn V mission when it successfully demonstrated its ability to re-start in a space environment. Two other Saturn V flight stages have already been delivered to the Kennedy Space Center. Another two will be transported to the Kennedy Space Center before the end of fiscal year 1968. Manufacturing, assembly, and checkout work is progressing on nine other stages at the Huntington Beach plant.

During FY 1969, fabrication of the last flight stage will commence, and a total of five flight stages are scheduled for delivery to the Kennedy Space Center. Manufacturing, assembly, and checkout of the five remaining Apollo stages will be underway during this year. Fiscal year 1969 funds support this extensive activity, as well as the related pre-launch activities at the Kennedy Space Center.

Instrument Unit (IU)

The Saturn V instrument unit is essentially the same as the one used on the Saturn IB. The instrument unit contains the guidance and control system that issues commands to the attitude control devices of each stage during powered flight to guide the Apollo Saturn V. The instrument unit also controls engine start and cut-off. The units are assembled and checked out by the International Business Machines Corporation in Huntsville, Alabama. Procurement activity for the first Saturn V flight unit began in January 1965, and the first flight unit was delivered to the Kennedy Space Center in August, 1966.

Effort in FY 1967 was devoted to assembly and inspection of the first four flight units, as well as continued manufacturing of components. The second and third instrument units have been delivered to Kennedy Space Center to support the AS-502 and AS-503 requirements. Instrument units for AS-504 and AS-505 will be shipped to the Kennedy Space Center during FY 1968.

During FY 1969, five Saturn V instrument units will be shipped to Kennedy Space Center to support the schedule,fabrication and assembly of two additional units will begin, and long-lead hardware on the last three units will be procured.

Vehicle Support

Vehicle support funds are required to provide services and equipment that are common to more than one stage of the vehicle. Funding in FY 1967 and FY 1968 included instrumentation, recording and data reduction equipment for the Saturn V dynamic test stand at Marshall Space Flight Center; shipping costs, which include use of marine vessels and aircraft for transportation of stages, engines and components; activation and operation of the Mississippi Test Facility; operation of the Slidell Facility; range safety and tracking devices for the vehicles; propellants; systems integration; and computation services, engineering services, quality control and inspection, contract administration, audit and property administration services by other government agencies.

In FY 1969, the emphasis will be focused on necessary support test operations at the Mississippi Test Facility and vehicle support at the Kennedy Space Center. Systems integration funds are also provided to continue proper configuration control of all stages, systems, and structures, as well as reliability and flight evaluation programs.

Ground Support Equipment (GSE)

The Saturn V ground support equipment consists of electrical and mechanical support equipment required to test and check out the stages, instrument units, and associated hardware. The checkout procedures developed for the Saturn V are based on the concept that improved vehicle reliability and minimum time at the launch site can be attained by using a computer-controlled system in which the operational soundness of components is automatically verified. Automatic checkout equipment is used at the manufacturing, static test, and launch sites.

The General Electric Company provides design, fabrication, checkout, and logistic support of the Saturn V electrical support equipment. The Boeing Company provides the Saturn V equipment management system, which includes a master record for all vehicle ground support equipment. Boeing is also responsible for the integration and logistic support of all mechanical support equipment. The Radio Corporation of American supplies computer systems, and provides the display systems for use at Launch Complex No. 39.

Activity in FY 1967 included preparation and verification of computer tapes for initial Saturn V flight missions. In addition, the vehicle GSE for the second set of facilities at Launch Complex No. 39 was installed and checked out. Delivery and installation of vehicle-associated GSE for the third launch umbilical tower, high-bay, and firing room was also initiated.

Fiscal year 1968 funds support preparation and verification of computer tapes for the manned Saturn V missions and also provide for completion of Saturn V - related GSE for the third launch umbilical tower, high-bay, and firing room at Launch Complex No. 39.

Fiscal year 1969 funding supports the operation of stage and vehicle ground support equipment, including mechanical and electrical support equipment to satisfy Saturn V requirements. This activity includes checkout and operations for the stages, instrument units, and assembled launch vehicles.

F-1 Engines

The F-1 engine was developed and is produced by the North American Rockwell/Rocketdyne Division at Canoga Park, California. Engine testing is conducted at Edwards Air Force Base, California. Five liquid oxygen/kerosene F-1 engines are clustered in the first stage of the Saturn V, with each engine generating approximately 1.5 million pounds of thrust.

The initial contract for the F-1 was awarded to Rocketdyne in January 1959. By the end of FY 1967, a total of sixty-three F-1 engines had been delivered to support the Saturn V. This total included spares, test, and flight engines.

Activity in FY 1968 emphasizes the delivery of flight engines to meet the Apollo Saturn V schedule. By the end of the current fiscal year, nineteen additional F-1 engines will have been delivered for the ground test and flight program.

Funds in FY 1969 provide for continued engine deliveries to meet flight requirements. Twelve F-1 engines are scheduled for delivery during this period. The funds also provide a quick-response capability for evaluating and resolving any F-1 problems encountered in the flight missions. This effort covers field and engineering support; maintenance of the test engines; testing of the components and engine systems, including propellants; and periodic verification of flight worthiness to assure mission reliability and safety.

J-2 Engines

The J-2 engines are also produced by North American Rockwell's Rocketdyne Division. These engines are used in the two upper stages of the Saturn V. The second stage is powered by five J-2 engines, each producing over 200,000 pounds of thrust, while the third stage is powered by a single J-2 engine with re-start capability. The J-2 entered development in September 1960, and the first flight demonstration was achieved in February 1966.

During FY 1967, the engine delivery rate intensified to meet the schedule requirements. By the end of that fiscal year, a total of 98 J-2 engines, including ground test and flight articles, had been delivered. During FY 1968, an additional 18 engines are scheduled for delivery.

The funds in FY 1969 provide for delivery of twelve more engines and for the field and engineering support activity required for flight evaluation and problem solving. The funds also assure maintenance of test engines in a configuration for rapid solution of problems; component and system testing, including propellants, as well as periodic verification of flight worthiness.

Engine Development

	1967	1968	1969
Engine development...........	$49,800,000	$18,700,000	---
Total......................	$49,800,000	$18,700,000	---

Fiscal Year 1968 is the last year of funding under the Engine Development project. Qualification of the H-1, F-1, and J-2 engines was accomplished during FY 1967. Funding during FY 1968 provides for government furnished propellants for continued test activity and for government in-house and independent contractor analysis of engine hardware. A major activity is the J-2 engine environmental test program conducted at the Air Force Arnold Engineering Development Center, Tullahoma, Tennessee. No funding is requested for the Engine Development project in FY 1969.

Mission Support

Operations...................	$184,120,000	$227,800,000	$262,100,000
Systems engineering..........	27,300,000	37,000,000	37,300,000
Supporting development.......	27,000,000	32,000,000	32,000,000
Total......................	$238,420,000	$296,800,000	$331,400,000

Mission support funds provide for the critical areas of launch, flight crew, and recovery operations and for the program-wide engineering and technical integrated support and supporting development necessary for the accomplishment of manned space flight.

Operations

There are two centers of operations activity - one at the Kennedy Space Center, Florida, where the launchings take place and the other at the Manned Spacecraft Center, Texas, where crew training, and flight and recovery operations are conducted and directed.

Funding for the Kennedy Space Center covers the operation of checkout, launch and instrumentation facilities including those contractor services and equipment and materials supplied by the Air Force Eastern Test Range for which the National Aeronautics and Space Administration reimburses the Department of Defense. Launch operations funding has been increased by

$19.8 million to cover the new reimbursable arrangements at the Air Force Eastern Test Range including operational support to launches, and general support from technical shops and instrumentation sites. In addition to the operation and maintenance of Launch Complexes 34 and 37, the Department of Defense provides continuous wave tracking services and technical shop and laboratory support. The major operational costs and elements at the Kennedy Space Center, however, are associated with operation and maintenance of Launch Complex 39; specialized maintenance and repair of launch facilities; maintenance of communications instrumentation, including the center computer complex; and the modification and up-dating of all launch associated equipment and facilities.

Funding for effort conducted and directed by the Manned Spacecraft Center includes the operation and maintenance of the very complex mission control center, the training of astronaut crews through the use of mission simulators and high performance aircraft. Manned Spacecraft Center operations activities also include the direction and funding of recovery operations, and important mission planning requirements including trajectory analysis, failure analysis and evaluation of the performance and operational characteristics of the Manned Space Flight Network.

Mission operations funding requirements increase significantly as the Apollo program momentum is re-established and the launch, flight, and recovery activity increases. Fiscal year 1969 requirements are related to the Manned Space flights scheduled during the fiscal year and to the preparation of crews and space vehicles for the subsequent missions.

This pace of the activity leads to a manned lunar landing and return before the end of the decade.

Systems Engineering

Systems engineering provides for integrated technical support, review, and analysis of manned space flight programs. These services include the development of functional and performance standards for the program, consistent with mission objectives; mission planning; technical integration and evaluation test objectives and integration; program and systems specifications; trajectory analysis; checkout effectiveness; and technical documentation. Bellcomm, Boeing and General Electric are the principal systems engineering contractors.

During FY 1967 and FY 1968, emphasis was placed on developing and maintaining a quick response capability for validation and analysis of flight data on a time scale compatible with the turn-around time of Apollo flight missions. Funding also provides for non-recurring maintenance and rehabilitation of government-owned industrial plants.

The systems engineering requisite for technical integration and evaluation, trajectory analysis, checkout effectiveness, analysis of flight mission results, detailed studies of specific lunar landing areas and constraints, and technical documentation will continue through FY 1969 to support the flight activity.

Supporting Development

Supporting development consists of individually selected engineering efforts which back up an on-going mainstream program with alternate or improved hardware or which provide a firm basis for specific hardware decisions which must be made in the relatively near-term future. The nature of these engineering efforts varies widely, extending from substitute space systems, materials to fabrication and test, and evaluation techniques. It is an essential characteristic of these tasks that they are undertaken with a specific hardware situation for a specific application in mind. When completed and the results applied to on-going manned space flight activities, there have been notable achievements in cost reduction and/or increase in performance, reliability, safety, confidence or simplicity. One hundred-fifty tasks are currently underway in FY 1968, with individual funding requirements ranging from $10,000 to $300,000. The tasks range from development of an astronaut microphone with superior noise-canceling characteristics and increased dynamic range to the development of a system at the Kennedy Space Center that will automatically and continously monitor the purity of fluids being supplied to space vehicles while they are on the launch pads undergoing checkout or actually in the count-down for launch. The astronaut microphone will be used for the second manned Apollo mission.

Other results of previous tasks that have been incorporated into manned space flight systems include high and low temperature resistant explosive devices for use on the CSM & LM; improved hand held maneuvering unit for extravehicular activity; an exploding bridgewire firing unit for rocket engines; a pressure transducer that can withstand the 6,000 °F temperature of rocket engine combustion, and a new type surfacing for the crawlerway at LC 39.

Effort in fiscal year 1969 will concentrate on continuing those promising tasks started in fiscal year 1968 and in undertaking new tasks designed to increase the reliability and usefulness of the present Apollo/Saturn systems and facilities.

OFFICE OF MANNED SPACE FLIGHT — APOLLO APPLICATIONS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Apollo Applications program is directed toward increasing the effectiveness of manned space flight operations in the accomplishment of experiments and other inflight activities. The program presented herein uses the capabilities developed for the Apollo Program and is designed to accomplish a limited but carefully selected spectrum of scientific technological and medical investigations. The Program is configured to maintain progress in manned space flight and provide the information required to permit knowledgeable decisions concerning potential follow-on space programs while operating within a severely limited budget.

Missions are built upon a strong base of flight experience, ground facilities, and trained manpower developed in the Gemini and Apollo Programs. Maximum economy is achieved through the use, modification, and expansion of present Apollo systems capabilities rather than moving toward wholely new developments. Further, any Apollo spacecraft and launch vehicles not required to meet Apollo objectives will be used for Apollo Applications missions.

The Apollo Applications mission objectives include:

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

2. The achievement of 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. The conduct of scientific, technical, and applications tasks with the aims of assessing, experimenting with, and increasing man's capabilities for performing these tasks; as well as the acquisition of useful data and results.

Because these activities are still exploratory in nature, and in many respects will establish the base for more extensive follow-on systems, the information will be obtained as early as possible within fiscal constraints by using to a large extent already developed Apollo hardware, and by employing revisit and reuse techniques in the flight missions.

During fiscal years 1968 and 1969 Apollo Applications funding provides for continuation of production of Saturn launch vehicles at a minimum rate and development and fabrication of the equipment and experiments for the orbital workshop, the solar astronomy, and the revisit missions. In addition, definition effort will be underway to determine the equipment and experiments necessary for the most effective exploration of the moon in the post-Apollo period. These activities support the following missions in the Apollo Applications program:

Orbital Workshop Mission - Initial orbital workshop operations are planned in 1970. The orbital workshop is set up inside the empty hydrogen tank of a spent S-IVB stage, i.e., after its actual use as a launch vehicle stage, the workshop then serves as the nucleus of an embryonic space station. Operating subsystems for power, life support, thermal controls and experiments, together with airlock; docking adapter and experiments modules, are carried in the volume occupied by the spacecraft adapter in the normal Apollo configuration.

The orbital workshop mission 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 hydrogen tank of the S-IVB stage will have been modified so that it is safe for crew occupancy and will be used for living and working quarters. Following venting, the hydrogen tank will be repressurized with the two-gas atmosphere of oxygen and nitrogen. The crew will transfer from the command module through the docking adapter and the airlock module into the orbital workshop, and complete preparations for the crew quarters. Elements of the space station will have already been pre-installed in the S-IVB stage before launch. The airlock module will have a suitable hatch to permit access to space without depressurizing the orbital assembly.

The experiments planned on this mission are chiefly devoted to determining and evaluating task performance of men in space over extended periods of time. Habitability experiments include crew quarters evaluation, food and food preparation, personal hygiene provisions, evaluation of space suits, and mobility devices. Extensive medical evaluations of the effect of long duration space flight on the crew will be made. Engineering experiments, including maintenance tasks, measurement of heat flow, electron beam welding, tube joining, and flammability in the zero gravity environment, will be conducted. Finally, various technology and scientific experiments, including earth science observations are planned. The planned mission duration for the crew will be 28 days. After completion of experimental activities, the equipments in the workshop, airlock and docking adapter will be placed in a standby mode for the orbital storage. The crew will return to the command module and separate from the docking adapter. The service module propulsion system will be used to place the command module on an earth return trajectory.

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Workshop Revisit Mission - The first workshop revisit mission uses a single Saturn IB launch of a three man Command and Service Module to rendezvous and dock with the orbital 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 28 to 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. For this reason, the primary in-flight experiment emphasis will be in the medical area. This will be the first mission in which a medical doctor is a member of the crew. Other crew activities will continue the experimental evaluation of the utility of the various habitability subsystems and accommodations of the workshop itself, and of the extra-vehicular activity devices carried in the initial workshop launch. The results of the initial workshop mission will be used to refine the operating procedures. Similarly, the results of this mission will be used to improve equipment and operating plans for subsequent missions.

Solar Astronomy Mission - The third mission, planned for 1971, uses the orbital workshop as a base of operations for a manned solar observatory. One Saturn IB will launch a three man Command and Service Module configured for a 56 day mission; a second Saturn IB launches the unmanned Apollo Telescope Mount (ATM) with its payload of solar instruments. After the Command and Service Module and ATM rendezvous and dock with the workshop, the crew reactivates the workshop and begins the operational phase of the mission. This mission will be the first flight test of equipment and operating concepts for future manned and man-tended astronomical observatories. The ATM incorporates high resolution solar telescopes and spectrographs for observing dynamic phenomena on the surface and in the corona of the sun. The mission is scheduled to fly at a time when there is a good expectation of sunspot activity. It is expected that an astronomer astronaut will be a member of the crew. Crew activities are structured to allow the maximum possible time for operation of the observatory. Medical observations of the crew during this second 28 to 56 day mission will add significantly to the data base on man's reaction to the space environment. Just prior to their return from the mission, the crew puts the workshop and the ATM into condition for orbital storage for further use on subsequent revisits. The ATM hardware and mission plans are designed to operate independently if the orbital workshop is not available for reuse.

Workshop/Observatory Revisit Missions - A series of three additional revisits to the orbital workshop is planned in 1971. These will use the same configuration of the Command and Service Module being developed to support the first revisit to the workshop and the Apollo telescope mount missions, with a nominal duration of 56 days.

Goals for these missions include continued use of the ATM for solar observations, the ferrying of additional experiments to the workshop, further evaluation of evolving concepts in the area of crew systems and habitability of the workshop, and continuation of experiments using instruments and equipments orbited on previous missions. A further goal is to achieve continuous operation of the orbital workshop by having later missions overlap the earlier ones. This will allow limited periods of operation with two crews in the workshop simultaneously and in turn provide the option to make the next progressive step in crew stay time to a duration of the order of 100 days.

Initial Space Station - Over the past several years NASA, with supporting effort from many contractors, has conducted a series of studies of the configuration and utilization of an orbital workshop or initial space station launched on a Saturn V. The ability of the Saturn V to orbit a workshop outfitted on the ground before launch, significantly enhances the effective use of manned operations in earth orbit. The flexibility in locating diverse mission experiment equipments, the ability to maintain continuous operation and to add new experiment payloads on resupply flights, and the possible increase in crew size are factors of great potential value.

The development and operation of the Saturn IB workshop will provide the engineering, biomedical, behavioral, and operational knowledge which will permit moving forward into this next step. In a similar manner, the diverse experimental activities to be undertaken in the first set of workshop missions will provide background to the operational employment of the more comprehensive research program which can be carried out in a Saturn V workshop.

Effective evolution and utilization of the space program and its capabilities require that the specific approach to the Saturn V workshop be determined within the next year. This definition effort will be directed toward the workshop; its scientific, engineering, and medical payloads; and operations plans.

Implementation of the Initial Space Station with its ability to support major scientific and engineering investigations, using crews of diverse scientific and technical abilities over extended periods of a year or more in orbit is a natural outgrowth of the progressive evolution which Mercury, Gemini, Apollo and the Apollo Applications Saturn IB workshop have established and will provide a very significant step forward in the utilization of our national space capability.

The specific S-IB workshop mission plans, definition of potential follow-on experiments and studies of initial space station configurations and systems all point to the logic of progressing to the Saturn V launched workshop or initial space station as the next follow-on step in an evolutionary manned orbital program. The effective utilization and progression of the space program and its capabilities require that the specific approach to a Saturn V workshop or initial space station be determined within the next calendar year. This definition effort will be directed toward the station; its scientific engineering and medical payloads; operations plans; resupply and supporting systems; and overall program plans.

This initial space station is a natural progression from the Saturn IB workshop, as well as from the Mercury, Gemini, and Apollo programs. It will enable astronaut crews to conduct major scientific and engineering investigations for a period of a year or more.

Lunar Missions - Following the first Apollo landings, we will continue exploration of the moon. During the continuing phase of lunar exploration one to two missions per year are envisioned.

Whereas the first Apollo missions will be restricted to a narrow zone along the lunar equator, the later missions are planned such that they can have access to over 50% of the visible face of the moon. In addition to increasing the accessible area, the extended lunar module will be capable of landing within one kilometer of a predesignated target. Study of candidate sites for post-Apollo missions continued at an increased pace during the past year abetted by the photographs received from the Lunar Orbiters. These photos were studied by several teams of scientists with the result that the 10 most highly desirable sites have been identified. These sites, scattered within the acceptable landing area, are under continuing study in order to better understand their impact on future mission planning.

In analyzing the requirements for the post-Apollo missions three important extensions to the projected Apollo surface mission capability were identified:

1. Extension of staytime for the astronauts.

2. Increase in exploration radius about the landing site.

3. Increase in landed payload for mission support.

Studies of ways to extend the missions in these areas were conducted during the past year and preliminary designs for the required modifications to the Apollo lunar module were under way. With these proposed modifications, missions in 1971 and 1972 can be planned with a surface staytime for 2 astronauts of 3 or more days during which time they will be able to explore within a 5 to 10 kilometer radius of the landing point. This increased capability is brought about by utilizing performance margins which have been identified in the Apollo lunar module and which we are confident will become available

The increased capability of the lunar module increases the scientific effectiveness of the lunar mission in two important ways. It allows much greater selectivity in the choice of scientifically interesting sites and second, it allows the carrying of a mobility device to increase the potentially accessible area on an individual mission.

The objectives of the three day lunar mission are to develop our ability to conduct investigations at high priority scientific sites and to provide information in support of future operational requirements. The scientific payloads will be used to collect detailed data at the landing site and will include deployment of packages similar to the Apollo Lunar Surface Experiment Package (ALSEP). These experiments will be directed primarily toward the establishment of instrument networks on the lunar surface. Scientific investigations will center about the collection of data at specific features selected from orbital photography. Sampling, and the return of samples to earth, will continue to be of the highest priority.

The increase in landed payload and staytime will significantly increase the scientific return of the missions improving the opportunity for effective analysis and sampling over a greatly expanded area on the lunar surface.

SUMMARY OF RESOURCES REQUIREMENTS:

	1967	1968	1969
Space vehicles..................	$37,700,000	$86,000,000	$201,300,000
Experiments.....................	37,600,000	139,000,000	190,300,000
Mission support.................	4,700,000	28,200,000	48,000,000
Total........................	$80,000,000	$253,200,000	$439,600,000

Distribution of Program Amount by Installation:

	1967	1968	1969
John F. Kennedy Space Center, NASA......................	$400,000	$2,000,000	$4,200,000
Manned Spacecraft Center......	31,291,000	120,300,000	197,900,000
Marshall Space Flight Center..	41,781,000	119,200,000	223,900,000
Goddard Space Flight Center...	---	3,000,000	3,000,000
Jet Propulsion Laboratory.....	---	800,000	1,100,000
Ames Research Center..........	365,000	---	---
Electronics Research Center...	---	400,000	1,000,000
Langley Research Center.......	1,345,000	1,000,000	1,000,000
NASA Headquarters.............	4,818,000	6,500,000	7,500,000

BASIS OF FUND REQUIREMENTS:

Space Vehicles

	1967	1968	1969
Saturn IB procurement...........	$21,900,000	$28,600,000	$35,400,000
Saturn V procurement............	1,300,000	2,400,000	61,300,000
Spacecraft modification.........	14,500,000	55,000,000	104,600,000
Total........................	$37,700,000	$86,000,000	$201,300,000

Funding of Space Vehicle requirements in support of the Apollo Applications program through fiscal year 1969 is limited to the procurement of Saturn IB and Saturn V launch vehicles and to the design, development production and installation of Apollo spacecraft systems that require modifications to meet the long duration objectives established for Apollo Applications missions.

To minimize expenditures, delivery of Saturn IB launch vehicles for use in the Apollo Applications program has been re-scheduled to two per year beginning in calendar year 1970. Funding of the production activities to support the delivery requirements began in fiscal year 1966 when funds were used to procure long leadtime components for the H-1 engines used in the first stage of the Saturn IB. Component fabrication was started in fiscal year 1967, and by the end of fiscal year 1968, vehicles 213 and 214 will be in manufacturing.

Funding in fiscal year 1969 provides for the continuation of production of vehicles 213 and 214 and long lead time procurement on subsequent vehicles. We will have to place orders late in 1968 in order to continue production beyond IB #216.

Production of Saturn V launch vehicles for Apollo Applications is also scheduled at two per year with the first delivery of a post-Apollo vehicle planned for 1971. Funding in fiscal year 1967 and fiscal year 1968 is related to long lead procurement for engines. The very low rate of funding in these years is directly related to the stretch out of Apollo production which has deferred any substantial funding of follow-on Saturn V's until fiscal year 1969. Although there is a sharp increase in AAP funding for Saturn V procurement in FY 69, this is offset by a reduction in Apollo Saturn V funding and the total shows a steady downward trend.

FY 1969 funds provide for initial production efforts on all three stages of launch vehicle 516 and on the S-II stage of vehicle 517.

The long-duration characteristics of the Apollo Applications missions require that spacecraft systems be modified to support these extensions in flight time. The Apollo spacecraft has been designed and produced to provide a 14 day operational capability and must be modified to accommodate the 56 day missions that are incorporated in the Apollo Applications program. The capability of the lunar module will be extended to permit a three day stay time on the lunar surface.

Major modifications to the command and service module include increasing the capacity of the reaction control system to support flight maneuvering during long duration missions. The life time and reliability of the fuel cells will be improved to assure performance for 56 days. Cryogenic tankage will be increased to provide the additional hydrogen and oxygen for powering the fuel cells and life support during extended duration flights. The communications and electrical systems will also be modified to accommodate an increase in voice and data recording units and to provide power regulation, current transfer, and interface controls between the command module and the space vehicle coupled to it. Display and control systems for the crew must be changed to reflect the increased capacity and performance of the spacecraft. The command and service modules used for Apollo Applications missions will provide an oxygen/nitrogen atmosphere as the environment to avoid the possible deleterious effects of a pure oxygen atmosphere during long-term spaceflight. This change requires modification of the environmental control unit and the associated plumbing, heating units and tankage. A waste liquid retention system will also be installed so that the discharge of unneeded liquids can be made at controlled times so as not to interfere with experiment activities.

Changes will be made to the software elements of the guidance and navigation system to accommodate the workshop and ATM missions requirements.

Major definition analyses of the modifications to the spacecraft were undertaken in FY 1967. Design and development of the major modification kits will begin in FY 1968 with component and material testing of prototypes of the modified subsystems commencing during this year. Procurement of the propellant and cryogenic tankage has been initiated.

Funding during FY 1969 provides primarily for the detailed engineering, fabrication, checkout, and test of the modified subsystems prior to their installation in Block II command and service modules. It is planned that all manufacturing of the modification kits for the first command and service module will be completed during FY 1969. The modification kits include those for the environmental control systems, electrical systems, electronics, fluid systems, crew systems, reaction control systems, communication systems and the service propulsion system. Start of installation of the modifications in spacecraft will be deferred to as late a time as feasible and will not begin until early in calendar year 1969.

The Apollo Applications program will include extended duration missions on the lunar surface greater than the one day stay times of the Apollo program.

Feasibility studies directed toward modifying the lunar module to operate for a stay time of three days were performed during FY 1967, with preliminary design of the modified spacecraft being conducted during FY 1968.

FY 1969 funding provides for the preparation of vehicle and test specifications and the initial procurement of long lead hardware. Test programs for the additional cryogenic tankage and the solar cell array for electrical power will be started.

Experiments

	1967	1968	1969
Definition	$10,974,000	$21,000,000	$25,000,000
Development	26,626,000	118,000,000	165,300,000
Total	$37,600,000	$139,000,000	$190,300,000

Apollo Applications experiments cover a wide range of objectives in the fields of space medicine, science, applications, technology, and engineering. The definition and development of experiment payloads to meet these objectives will include activity by elements of NASA, other government agencies and the scientific and industrial communities.

Definition

Unlike preceding manned space flight projects, in which the successful demonstration of the basic systems capability was the principal objective, Apollo Applications must achieve its objectives primarily through the judicious selection and carefully planned accomplishment of specific experiments. Therefore, the early and accurate definition of the experiments and experimental systems in this program is absolutely vital to eventual mission success and the achievement of program objectives.

Before an experiment can be committed to an on-going flight program it must be determined to be feasible for missions in the program and be assessed in terms of its specific contribution to the program objectives. In addition, it must be well-defined in terms of requirements for funding, schedule, power, temperature, volume, and other mission constraints. Formal approval for inclusion in a flight program is given by the Manned Space Flight Experiments Board which bases its decisions on the facts developed in the definition process. The program manager must be assured not only that the experiment is suitable but that it can be smoothly incorporated in the program and managed effectively.

In FY 1969 the funds requested for experiment definition will be used principally to clarify and define candidate experiments for the Saturn V launched initial space station and to determine what experiments and equipment can provide the most effective post-Apollo exploration of the moon. Lead times are such that this definition work must begin now along with the preliminary design studies.

A major portion of the 1969 definition funds will be required to translate the experiment portion of potential payload capability of the initial space station into specific experiments which utilize man's capability to perform effectively in space for an extended period of time.

A continuing program of experiment definition will be required in FY 1969 in order to support the goals identified for lunar exploration. To do this, definition funds are required in 1969 which will enable us to select mobility devices for the lunar surface. In addition, experiment definition will continue in support of the scientific disciplines which are required to carry out an effective program of scientific exploration. Definition studies will also be conducted which will lead to the grouping of related experiments into mutually supporting experiment packages both for lunar surface and lunar orbital investigations.

Development

The measure of success in the Apollo Applications Program will be the degree to which the planned experiments meet the overall objectives of investigating, demonstrating, and utilizing man's effectiveness in space, extending his useful staytime, and contributing to the basic store of human knowledge. Each of the experiments currently included in the program will contribute substantially to one or more of these objectives.

Development of the orbital workshop has been started. The basic piece of hardware involved in this system is an S-IVB stage modified to be suitable for human habitation. Included in this payload section will be: 1) an airlock which will permit crew transfer from the command and service module to the workshop without extra-vehicular activity; 2) a multiple docking adapter which will permit more than one space vehicle to rendezvous and dock with the Workshop simultaneously; and 3) systems which will make the workshop a habitable and effective space vehicle for a long period of time.

The concept of the orbital workshop is particularly promising for long duration flights in earth orbit. In 1969 we plan to initiate a substantial extension of this capability by beginning work on the Saturn V launched initial space station, which will provide a much greater capability than the present generation workshop. This concept provides for inserting the workshop into orbit with a 1st and 2nd stage Saturn V vehicle and provides a potential payload increase of 200,000 lbs. The internal systems, experiments and equipment composing this payload will be installed and ready for use prior to launch.

The other major piece of experiment hardware initiated in prior years is the Apollo Telescope Mount (ATM). Whereas the basic purpose of the Saturn IB Workshop is to provide a suitable platform for a large number of multi-disciplinary experiments including the study of man's effectiveness in space, the ATM is devoted entirely to astronomy. The focus of the project will be on the scientific study of the sun. The surface of the sun, the sun-spot cycle observable there, and the nature and pattern of the solar flare activity erupting from the sun hold the key to understanding the basic forces and elements which control the solar system. The orbiting solar observatory

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(OSO) unmanned spacecraft provided the first opportunity to study the sun without hindrance from the earth's atmosphere. The ATM will provide a significant increase in the quality and depth of our knowledge of the sun by providing 1) greater pointing accuracy than was possible with the smaller OSO, 2) the capability of film return which can provide better quality pictures than were previously possible, and 3) most importantly, the selective discrimination capabilities of a man can be used to concentrate on phenomena of the greatest scientific interest.

The basic ATM system will be derived from the lunar module being developed for Apollo. The ascent stage of the lunar module will be modified and will serve as a command post for two astronauts conducting the experiments. The descent stage is replaced by a structural rack with associated power and pointing equipment which contains the various experiments to be flown.

Major contractor development effort is currently in process on the systems and components required for most of the major experiments described above. The basic pieces of hardware required for the workshop are well into their development phase at present. The modification of the basic S-IVB, which will convert the spent stage into the workshop, is being done by the McDonnell-Douglas Corporation, Huntington Beach, California. An extensive testing program utilizing boilerplates and special test hardware is currently in process and will continue through FY 1969.

The airlock module is currently under development by the McDonnell-Douglas Corporation in St. Louis, Mo. A test article is being fabricated and a test program utilizing this article will begin in 1968 and extend through 1969. Initial fabrication has begun on the first flight article, which will be ready for delivery to Cape Kennedy in late 1969.

The multiple docking adapter is being developed and fabricated in-house by NASA at the Marshall Space Flight Center, Huntsville, Alabama. Design of this unit has been in process for a year. An engineering mock-up has been built and the fabrication of a structural test unit is currently in process. Structural and vibration testing of this unit is scheduled to begin before the end of FY 1968 and extend into FY 1969. Manufacture of the initial flight unit will begin in 1969 and will be completed early in FY 1970.

Work is also in process on the ATM at the Marshall Space Flight Center, with major subsystem development having been underway for a year. Fabrication and assembly of a complete mock-up was initially completed in early 1967 and the article was recently updated to incorporate results of the continuing design work. A neutral buoyancy test article has been built and will be tested shortly. Fabrication of a structural test unit is currently in process with testing scheduled to begin before the end of FY 1968. Five specific experiments comprised of 13 major instruments have been selected for the ATM and are currently in the process of fabrication. These include a White Light Coronagraph, being developed by the High Altitude Observatory, Boulder, Colorado; an Ultra/Violet Spectro-Heliograph being developed by the Naval Research Laboratory, Washington, D. C.; an X-ray spectrographic telescope being developed by American Science and Engineering Company, Cambridge, Mass; an X-ray telescope being developed at the Goddard Space Flight Center in Greenbelt, Maryland; and an Ultraviolet Scanning Spectrometer being developed by the Harvard College Observatory, Cambridge, Mass.

Mission Support

	1967	1968	1969
Payload integration..............	$3,900,000	$21,000,000	$31,000,000
Operations.......................	800,000	7,200,000	17,000,000
Total........................	$4,700,000	$28,200,000	$48,000,000

Payload Integration includes mission payload analysis and systems engineering, design, development, fabrication, test, and program management support for the integration of experiment and resupply payloads into Apollo Applications space vehicles. It provides requirements, plans and program data for the integration of payloads; performance and interface specifications; design, test, and checkout plans and procedures; and ground and in-flight support equipment. Overall program coordination, engineering analysis and design of the integration of spacecraft and payloads into a coordinated space system qualified for flight is provided. Fiscal year 1967 efforts were concerned with preliminary definition of the payload integration requirements. Fiscal year 1968 funds support final definition and the implementation of design and development efforts. Fiscal year 1969 funding will support continued efforts in such areas as experiment grouping, payload carrier design development and integration, experiment support requirements, and feasibility, compatability and systems interface analyses for all near term Apollo Applications Missions. The Martin Company, Denver, Colorado is the prime contractor for payload integration.

Operations include efforts at the Kennedy Space Center and the Manned Spacecraft Center that are directly concerned with pre-launch, launch, flight, crew and recovery activity. In fiscal year 1967 operations efforts were related to accomplishing definition of Apollo Applications requirements peculiar to pre-launch, launch, mission planning and mission control. Fiscal year 1968 funding is supporting activities associated with crew training, flight operations, mission analysis, landing and recovery, launch operations and launch support.

Fiscal year 1969 funds are required for continuation of current year efforts, procurement and/or modification of flight simulators and associated maintenance and operation and flight crew training and related equipment procurements in preparation for Apollo Applications flights scheduled in early 1970.

OFFICE OF MANNED SPACE FLIGHT — ADVANCED MISSIONS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objective of the Advanced Missions program is to examine advanced manned space flight mission concepts in support of timely decisions with regard to future programs. Included are: logical extensions of the NASA space program through analysis of present hardware systems for growth potential; development of requirements for future systems; guidance for research and technology activities; provision of technical information and cost data upon which future program decisions can be based; and initiation of the definition, preliminary design and specification of probable future missions.

SUMMARY OF RESOURCES REQUIREMENTS:

	1967	1968	1969
Advanced missions studies..........	$6,200,000	---	$5,000,000
Distribution of Program Amount by Installation:			
John F. Kennedy Space Center, NASA..........................	$500,000	---	$500,000
Manned Spacecraft Center.........	2,800,000	---	2,000,000
Marshall Space Flight Center.....	1,600,000	---	2,000,000
NASA Headquarters................	1,300,000	---	500,000

BASIS OF FUND REQUIREMENTS:

Advanced Missions Studies

Advanced studies..................	$6,200,000	---	$5,000,000

Advanced studies have in past years encompassed a wide spectrum of missions and related hardware. They were grouped into the categories of Earth Orbital Studies, Planetary Mission Studies, and Flight Vehicle Studies. The advanced missions program office in the Office of Manned Space Flight was organized along lines that reflected this categorization. Recently, however, the Advanced Manned Missions program office was realigned to concentrate on the immediate task of the manned earth orbital space flight program both with respect to direct support of the later phases of the Apollo Applications program and to the long term implications of these plans. As a result of manned space flight experience to date and of a series of studies conducted over the past several years, there has developed a strong conviction among space planners that a space station is logical, practical, and necessary in the development and use of our national capability for manned space flight. Such a station, with its supporting equipment and expendables, could be launched with a Saturn V. It would make use of equipment and experience developed for Apollo, the orbital workshop and other projects such as MOL, to the extent practical. Once in orbit, it would serve as a semi-permanent base of operation for astronomical and other scientific observations, earth resources studies, biomedical research, technological developments, and for operational research and development to further enhance our national capability for manned space flight. By utilizing a modular approach, with a capability to operate in conjunction with automated but man tended spacecraft in the near vicinity, great operational flexibility can be achieved. This flexibility should make the space station system capable of meeting a wide variety of national needs.

A further aspect of the flexibility envisaged for the system, is that its occupancy and use could be varied from full crew/full time to a part time or standby operation, depending on requirements of users, funding availability, or other factors. The space station would constitute a continuing capability, in being, in orbit to serve national needs in accordance with future decisions on specific objectives and on resources to be allocated.

Space Station Studies

Most of the funds requested for FY 1969 will be expended on efforts to provide logical long term direction for manned earth orbital operations. Lead times are such that this work cannot be deferred if we are to maintain a national capability for a continuing manned space flight program in earth orbit. The preliminary design and definition effort will build on previous work and will include all aspects of space station missions and configurations, including the related logistics transportation system.

Intermediate Vehicles

A portion of the space station study funds will be allocated to determining the need for a launch vehicle to carry out logistic support of the space station. The determination of need for a logistic support vehicle is part of a larger picture, however, since other programs and agencies may also have requirements for a vehicle capable of drastically reducing the cost of transportation to orbit. In particular, NASA will join with DOD in evaluating possible future space flight systems and the extent to which future requirements can best be met with NASA hardware, DOD hardware, or jointly developed systems.

Other Advanced Studies

In addition, it is planned in FY 1969 to continue some advanced studies of other missions and vehicles, particularly those applicable to lunar exploration.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1969 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR

SPACE SCIENCE AND APPLICATIONS PROGRAMS

Program	Fiscal Year 1967	Fiscal Year 1968	Fiscal Year 1969
Physics and astronomy.......	$129,800,000	$142,950,000	$141,900,000
Lunar and planetary exploration...............	184,150,000	141,500,000	107,300,000
Launch vehicle development..	31,200,000	---	---
Launch vehicle procurement..	117,650,000	127,100,000	128,300,000
Bioscience..................	42,000,000	41,800,000	48,500,000
Space applications..........	71,300,000	99,500,000	112,200,000
Total..................	$576,100,000	$552,850,000	$538,200,000

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1969 ESTIMATES

OFFICE OF SPACE SCIENCE AND APPLICATIONS — PHYSICS AND ASTRONOMY PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Physics and Astronomy program is directed toward the increase of our knowledge of the earth, sun, the interplanetary medium, and the nature of the universe. The program is a coordinated effort for national participation in research which involves: the space environment of the earth, the sun, and the solar relationship to the earth's environment and to interplanetary space, interplanetary dust, meteors, comets, stars, nebulae, galaxies, interstellar and intergalactic phenomena, and the basic nature of the universe. The program uses a variety of tools including automated observatories, manned spacecraft, interplanetary spacecraft, explorers, sounding rockets, balloons, aircraft, ground-based observatories, and laboratory and theoretical research. Each tool is selected for a specific application because of a unique capability or because it is the most efficient way to do the research.

Many of the studies contribute to the over-all objective of the program as well as provide knowledge for a specific area. Although many practical applications have been made of the knowledge gained, the primary objective continues to be one of basic research dedicated to the expansion of knowledge. Therefore, considerable effort has been expended to insure that the knowledge gained is made available and that the program is integrated with the programs of educational and scientific institutions.

SUMMARY OF RESOURCES REQUIREMENTS:

	1967	1968	1969
Supporting research and technology/Advanced studies	$20,365,000	$23,050,000	$25,300,000
Solar observatories..........	10,106,000	12,100,000	12,000,000
Astronomical observatories...	27,700,000	40,400,000	35,200,000
Geophysical observatories....	24,770,000	20,200,000	13,200,000
Pioneer......................	6,900,000	7,000,000	6,000,000
Explorers....................	18,224,000	17,300,000	23,200,000
Sounding rockets.............	20,000,000	20,000,000	22,000,000
Data analysis................	1,735,000	2,900,000	5,000,000
Total......................	$129,800,000	$142,950,000	$141,900,000

DISTRIBUTION OF PROGRAM AMOUNT BY INSTALLATION:

	1967	1968	1969
Manned Spacecraft Center.....	$40,000	$359,000	$300,000
Marshall Space Flight Center.	158,000	36,000	40,000
Goddard Space Flight Center..	97,020,000	109,881,000	105,500,000
Jet Propulsion Laboratory....	339,000	196,000	400,000
Wallops Station..............	496,000	1,200,000	950,000
Ames Research Center.........	9,828,000	9,383,000	9,100,000
Electronics Research Center..	60,000	140,000	140,000
Flight Research Center.......	10,000	---	---
Langley Research Center......	1,607,000	1,532,000	2,930,000
NASA Headquarters............	20,242,000	20,223,000	22,540,000

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology/Advanced Studies

	1967	1968	1969
Particles and fields.........	$5,867,000	$5,731,000	$5,900,000
Ionospheres and radio physics	1,457,000	1,263,000	1,300,000
Interplanetary dust and cometary physics...........	1,725,000	1,652,000	1,600,000
Solar physics................	4,048,000	3,699,000	4,400,000
Astronomy....................	3,391,000	3,342,000	4,500,000
Interdisciplinary space science....................	2,615,000	6,256,000	4,800,000
Spacecraft technology and advanced studies...........	1,262,000	1,107,000	2,800,000
Total......................	$20,365,000	$23,050,000	$25,300,000

In the Supporting Research and Technology program, we support the basic research required to provide for a firm foundation for the Physics and Astronomy program. It is in this program that development of new instruments is initiated. Laboratory, balloon, and aircraft data are provided as a basis for evaluation of flight results.

Particles and Fields

Work in this area is concerned with understanding the processes which lead to the production of galactic cosmic rays, the role of cosmic rays in evolution of a galaxy and properties of the interstellar medium, the dynamics of the magnetosphere, the generation of nonthermal solar particles and their dynamics, and the determination of the character of ultrahigh energy cosmic rays. We are continuing the work in this area at about the same level as last year. The development of trapped and auroral radiation detectors and magnetometers is receiving emphasis this year. The slight increase is in reality the result of the reduction of forward funding in FY 1968 to maintain the program in the face of a constrained budget.

Ionospheres and Radio Physics

Major problems in ionospheres and radio physics involve the understanding of the basic processes of formulation, change and decay of ionization, the perturbations of the ionosphere and atmosphere, and particle wave interactions, plasma and very low frequency wave phenomena. These problems are being investigated through laboratory and ground-based research.

Interplanetary Dust and Cometary Physics

Research in this area involves the study of extraterrestrial particulate matter; its characteristics, origins, structure, and behavior. Work in determination of the composition and distribution of cosmic dust by collection techniques and study of the aurora and polar cap phenomena during solar maximum is also funded in this program which is being held at about the FY 1968 level.

Solar Physics

Primary research in this area is concerned with two major problems; understanding the quiescent sun and solar activity, and the development of instrumentation. This work involves ground, aircraft, and balloon-borne observations; theoretical studies, and development of instruments for spacecraft observations. The increase shown in this area is attributable to the development of instrumentation for observations from the CV-990 research aircraft and to expansion of laboratory and theoretical research in support of a proposed future expansion of the solar astronomy flight program.

Astronomy

Astronomical research and technology efforts provide for some augmentation of effort in those areas where major changes in performance are required to improve space astronomy capability. Advanced development of instruments includes work on narrow band filters, selective coatings, polarizing devices, image tubes and image intensifiers for UV and X-rays, films and film handling techniques, and telescope systems with offset pointing capability. The problems of understanding the source of gamma rays and assessing the nature of X-ray stars is requiring the development of large spark chambers and balloon observations of hard X-rays. Other research includes theoretical studies of stellar astrophysics, laboratory spectroscopy; ground-based, balloon, and aircraft observations. Advanced development work is underway on experimental tests of the validity of Einstein's theory of relativity.

Interdisciplinary Space Science

This area provides for support of the Space Science Board and for research fellowships administered by the National Academy of Science, which provide an opportunity for selected fellows to work with scientists at the Goddard Space

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Flight Center in theoretical and laboratory research. Support of the Astronomy Missions Board falls in this area. Balloons, launch support, and a small research program on the balloons are supported.

This area also provides for procurement of the additional core storage and computer support for the Goddard Institute for Space Studies. The core storage is being procured in FY 1968. In FY 1969, it provides for computer rental, programming, and support costs for theoretical studies in astrophysics and for development of atmospheric models using meteorological satellite data.

Spacecraft Technology and Advanced Studies

Studies to establish the concepts, characteristics and feasibility of future missions are funded in this area. Studies of materials and techniques for advanced astronomical, geophysical, and interplanetary spacecraft subsystems are being continued. Expansion in FY 1969 takes place here to lay the ground work for a major program in space astronomy. The primary effort will be system definition studies aimed at the development of ASTRA, a system which combines the automated precision observatory with manned support. Other work to be supported includes some definition of the National Astronomical Space Observatory concept.

Solar Observatories

	1967	1968	1969
Orbiting Solar Observatory (OSO):			
Spacecraft....................	$6,519,000	$6,055,000	$7,308,000
Experiments....................	3,587,000	6,045,000	4,692,000
Subtotal OSO................	$10,106,000	$12,100,000	$12,000,000
Delta (Launch Vehicle Procurement Program)......................	(2,000,000)	(2,600,000)	(4,050,000)
Total (including Launch Vehicles)...................	($12,106,000)	($14,700,000)	($16,050,000)

The Orbiting Solar Observatory (OSO) is a stabilized satellite orbited above the earth's atmosphere to obtain fundamental knowledge of the sun, and the effect of the sun on the solar system using carefully selected scientific experiments. The OSO's permit investigation of the solar spectrum from the high energy gamma radiation through the X-ray and ultraviolet to the visible region in order to study the long-term changes in solar radiation, as well as the more rapid, short-period changes. The first two of the approved OSO missions were launched during a period of minimum solar activity; two more missions launched in 1967 are obtaining data during a period of increased activity; and the last three will be launched during and following solar maximum. This will provide data during the major part of the 11-year solar cycle.

The OSO's are spin stabilized spacecraft with a demonstrated capability of pointing the instruments in the "sail" section, at the center of the sun, with an accuracy of 10 arc seconds. Current spacecraft in the series also are able to scan across the solar disc. This capability will be enhanced to permit both offset pointing and offset raster scanning. The wheel section spinning at about 30 rpm permits investigation of radiation from the galaxy and the intergalactic and interstellar space.

The program consists of eight approved missions, five of which have been launched and three of which remain to be launched in the next three years. All OSO's are launched by the Delta vehicle into a nominal 350 statute mile circular orbit inclined 33 degrees.

OSO-I and OSO-II were launched in 1962 and 1965, respectively. Both have ceased operating but during their useful life, they obtained more than 8,600 hours of scientific data.

OSO-C was launched August 25, 1965. Malfunction of the vehicle's third stage prevented achievement of orbit. The payload of this mission was rescheduled to fly on the OSO-E spacecraft.

The fourth OSO flight (OSO-E) was successfully launched on March 2, 1967, and was designated OSO-III. This spacecraft which contained nine experiments from the Air Force Cambridge Research Laboratory, the Goddard Space Flight Center, the Universities of Michigan, Rochester, and California, Massachusetts Institute of Technology, and the Ames Research Center provided a capability to study the gamma-ray, X-ray, ultraviolet, and visible emissions from the sun, earth, the galaxy, and other regions of the celestial sphere. Analysis of data from OSO-III is continuing. Preliminary results were made available by the experimenters to the scientific community during meetings held in 1967 and will be published in 1968.

The fifth OSO (OSO-D) was placed in orbit on October 18, 1967, and became OSO-IV. This spacecraft also carried instrumentation for nine experiments. Principal investigators from Harvard College Observatory, American Science and Engineering, Naval Research Laboratory, University College, London (England), and Lawrence Radiation Laboratory are attempting to better understand the physical processes by which the sun influences the earth and to continue to advance our understanding of the sun's composition and behavior. The Harvard scientists have obtained over 4,000 ultraviolet spectroheliograms of the sun. These data, some of which have already been published, will permit development and assessment of realistic models of the sun and will provide insight into the problem of energy transport through the chromosphere and corona.

The three remaining OSO missions (OSO-F, -G, and -H) are scheduled to be launched about one year apart starting in 1968. Payloads for these missions have been selected and the hardware is in various stages of design, fabrication, test, and integration.

Project management for the OSO systems, including the Delta vehicle, is assigned to the Goddard Space Flight Center. The spacecraft are being developed by Ball Brothers Research Corporation. Ball Brothers is responsible for experiment instrumentation, observatory test and delivery to the launch site of a flyable system. In-orbit operations are controlled from Goddard Space Flight Center through the STADAN telemetry system.

Funding prior to FY 1967 provided for the design, development, integration, testing, operations, and data analysis of the first two OSO's to orbit the earth and the OSO-C mission which failed. These funds also provided for continuing work on the OSO-III and OSO-IV missions and for the initiation of work on the spacecraft and experimental packages for the last three missions.

Fiscal year 1967 funds provided for the launch preparations, launch and initial orbit operations of OSO-III; completion of the test and integration of OSO-IV; and continued the work on the last three missions.

Fiscal year 1968 funds support the launch, orbital operation, and initiation of data analysis for OSO-IV; continued orbital operation, data reduction and analysis for OSO-III; and continued the development work on the OSO-F, -G, and -H missions.

Fiscal year 1969 funds will provide for publication of data from the OSO-III and OSO-IV, for completion and launch of the OSO-F, and continuing hardware effort on the OSO-G and OSO-H.

Fiscal year 1966 and prior funding for the OSO project including launch vehicles was $59,279,000. Fiscal year 1970 and later funding requirements to complete the eight-observatory program are estimated to be $7,350,000, including launch vehicles.

Astronomical Observatories

	1967	1968	1969
Orbiting Astronomical Observatory (OAO):			
Spacecraft and support.........	$21,313,000	$35,004,000	$31,074,000
Experiments....................	6,387,000	5,396,000	4,126,000
Subtotal OAO.................	$27,700,000	$40,400,000	$35,200,000
Centaur (Launch Vehicle Procurement Program)..................	(6,003,000)	(7,060,000)	(9,500,000)
Total (including Launch Vehicles)...................	($33,703,000)	($47,460,000)	($44,700,000)

The Orbiting Astronomical Observatories (OAO) program requires the development of space-borne hardware and operational capability which must meet the most advanced scientific and technical requirements of the space program. This major advance in the state-of-the-art is essential in realizing the potential of space astronomy. It will provide opportunities to obtain astronomical observations of celestial objects and phenomena in those regions of the electromagnetic spectrum that are inaccessible to ground-based instrumentation because of atmospheric absorption. Experiments selected for the OAO missions will: perform exploratory sky mapping surveys in the ultraviolet region, obtain moderate resolution spectrometer data of stars down to tenth magnitude, carry out high resolution ultraviolet spectral analysis of faint objects, and make studies of galactic X-rays.

The OAO spacecraft is designed to point in any direction with an accuracy of one minute of arc during any particular astronomical observation. Pointing accuracy of 0.1 second of arc will be obtained using sensors associated with the experiment instrumentation. The attitude control system performs five functions: stabilization and solar orientation subsequent to orbital injection or following loss of stabilization; roll search to acquire guide stars; slow to and hold at attitudes required for scientific observation; hold in inertial space without star trackers; and sun bathing, which provides a safe observatory holding mode while providing for maximum recharge of the spacecraft batteries.

Extensive ground facilities in the United States and in four other countries (Ecuador, Chile, Australia, and Madagascar) are provided for control of the mission in orbit and to receive telemetry for transmission to the OAO Control Center at the Goddard Space Flight Center.

The first OAO (OAO-I) was launched on April 8, 1966. It achieved orbit, performed planned functions for a short period of time, and attained the design objectives in a number of complex areas. The spacecraft failed on April 10, 1966. No scientific data were obtained from any of the scientific instruments.

The problem areas identified with the OAO-I operation have been thoroughly analyzed and reviewed. Based on the knowledge gained from the first flight, modifications have been made to the OAO including testing for the subsequent observatories, as well as expanded ground operations facilities. In addition, a significant number of improvements have been made to the OAO system to enhance the prospects for the success of the next three flight missions.

The second OAO (OAO-A2) is on schedule for a 1968 launch. The spacecraft subsystems have been modified, on the basis of the OAO-A1 tests, to assure satisfactory long-term operation of the power subsystem; provide better thermal environment; prevent arcing in the star trackers; minimize noise susceptibility and generation; and provide a safe holding mode independent of the star trackers. The ground systems to support this and follow-on missions have been improved and expanded to increase the real-time knowledge of the in-orbit operation. This mission will carry the Wisconsin Experiment Package, identical to the equipment flown on OAO-I, and the Smithsonian Astrophysical Observatory Celescope experiment. The Wisconsin Experiment Package consists of multicolor filter photometers with spectrometers and eight and 16-inch telescopes.

Measurements will be made of the emission characteristics of diffuse nebulae and the extension of the opacity of the interstellar medium into the ultraviolet. The Smithsonian Astrophysical Observatory Celescope contains four telescopes with ultraviolet-sensitive uvicon image tubes to survey the sky in four ranges. It will map the form and brightness characteristics of faint nebulae and record the brightness of hot stars, primarily spectral Type A and earlier.

The third OAO (OAO-B), to be launched in 1969, will carry the Goddard Space Flight Center 36-inch telescope to obtain absolute spectrophotometry data on stars, nebulae, and galaxies in the higher range. This mission will be the first to include the Inertial Reference Unit, under development by the Massachusetts Institute of Technology to reduce the dependence of the stabilization and control system on the star trackers.

The fourth OAO (OAO-C), scheduled for a 1970 flight, will fly experiments for Princeton University and the University College London. The Princeton Experiment Package is a 32-inch Cassegrainian reflecting telescope with a concave grating experiment. Studies will be made of spectra of interstellar gas and of composition and physical characteristics of interstellar gas and dust. The London experiment consists of three telescopes with paraboloidal reflectors, photon detectors, and gas counters to study X-ray emissions and to search for interstellar absorption.

The Goddard Space Flight Center is responsible for the management of the OAO project including the procurement of the spacecraft and experiments. The Lewis Research Center will procure the Atlas-Centaur vehicles and provide the launch services at the Eastern Test Range. The Grumman Aircraft Engineering Corporation has designed and is fabricating the spacecraft. Goddard Space Flight Center will integrate the experiments in the spacecraft, perform the environmental tests, and operate the observatory in orbit.

Development of the OAO spacecraft was initiated in 1960. Funding prior to FY 1967 provided for the design and development of the basic spacecraft; fabrication, integration, and testing of the OAO-I prototype and flight spacecraft; ground operations software and hardware and pre-launch and launch services for the OAO-I; fabrication, integration, and test of the third flight spacecraft; procurement and fabrication of assemblies for the fourth flight spacecraft; development, fabrication, and tests of experiment instrumentation for four flight missions; and initiation of the recovery plan for the OAO spacecraft.

Fiscal year 1967 funds provided for the completion of the analysis of the OAO-I operation and the bulk of the redesign, modification, and retest of the OAO-A2 spacecraft assemblies. A prototype spacecraft (TA-1) in the OAO-A1 configuration was delivered to Goddard Space Flight Center for training personnel in test and flight operation procedures and for electromagnetic compatibility tests. The TA-1 was returned to the spacecraft contractor for rework to the OAO-A2 prototype (TA-2). The planning for the ground support system for the next OAO flight was initiated, as was the associated software and hardware. The instrumentation for the Wisconsin Experiment Package and Smithsonian Astrophysical Observatory were delivered to Goddard Space Flight Center and acceptance tests were initiated. The most essential work on the OAO-B and OAO-C spacecraft and experiment components is being carried out toward the planned launch dates in 1969 and 1970.

Fiscal year 1968 funds provided for the completion of the fabrication and test of the equipments for OAO-A2 spacecraft and the integration of the spacecraft. The acceptance tests of the Wisconsin Experiment Package and Smithsonian Astrophysical Observatory instrumentation were completed and the instrumentation was integrated in the spacecraft. The TA-1 prototype spacecraft was converted to the TA-2 configuration. The remaining effort in FY 1968 will be concentrated on performing flight acceptance on the OAO-A2 observatory, testing the TA-2 at qualification vibration levels, performing thermal tests and initiating the modifications and retest on the subsystems for the OAO-B spacecraft. Efforts planned for starting the OAO-C spacecraft structure, the acceptance tests of the Goddard Experiment Package instrument for OAO-B, and restart of the experiment flight hardware for the OAO-C mission are being delayed due to funding constraints in FY 1968.

Fiscal year 1969 funding will complete the acceptance testing of the OAO-A2 flight observatory, launch of this mission, and initiation of scientific data reduction and analysis. The OAO-B spacecraft will be integrated and tested, the Goddard Experiment Package flight instrumentation will be tested and integrated in the observatory, and observatory acceptance tests will be started. The OAO-C spacecraft assemblies will be completed and the Princeton Experiment Package prototype instrument will be tested at qualification levels and the fabrication of the Princeton Experiment Package flight assemblies will be completed and the instrument assembled.

Fiscal year 1966 and prior funding, including launch vehicle was $197,235,000. Fiscal year 1970 and later funding required to complete four missions is estimated to be $44,537,000, including launch vehicles.

Geophysical Observatories

	1967	1968	1969
Orbiting Geophysical Observatory (OGO):			
Spacecraft....................	$16,577,000	$13,376,000	$4,410,000
Experiments...................	8,193,000	6,824,000	8,790,000
Subtotal OGO................	$24,770,000	$20,200,000	$13,200,000
Thor-Agena (Launch Vehicle Procurement Program).............	(2,000,000)	(2,996,000)	(1,419,000)
Atlas-Agena (Launch Vehicle Procurement Program).............	(2,000,000)	(3,061,000)	(3,000)
Total (including Launch Vehicles)..................	($28,770,000)	($26,257,000)	($14,622,000)

The Orbiting Geophysical Observatory (OGO) program has as a primary objective the accomplishment of a series of scientific measurements for study of the near-earth environment and for correlation of geophysical phenomena with the effluent activity of the sun and with phenomena in interplanetary space.

Four OGO missions, each including 20 or more experiments, have been launched, one each year starting in 1964. These missions have alternated between high altitude, low-inclination orbits for magnetospheric and interplanetary studies and low altitude, nearly polar orbits for global studies of atmospheric and related phenomena.

The most recent mission (OGO-IV; launched July 28, 1967, into a nearly polar orbit) has met all major objectives and continues to perform well with active three-axis stabilization and 18 of the 20 experiments operating. These experiments are providing new data describing the salient characteristics and phenomenology of the atmosphere on a global basis.

OGO-I, launched near the minimum period of solar activity in 1964, continues to operate on a periodic basis and is providing data from 12 remaining experiments. The second OGO, OGO-II, has completed two years of operation and, although it is still functional at certain times of the year, data acquisition has been discontinued. OGO-III was the first of the geophysical observatories to provide satisfactory three-axis stabilization for an extended period. It was placed in a spin stabilization mode in July 1966 and has provided continuous data acquisition for magnetospheric studies. Most notable of these has been the first detailed observation of the solar storm ring current by the Van Allen experiment. During a period in November 1967, all four OGO-s with a total of 55 experiments were operating simultaneously in widely separated regions of space.

The timing of the initial OGO missions and the long lifetime has provided good coverage from solar minimum through the period of increasing solar activity. The fifth (OGO-E) and sixth (OGO-F) are scheduled for launch in early 1968 and 1969, respectively, and will extend this coverage through solar maximum. OGO-E, which is in the final stages of testing and launch preparations, includes a number of new and challenging experiments and will be capable of detecting particle energies from a few electron volts to ten billion electron volts. These experiments, together with electric and magnetic field experiments, should make possible the most comprehensive studies of the magnetosphere yet undertaken. Similarly, the complement of OGO-F experiments which are now being integrated into a completed spacecraft for a low altitude polar mission, should provide detailed information on atmospheric physics during the important period of maximum solar activity.

Management of the OGO project has been the responsibility of the Goddard Space Flight Center. Development of the spacecraft system and fabrication and testing of flight observatories is under contract to Thompson Ramo Wooldridge Systems, Incorporated.

Funding prior to FY 1967 provided for design and development of the basic spacecraft, launch of the first three observatories, beginning work on OGO-D and OGO-E, and support of data analysis for the first two missions.

Fiscal year 1967 funds provided for continuation of preparation of the OGO-D and OGO-E missions, initiation of hardware development for OGO-F, and for continued data support for three operational missions.

Fiscal year 1968 funds are providing for launch of OGO-D, preparation of OGO-E for launch, completion of spacecraft and experiment fabrication for the OGO-F mission, operational support for four OGO's and support of data analysis. Data analysis support for OGO-I and -II were terminated early in FY 1968 at the end of the planned support period and will be terminated for OGO-III in June 1968. Funding for analysis of data beyond these periods is being provided under the Data Analysis line item in the budget.

Funds in FY 1969 will provide for launch of OGO-F, operational support for data acquisition, and data analysis support for OGO-IV, OGO-E, and OGO-F.

Fiscal year 1966 and prior funding for the OGO project including launch vehicles was $198,341,000. Fiscal year 1970 and later funding requirements are estimated to be $5,300,000.

Pioneer

	1967	1968	1969
Spacecraft and support, A - E...	$2,479,000	$3,913,000	$3,158,000
Experiments, A - E..............	4,421,000	3,087,000	1,242,000
Spacecraft experiments and support, F & G................	---	---	1,600,000
Subtotal Pioneer..............	$6,900,000	$7,000,000	$6,000,000
Delta (Launch Vehicle Procurement Program)................	(1,217,000)	(2,834,000)	(650,000)
Total (including Launch Vehicles)..................	($8,117,000)	($9,834,000)	($6,650,000)

The objectives of the Pioneer program are to investigate the interplanetary environment and the propagation of solar and galactic phenomena through this medium. Correlation with similar measurements made near the earth by satellites is required to attain the full objective.

The current series of Pioneer spacecraft weigh about 140 pounds and are launched with the Thrust-Augmented Improved Delta. The first two of these, Pioneer VI and Pioneer VII were launched successfully in December 1965 and August 1966, respectively. Both continue to operate successfully. Pioneer VIII, successfully launched on December 13, 1967, appears to be

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operating nominally. Two additional Pioneer spacecraft are scheduled for missions approaching as close to the sun as 0.7 AU and going away as far as 1.2 AU. (One AU is equal to the mean earth-to-sun distance, 92,900,000 miles.)

The Pioneer experiments 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 performance of these experiments on the three widely separated satellites in deep space provides some very unique and valuable scientific opportunities in this program. The combination of measurements from the three widely separated scientific payloads will enable us to detect and track solar storms. This information provides advance warning of radiation dangers for our spacecraft and variations in the protective magnetic envelope of the earth which affects the long-range radio communications of the world. The orbit of Pioneer VIII will allow measurements of the earth's magnetic tail at two million miles. Measurement of the tail's thickness and other properties at this distance will help determine the exact state of the earth's protective magnetic envelope.

We are proposing to initiate the development of two additional spacecraft, Pioneer F and Pioneer G, to be launched into trajectories that will carry them out beyond the orbit of Mars, through the asteroid belt, and toward the orbit of Jupiter. With this type of trajectory, we should be able to obtain information on the hazardous region of the asteroid belt and gain knowledge of the gradient of the sun's influence on interplanetary space and the penetration of galactic cosmic radiation into the solar system. The new trajectory will require modifications to be incorporated in 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. These spacecraft will be launched in the 1973-1974 time period by Centaur launch vehicles. The change from the Delta launch vehicles used on earlier missions is required to provide the velocity for this new trajectory.

Measurement of the Pioneer project has been the responsibility of Ames Research Center. Thompson Ramo Wooldridge Systems, Incorporated, is the prime spacecraft contractor. Tracking and data acquisition systems management is the responsibility of the Jet Propulsion Laboratory, and Goddard Space Flight Center has responsibility for Delta launch vehicle systems management. Lewis Research Center will be responsible for Centaur launch vehicle systems management.

Funds in FY 1966 provided for testing, launch and post-launch operations for Pioneer VI, and the assembly and testing of Pioneer VII. Funds for FY 1967 cover the launch of Pioneer VII and post-launch operations for Pioneer VI and Pioneer VII, and the initiation of the subsystems for the third, fourth, and fifth spacecraft. Fiscal year 1968 funds continue to support the post-launch operations for Pioneer VI and Pioneer VII, final testing and launch of Pioneer VIII, and initial integration and testing for the fourth spacecraft.

Fiscal year 1969 funds will be used to provide for the preparation of Pioneer D and Pioneer E for launch of Pioneer D in 1968 and Pioneer E in 1969, operational support for the three Pioneer spacecraft and support of data analysis.

Fiscal year 1966 and prior funding, including launch vehicles, was $56,911,000. Fiscal year 1970 and later funding required to complete the seven flight missions, including launch vehicles, is estimated to be $64,300,000.

Explorers

	1967	1968	1969
Geophysical and interplanetary explorers....................	$12,571,000	$11,800,000	$17,400,000
Astronomy explorers............	5,653,000	5,500,000	5,800,000
Subtotal Explorers...........	$18,224,000	$17,300,000	$23,200,000
Scout (Launch Vehicle Procurement Program)................	(4,500,000)	(1,850,000)	(5,800,000)
Delta (Launch Vehicle Procurement Program)................	(13,317,000)	(12,466,000)	(12,600,000)
Total (including Launch Vehicles)..................	($36,041,000)	($31,616,000)	($41,600,000)

The Explorer satellites are the smallest of NASA's scientific spacecraft and are normally launched on Scout and Delta vehicles.

The Explorers are specifically designed and instrumented to provide for specialized scientific investigations and are flown in orbits especially selected 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.

Explorer class satellites launched successfully to date include: three Air Density Explorers (12-foot balloons), and two Atmosphere Explorers (measuring temperature, density, and composition by instrumentation). Foreign satellites launched cooperatively were two Italian San Marco Satellites, and one Ariel Satellite (United Kingdom). Under development in Italy is a third satellite which will carry Italian and U. S. experiments to measure atmospheric density and composition in equatorial regions. We are proposing to initiate development of two more Atmosphere Explorers in FY 1969 to be flown in 1971 and 1972 to make studies in the region of the atmosphere between 75 and 150 miles which has not previously been explored except limited sampling by sounding rockets.

Four U. S. Explorers have been successfully launched with a primary mission to explore the ionosphere: one topside sounder, one beacon, and two direct measurements satellites. An additional five satellites were launched in cooperative efforts with Canada, the United Kingdom, and France. The cooperative program with Canada is continuing with three more satellites scheduled for launch over the next four years.

Eleven Explorer class satellites were launched between 1958 and 1964 to study the radiation belt and related phenomena and to monitor the radiation caused by high altitude nuclear tests. All of these were U. S. spacecraft. Six satellites under development by two universities in the United States and by the European Space Research Organization and Germany will be launched during 1968 and 1969 to perform specialized studies of particle radiation and its relationship to the atmosphere, ionosphere, airglow, and the aurora.

A cooperative effort with Germany is planned to launch a probe into the magnetosphere to release barium ions for study of electrostatic fields.

NASA had planned to launch a series of small scientific satellites beginning in 1969 to conduct interdisciplinary studies aimed at a better understanding of magnetic storms, the ring current and low energy charged particles in the magnetosphere. Because of manpower limitations at the Goddard Space Flight Center and general budgetary reductions, it has been necessary to defer first launch of this series until 1970.

In 1961, Explorer X was launched out of the earth's magnetosphere and into interplanetary space, returning to orbit the earth before its demise. It was not until 1963, however, that we were able to mount a continuing exploration of boundary region of the earth's magnetosphere with the first IMP Explorer. Six of these IMP Explorers have been launched and four more are planned during the period 1968 to 1972. We are progressively increasing the experiment capacity and data rate on these satellites because they will have to assume the role of an interdisciplinary satellite with phase-out of the OGO series. We have found it necessary to reschedule the IMP series because of manpower limitations and general budget restrictions, but the outstanding reliability of the IMP spacecraft launched to date may make it possible to continue coverage of magnetosphere boundary phenomena.

Also deferred until 1970 is the first launch of a series of five Sunblazer spacecraft designed to orbit the sun. These small spacecraft, to be launched by a five-stage Scout vehicle, will transmit signals from beyond the sun through the solar corona to earth for studies of variations in the solar corona, magnetic field, and solar particle fluxes. Other possible missions for these spacecraft include interplanetary field and plasma studies, solar neutron studies, and comet simulation studies.

In astronomy, Explorer satellites are devoted primarily to nonoptical missions of a survey nature, X-ray, gamma ray, and low frequency radio astronomy. The Radio Astronomy Explorer is designed to measure the direction and intensity of celestial radio signals as a function of frequency and time. Two missions are presently scheduled, the first in 1968. The spacecraft has a large antenna capable of being deployed in orbit to form a large "X" measuring 1500 feet tip-to-tip. It will be launched by a Delta vehicle.

A Scout launched astronomy Explorer called the Small Astronomy Satellite is scheduled for two missions beginning in 1970. The objective of the first of these is the detection and measurement of X-rays over the entire celestial sphere. This satellite should give us a map of X-ray sources which are as much as 1,000 times weaker than the strongest X-ray source so far detected.

The second Small Astronomy Satellite mission will continue the search for diffuse or point sources of high energy cosmic gamma rays and to map any sources that are found. Relatively short lived rocket and balloon experiments conducted so far have failed to detect any gamma ray sources. The gamma ray telescope on this mission is an enlarged version of an instrument called a digitized spark chamber flown successfully on balloons. This detector will be capable of detecting any sources which are 100 times fainter than the existing limits set by sounding rockets and balloon experiments.

The Naval Research Laboratory is preparing another small Explorer for launch in 1968 to continue a program carried out previously with Explorer XXX of monitoring of the sun's energetic X-ray emissions. The satellite funded by the Navy will be launched by a NASA-funded Scout vehicle.

Funding prior to FY 1967 provided for the development and successful launch of U. S. Explorers through number 33, and for cooperative efforts with other countries to launch six satellites. Major development work was also accomplished on ten other U. S. Explorers, and six other cooperative missions.

In FY 1967, work was initiated on the series of small scientific satellites and the Small Astronomy Satellite, and the IMP Explorers program was extended by three more missions. A small amount of support was provided for our cooperative effort with Germany.

In FY 1968, no new U. S. Explorers are being started because of limitations on manpower and funding. Work on a number of spacecraft is being deferred.

In FY 1969, work will be initiated on two new atmosphere Explorers and efforts will be expanded on the IMP, small scientific satellites, and Small Astronomy Satellite Explorers. The expansion of the Explorer program will only partly offset the phase-out of the OGO program. The Sunblazer, on which we had planned to start full-scale development efforts in FY 1968 will be held in a Supporting Research and Technology status until FY 1969.

Post FY 1969 funding for all of the Explorers initiated through FY 1969 will involve about $87,895,000, including launch vehicles.

Sounding Rockets

	1967	1968	1969
Experiments....................	$6,699,000	$7,430,000	$7,891,000
Rocket development..............	1,375,000	1,350,000	1,669,000
Attitude control systems........	3,962,000	3,060,000	3,648,000
Engineering support.............	440,000	750,000	640,000
Test and evaluation.............	275,000	290,000	325,000
Ground instrumentation..........	3,178,000	3,220,000	3,581,000
Rocket procurement..............	4,071,000	3,900,000	4,246,000
Total........................	$20,000,000	$20,000,000	$22,000,000

Sounding rockets have proven to be a most effective means of making scientifically valuable studies of the upper atmosphere at altitudes between 40 and 175 miles. These rockets are relatively small and inexpensive vehicles, capable of carrying wide varieties of instrumentation for the study of the atmosphere, ionosphere, energetic particles, the stars, and the sun. The relatively low cost and short leadtimes of sounding rockets make them extremely useful for carrying out exploratory experiments and testing new instruments.

Sounding rockets have been used to measure atmospheric density and temperature; to analyze the various gases present in the upper atmosphere, and responses of the atmosphere to varying solar activity. Chemicals released from sounding rockets for wind and temperature measurements launched from various sites all over the world have improved our knowledge about the dynamics of the ionospheric region and the nature of the earth's magnetic field. Recoverable sounding rocket payloads have been used to collect extraterrestrial dust originating in meteor streams, comets, and asteroids. Noctilucent clouds formed by the condensation of ice about this dust have been probed by flights from Sweden and Ft. Churchill, Canada; interplanetary dust has been sampled by rockets over White Sands, New Mexico.

The aurora and airglow have been investigated by rocket probes containing spectrophotometers, filter photometers, and particle detectors.

Ionospheric experiments carried out with sounding rockets have been extremely valuable both for scientific investigations of the physics of the ionosphere and for calibrating instrumentation on satellites already in orbit by simultaneously measuring the same region of the ionosphere. Instruments have been developed to measure electron concentrations and temperature, electromagnetic waves, ionic and neutral mass spectra, magnetic fields, and E-region currents.

Sounding rockets are now being effectively utilized for astronomical observations of the sun and the stars in the X-ray and ultraviolet regions of the spectrum. These experiments were made possible by the development of improved attitude control systems.

Responsibility for sounding rocket support activities has been assigned to the Goddard Space Flight Center. NASA Headquarters has responsibility for experiments developed by researchers at universities, in industry, at other agencies, and in other countries.

One hundred and five physics and astronomy sounding rockets of the Nike Cajun/Apache/Tomahawk, Aerobee, and Javelin types were launched during 1967 from sites in the United States, Canada, Brazil, India, Sweden, and Norway. Included in these flights were: (a) tests of instruments being developed for the German Research, Injun V, and Alouette Satellites using Javelin rockets; (b) ozone and nitric oxide experiments that complement experiments on OGO-D, using Arcas and Nike Apache rockets coordinated with flybys of the satellite; (c) solar UV experiments that complement similar experiments on OSO-C using an Aerobee 150 coordinated with a flyby of the satellite; (d) hydrogen and Lyman Alphas experiments that complement similar experiments on Mariner V using an Aerobee 150 rocket coordinated with the spacecraft flyby of Venus on October 19, 1967; (e) a "gravity preference" experiment using mice flown on an Aerobee 150 in support of the Bioscience program; (f) a series of magnetic and electric field coordinated experiments utilizing instruments and chemical releases under Nike Tomahawk rockets; and (g) the first experiments utilizing the SCAT and STRAP III pointing controls with pointing accuracies on the order of one arc second using Aerobee 150 rockets.

NASA plans to continue the sounding rocket flight program in 1968 at the current level of roughly 100 flights per year. Major flights planned for 1968 include: (a) an experiment to create an artificial aurora with an "electro-gun" using an Aerobee 350 rocket; (b) auroral spectra and VLF experiments to test instruments being developed for the Injun V, ISIS, Owl, and ATS satellites using Javelin rockets; (c) continued experiments of the "gravity preference" of mice using Aerobee 150 rockets; (d) auroral spectra experiments to test instruments being developed for the ISIS A and B, and Alouette II satellites using Nike Apache and Nike Tomahawk rockets; and (e) a series of experiments to study the aurora using Aerobee 150, Javelin and Nike Tomahawk rockets coordinated with flybys of the OGO-D satellite and the Auroral Expedition 990 aircraft.

During FY 1969, we will begin to exploit the capability we developed over the last few years. The improved attitude control systems and larger vehicles are enabling us to incorporate heavier payloads of multiple and complementary experiments. By use of the more complex payloads, we are getting more scientific data return for the resources expended. Experiments in planetary atmospheres, energetic particles and fields, galactic and radio astronomy, ionospheric physics, and solar physics are being continued with emphasis on stellar and solar, X-ray, and UV astronomy.

Data Analysis

	1967	1968	1969
National Space Science Data Center..	$350,000	$703,000	$1,162,000
Research tasks:			
Particles and fields..............	957,000	1,147,000	2,253,000
Ionospheric physics...............	366,000	765,000	1,010,000
Solar physics.....................	32,000	65,000	140,000
Astronomy/astrophysics............	---	95,000	195,000
Meteorites/micrometeorites........	30,000	25,000	40,000
Interdisciplinary.................	---	100,000	200,000
Total.............................	$1,735,000	$2,900,000	$5,000,000

The National Space Science Data Center, located at the Goddard Space Flight Center, provides for the collection, cataloging, storage, and dissemination of reduced data from space science flight experiments. The data are made available to those interested in further research. Support is provided for research involving the correlation of data from several separate investigations and also for research not included in the initial investigations. Proposals for research are competitively evaluated and support is provided for those efforts which can be expected to contribute most to the total advancement of knowledge. The support given to particles and fields, and ionospheric physics reflects the fact that most of the experiments flown to date are from these disciplines. However, the amounts for solar physics and astronomy/astrophysics are increasing and should continue to do so with the availability of data from OSO and the forthcoming OAO and Apollo Telescope Mount.

In order to increase the holdings of the National Space Science Data Center, resources are also being devoted to completing data reduction and prime analysis, and acquiring data records for experiments which predate the establishment of this facility. Elimination of this backlog accounts for most of the increase in FY 1968 and FY 1969. Due to financial restraints, FY 1968 funding is extremely limited, but the FY 1969 level more adequately supports this effort. The funding for the National Space Science Data Center reflects the expansion of operations of the Data Center as the pace of collecting data is accelerated.

OFFICE OF SPACE SCIENCE AND APPLICATIONS

LUNAR AND PLANETARY EXPLORATION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objective of the Lunar and Planetary Exploration program is the scientific exploration of our solar system utilizing automated spacecraft and earth-based research. Immediate objectives include the exploration of the Moon, the planets Mars, Venus, and Mercury, and the intervening interplanetary space. The fulfillment of long range objectives will see the eventual exploration of the outer planets and their moons, comets, asteroids, and the corresponding planetary and interplanetary deep space environment. The ultimate achievement of these objectives will provide data to better explain the origin, history, and mechanisms of development of our solar system and may provide evidence of the existence of forms of life elsewhere in the solar system.

The Lunar Exploration program has already played a major role in the scientific understanding of the moon and preparing for the first manned exploration of the moon by providing valuable data from three types of missions. The first, Ranger, has yielded over 17,000 photographs providing a better understanding of the nature and surface of the moon. The second, Lunar Orbiter, provided detailed photography of the moon which significantly contributed to the selection and certification of landing sites for the Apollo manned lunar landing missions. In addition, the Lunar Orbiter has provided valuable scientific data by photographing the entire lunar surface and thus contributing to the fundamental knowledge of lunar surface topography and geology, provided the first photographs of the earth from the immediate vicinity of the moon, obtained data on the lunar micrometeoroid flux and radiation intensity near the moon, and contributed to the improvement in the definition of the lunar gravitational field. The Lunar Orbiter project has demonstrated the capability to develop complex technology required to place automated spacecraft into precise orbits about another body of the solar system. This technology will have direct application to planetary exploration. With the completion of the last Lunar Orbiter flight in FY 1968, the project has conducted five successful missions over a thirteen-month period. No funds are being requested for this project in the FY 1969 budget.

The Surveyor project, also completed in FY 1968, has demonstrated the capability to develop complex automated spacecraft to soft land on another planet. To date, five successful missions have been achieved. The final Surveyor mission was conducted early in calendar year 1968. No funds are being requested for this project in FY 1969. The Surveyor missions have produced several thousand close-up photographs of lunar surface detail, data on lunar surface bearing strength required for Apollo, and have performed the first on-site chemical analysis at various locations on the

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lunar surface. Part of the FY 1969 funds requested under the Data Analysis project are for Surveyor and Lunar Orbiter. These funds will provide for the continuation of analysis and reporting on the scientific and engineering data obtained from these successful missions to the moon. The funds will support the Surveyor principal investigators and members of the advisory teams and working groups in the fields of lunar geology, chemistry, mechanical properties, soil mechanics and electromagnetic phenomena.

The Planetary Exploration program has experienced a high degree of success and increased our knowledge about the planets Mars and Venus. The Mariner II mission in 1962, provided new data on the physical characteristics of the Venusian atmosphere. The Mariner IV mission to Mars in 1965, provided the first close-up photography of the planet and the first data on its low density atmosphere. Mariner V, launched in June 1967, flew by Venus on October 19, 1967, and made determinations of mass and ephemeris, measured the solar wind interaction with the planet, determined the magnetic field of Venus to be less than 1/300 of that of the earth and indicated no radiation belts around the planet. Preliminary analysis of the data indicates the atmospheric pressure is five to seven atmospheres at a temperature of 330 to 350° F about 24 miles above the planet's surface. Should Mariner V survive its close approach to the sun in January 1968, earth-based antennas will re-acquire the spacecraft in an attempt to obtain additional data in August or September 1968.

The next step in the exploration of the planets will be to gain further information about the planet Mars. In 1969, a Mariner mission will be launched to fly by the planet to obtain high resolution topographic information about the Martian surface, provide atmospheric profile measurements by means of occultation experiments and perform measurements of the atmospheric consituents including polyatomic molecules, atomic hydrogen, oxygen, and nitrogen; ionic molecular nitrogen and carbon monoxide; and molecular nitrogen, nitric oxide, carbon monoxide, and cyanogen with infrared and ultraviolet instruments. The fly by distance will be about 1/3 that achieved by Mariner IV in 1965. The 1971 Mariner-Mars mission will perform similar experiments in orbit rather than in a fly by mode. The orbital mode of operation will enable us to gain detailed information about the dynamic characteristics of the planet and provide continuous measurements of seasonal and diurnal variations. Voyager, which was being developed to provide Saturn V launched orbiting and landing missions to Mars in 1973, has been terminated upon the completion of Phase B closeout activities. No funds are being requested for this project in the FY 1969 budget. The 1973 Mars mission with a Titan Mars 1973 orbiter and probe will extend the scientific measurements in orbit and provide for direct measurements of the atmospheric composition, temperature, pressure, and density profile. The Titan Mars 1973 mission will provide the first correlation of remote measurements from orbit with direct entry measurements from a probe. This program will establish the basic steps for more detailed surface exploration of the planet Mars and an orbiter baseline configuration for future planetary exploration.

SUMMARY OF RESOURCES REQUIREMENTS:

	1967	1968	1969
Supporting research and technology/advanced studies......	$22,350,000	$19,800,000	$30,000,000
Advanced planetary mission technology...................	---	12,000,000	6,700,000
Data analysis..................	---	600,000	2,600,000
Surveyor......................	79,942,000	35,600,000	---
Lunar orbiter..................	26,000,000	9,500,000	---
Mariner IV & V................	13,058,000	3,800,000	---
Mariner Mars 1969..............	30,130,000	59,200,000	30,000,000
Mariner Mars 1971..............	---	---	18,000,000
Titan Mars 1973................	---	---	20,000,000
Voyager.......................	12,670,000	1,000,000	---
Total......................	$184,150,000	$141,500,000	$107,300,000

Distribution of Program Amount by Installation:

	1967	1968	1969
Kennedy Space Center.........	$159,000	$90,000	$100,000
Manned Spacecraft Center....	65,000	650,000	1,100,000
Marshall Space Flight Center	1,411,000	385,000	100,000
Goddard Space Flight Center.	355,000	1,292,000	2,000,000
Jet Propulsion Laboratory...	141,885,000	113,479,000	62,300,000
Ames Research Center........	620,000	1,098,000	1,700,000
Electronics Research Center.	40,000	75,000	100,000
Langley Research Center.....	28,625,000	12,700,000	22,000,000
NASA Headquarters...........	10,490,000	11,731,000	17,900,000

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology/Advanced Studies

	1967	1968	1969
Lunar science, advanced technical development, and advanced studies........	$4,500,000	$4,000,000	$14,200,000
Planetary science, advanced technical development and advanced studies............	17,850,000	15,800,000	15,800,000
Total......................	$22,350,000	$19,800,000	$30,000,000

The Supporting Research and Technology/Advanced Studies program provides support to the flight missions by developing science experiments and engineering capabilities, and by studies defining the objectives and requirements of various flight mission possibilities.

The activities in the Science program include the development of new and improved flight experiments, the advancement of the state of knowledge of the moon, planets, and the earth's upper atmosphere by theoretical studies, the determination of essential data by laboratory, astronomical, balloon and sounding rocket investigations, and data analysis and interpretation of the results from flight experiments. Research emphasis is directed at the characteristics of the earth's upper atmosphere and the atmospheres, surface features, and solid body properties of the moon and the planets. Laboratory research includes investigations into the physical and chemical nature and behavior of likely constituents of planetary atmospheres and the solid material of the moon and planets, and the reactions that occur through the influence of external forces and effects such as solar radiation, cosmic rays and meteoroids. Other investigations utilize optical and radio techniques of astronomy to obtain information about the moon and the planets from balloons, sounding rockets, and ground-based observatories. During FY 1969, it is expected that construction will be completed on the 105" telescope at the University of Texas and the 84" telescope at the University of Hawaii.

The most important research areas continue to be the nature of the atmospheres of Mars and Venus, and the characteristics of the surfaces of the Moon and Mars. The data obtained from these ground based activities when combined with flight results (Mariner II, Mariner IV, Mariner V, Lunar Orbiter I through V, and Surveyor missions) continue to advance our knowledge through theoretical and modeling studies. The better understanding of the moon and planets obtained in this way is paving the way for manned landings on the Moon and automated probes for descent through the atmospheres of Venus and Mars and landing on the planets.

The objectives of the Advanced Technical Development program are to advance technology for application in new and improved spacecraft hardware and provide better alternative designs that will successfully allow the conduct of proposed flight missions to the moon and planets. The success of these missions will be dependent upon the development of equipment which can operate reliably after long term exposure in deep space. For flight missions planned to the planets, the spacecraft hardware developed must also operate successfully after being fumigated by gas and sterilized with heat. During FY 1968, the program covered a number of phases of spacecraft advanced development including the design and development of telecommunication and data automation concepts and techniques, the investigation of techniques for sterilization of hardware, the development of landing and capsule system technology, and the improvement of component reliability and lifetime. In FY 1969 funds will be used to continue the current efforts, to support possible future Mars missions, and to start advanced development of critical technologies required for missions to Mercury and other planets.

The Advanced Studies program plays an essential role in developing the plans for future lunar and planetary missions. The identification and evaluation of potential missions is a continuing process which takes into account new information about the moon and the planets, advances made in spacecraft technology, and improved booster capabilities. In Fiscal Year 1968, funds were used (1) to conduct a study of a survivable Venus probe based on design studies of nonsurvivable probe concepts; (2) to evaluate possible Mariner missions for the early 1970 time period; and (3) to investigate the use of solar electric propulsion for missions to Jupiter and beyond. A combined Venus/Mercury mission using nominal on-board propulsion systems was studied. During FY 1969 funds will be used to continue the survey of missions in the distant future and determination of the requirements, characteristics, and feasibility of these missions to the moon and planets and their associated technology requirements. Primary emphasis will be placed on studies of outer planet fly-by missions and orbiter missions to Jupiter. In addition, preliminary studies of automated Mars surface sample return missions are planned. Other studies will include the definition of a Jupiter atmospheric probe and an analysis of rendezvous missions to comets and asteroids.

During FY 1969, Supporting Research and Technology efforts directed toward the planets will continue at the same level as FY 1968. Efforts directed towards optimizing manned exploration of the moon will be increased.

The opportunity presented by Apollo to explore the moon is a major challenge to the scientific community. Large payloads can be delivered into lunar orbit and onto the lunar surface; astronaut stay time will be gradually increased; mobility systems will be introduced, and, above all, man will be there to manipulate the equipment and observe and report on the results. Our efforts toward optimizing this exploration and fully utilizing the capability of the system must be increased. New exploration methods must be developed, and existing earth exploration methods must be modified to fit the lunar parameters. Instruments must then be designed and breadboards constructed. A major contribution to this effort will be increased emphasis on research based on the scientific data from the Surveyor and Lunar Orbiter spacecraft. This research will significantly contribute to our decisions on what we should look for on the surface and in the interior of the moon, how we should look for it, and where we should concentrate our efforts. Continued refinement of existing mission plans must keep pace with these activities.

The initiation of the above activities are essential if we hope to take full advantage of the Apollo missions in the early 1970's. The accomplishment of these goals in this time span will necessitate increasing the activities of scientists and groups of scientists currently in the program, as well as supporting new groups that are currently anxious to participate.

Advanced Planetary Missions Technology

	1967	1968	1969
Orbiters and fly-bys..........	---	$6,000,000	$1,500,000
Probes and landers............	---	4,000,000	2,600,000
Surface laboratories..........	---	2,000,000	2,600,000
Total.........................	---	$12,000,000	$6,700,000

The Advanced Planetary Missions Technology program commenced in Fiscal Year 1968 in view of the conclusion of the Mariner V, Lunar Orbiter, and Surveyor programs and the deferral of Voyager after the Phase B completion. These programs represent an estimated experience of about 20,000 to 30,000 man years. The Advanced Planetary Missions Technology effort is maintaining a nucleus of the scientific, technical, and management competence made available by the completion of these successful programs to conduct the necessary mission design studies to shorten lead time requirements for future missions, to accelerate specific technology tasks in advanced subsystem development essential for executing missions in the early 1970's, and to advance scientific instrumentation development associated with probes and landers.

The Advanced Planetary Missions Technology program has been divided into three major types of missions: Orbiters and Fly-bys, Probes and Landers, and Surface Laboratories. Within each mission type there are three major areas of activities: Mission Design Studies, Advanced Subsystem Research and Development, and Science Definition and Instrument Development.

The Mission Design Studies started in FY 1968, and to be continued in FY 1969, are directed toward the mission opportunities that exist during the early 1970's. These missions include various possible Venus missions in 1972, missions to Venus considering the deployment of a Buoyant Station, a Venus swingby to Mercury in 1973 and soft landing capsules and surface laboratory missions to Mars in the mid 1970's.

For each potential mission, trade-off studies are performed between various possible combinations of mission objectives, applicability and use of information and equipment from earlier missions, modification and reuse of remaining spare hardware from previous missions, and contribution to follow-on missions. To determine the energy requirements and compatibility of various classes of payloads with available launch vehicle capability, trajectory studies are conducted. These studies are combined to evaluate the mission mode, size, weight, and trajectories so that efficient, scientifically desirable, and effective missions can be defined. After defining desirable mission concepts, studies are performed to provide conceptual designs of systems and subsystems, spacecraft/capsule integration, launch vehicle integration, program and test planning and sterilization planning.

From these Mission Design Studies, a foundation is established for the initiation of planetary flight projects on a shorter lead time than is normally required. In addition, a sound basis is formulated for the selection of missions that are compatible with schedule and resource limitations as well as scientific attractiveness. By performing this design study we are afforded the flexibility to implement existing mission options at a later date.

The Advanced Subsystem Research and Development activity initiated in FY 1968 was based on an evaluation of the critical technology requirements for the three mission classes and the lead times involved in developing these technologies. In this way, subsystem technology would be developed to the stage of demonstrated engineering feasibility for specific classes of missions. This effort is directly applicable to the specific 1971 and 1973 Mars missions included in the FY 1969 budget request and will be supported by the flight projects when they are approved. The funds requested in FY 1969 will continue work in heat shield development, analysis of radiating boundary layers and in entry vehicle development. These funds will also provide for continued work in telecommunications, data handling and processing, propulsion, entry aerodynamics, guidance and control, structures and mechanics, sterilization and ground support equipment. Significant advances are required in transmitted power subsystems and in higher efficiency coding and modulation techniques to enable planetary orbiters to effectively transmit photographic data over long distances. Advanced investigations are required in parachute dynamics, in order to develop large parachutes deployable at high Mach numbers in a low density atmosphere.

The third major activity in the Advanced Planetary Mission Technology program is concerned with the definition of science objectives and rationale for the various classes of missions, and with the advance development of instrumentation to be carried on these missions. The FY 1969 scientific instrumentation effort would provide for the definition of scientific experiments and the fabrication of laboratory breadboard models to verify instrument performance for missions to Mars, Venus, and Mercury. The surface laboratory will require the development of integrated science instrumentation that can be sterilized and function as an interrelated set of experiments. To define this integrated laboratory effectively, science teams will be organized to work with design engineers in the early breadboard stage so that significant problem areas will be identified early. In order to achieve an operational surface laboratory in the mid-1970's, work will be done on advance instrumentation and techniques for sample processing, microchemical analysis, and imaging discrimination.

The exploration of Venus will require the same effort in terms of instrumentation and experiment design. Data from the successful Mariner V and Venus IV will be interpreted to provide information for the definition of missions and experiments to be flown later.

Data Analysis

	1967	1968	1969
Surveyor	---	---	$1,200,000
Lunar Orbiter	---	---	800,000
Mariner	---	$600,000	600,000
Total	---	$600,000	$2,600,000

Data analysis is shown as a separate project in the Lunar and Planetary program this year, in view of the fact that the Lunar Orbiter, Surveyor, and Mariner IV and V projects are completed but the analysis of data gathered is not yet fully accomplished. The funds shown in FY 1968 were included in the Mariner project in the FY 1968 budget and are being used for Mariner Data Analysis.

The Lunar Orbiter project has photographed the entire Moon, providing topographic and geologic information in great quantity and detail. The Surveyor project has accomplished soft landings at selected sites on the Moon. By television photography, manipulation of the surface material, chemical analysis and magnetic tests, Surveyor spacecraft have provided valuable information about the lunar surface material, its bearing strength, texture, cohesive properties, and chemical composition. Lunar Orbiter data have provided for selection of eight candidate Apollo landing sites. Four of these site areas were investigated by Surveyor. Fiscal year 1968 marks the end of these successful programs. A portion of the funds requested in FY 1969 for data analysis will be used to continue the analysis of and reporting of the vast amount of scientific and engineering data obtained from these successful programs. The funds will support the work of the Surveyor and Lunar Orbiter Principal Investigators, members of the Surveyor Science Evaluation and Advisory Team and Working Groups in the fields of lunar geology, topography, cartography, chemistry, mechanical properties, soil mechanics, and electromagnetic properties.

Mariner missions have also provided a wealth of data about the planets Mars and Venus, as well as the interplanetary medium. Mariner II acquired interplanetary and planetary data on a fly-by mission to Venus in 1962. Mariner IV, launched in November 1964, flew past Mars in July 1965. It acquired data on the interplanetary medium, the atmosphere of the planet and transmitted to earth 22 pictures of the surface of the planet. After completion of the Mars mission, Mariner IV continued on its trajectory in orbit about the sun. In 1966-67 it came within range of the earth-based deep space network antennas and was determined to be in good operating condition. It continued to function normally throughout the two-year period until the on-board attitude-control gas supply was finally exhausted in December 1967.

Mariner V, launched in June 1967, acquired data on the interplanetary medium and planetary atmosphere of Venus which improved and augmented significantly the data acquired five years earlier by Mariner II. Although the analysis of Mariner V data is still in process, preliminary findings indicate a planetary surface of high temperature under very high atmospheric pressure. Carbon dioxide is a principle constituent of the Venus lower atmosphere. The planet is enveloped in a sphere of hydrogen analogous to that of earth. Neither a magnetic field nor trapped energetic particles were detected near the planet.

In the event that Mariner V survives its close approach to the sun in January 1968, its trajectory will bring it within range of earth-based antennas again in August or September 1968, and provide an opportunity to acquire additional data during such a period of reacquisition. Funds are budgeted in FY 1969 to support this activity.

Mariner

	1967	1968	1969
Mariner-Mars 1964..................	$200,000	---	---
Mariner IV.........................	800,000	$620,000	---
Mariner V..........................	12,058,000	3,800,000	---
Mariner-Mars 1969..................	30,130,000	59,200,000	$30,000,000
Mariner-Mars 1971..................	---	---	18,000,000
Total Spacecraft and Support....	$43,188,000	$63,000,000	$48,000,000
Atlas Agena (Launch Vehicle Procurement Program)............	($200,000)	($71,000)	(---)
Atlas Centaur (Launch Vehicle Procurement Program)............	(8,800,000)	(8,000,000)	($6,600,000)
Total (including launch vehicles)....................	($52,188,000)	($71,071,000)	($54,600,000)

The Mariner program objective is to conduct precursory missions with 400 to 1,200 pound class spacecraft, for the exploration of the planets and interplanetary medium. These missions are to provide a scientific and technological basis for more detailed exploration by larger orbiting spacecraft, probes, and landers. Mariners II and IV measured the magnetic fields, charged particle fluxes, and cosmic dust in interplanetary space and in the vicinity of Venus and Mars respectively. On December 14, 1962, Mariner II observed microwave brightness temperatures of approximately 800°F on Venus,

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but did not detect a magnetic field when it passed within 22,000 miles of the planet's surface. On October 12, 1967, Mariner V passed within 2,500 miles of the surface of Venus. The preliminary results are stated above. Mariner IV transmitted to earth the first close-up photographs of another planet after it passed within 6,200 miles of the surface of Mars on July 15, 1965. The next step in the Mariner program for the exploration of the planets is a fly-by mission of Mars in August 1969. Mission definition and flight plans which are now nearing completion call for the launch of two Mariner-class spacecraft which will be instrumented to obtain more scientific information during this one opportunity than has been collected by all previous planetary missions combined.

The basic spacecraft looks much the same as earlier Mariners although it is larger and heavier (approximately 850 pounds as compared to Mariner IV which weighed 570 pounds) because of the increased science requirements. 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 launch period for this opportunity opens in mid-February 1969 and extends for about seven weeks into early April. By making use of in-flight trajectory corrections, it is possible to have both spacecraft encounter the planet within a given ten-day period. As each spacecraft approaches the planet, one of the two TV cameras on board will commence a picture taking sequence permitting full photographic coverage of Mars at increasing resolution. During the near encounter phase, the other TV camera will be turned on along with the IR and UV instruments. All data will be collected and stored on magnetic tapes up to the time the spacecraft is occulted by the planet. After the spacecraft exits from occultation, the tapes will be played back to the earth tracking stations.

The experience in lunar exploration has been carefully reviewed to determine its applicability to the planetary exploration program. This experience indicates that several orbiter missions (about four as a minimum) are required to make the necessary remote observation and to support landing missions. Two orbiter missions to Mars are planned for both the 1971 and 1973 opportunities. While Titan class launch vehicles are required in 1973, Atlas Centaurs can be used in 1971 because of the low energy requirements associated with the 1971 opportunity.

The 1971 Mariner missions planned for Mars will use the basic Mariner 1969 fly-by spacecraft configuration modified to go into orbit about the planet. Because 1971 is a minimum energy year for both heliocentric injection and orbit insertion about Mars, we are able to launch on an Atlas Centaur a Mariner class spacecraft that will orbit Mars with a significant science payload.

The scientific instruments for the Mariner Mars 1971 missions will be similar to those carried on the Mariner Mars 1969 fly-by. However, the scientific data return will be increased up to ten times that of the 1969 mission. This increase in data return results from the spacecraft being in orbit about the planet allowing multiple measurements and observations of the planet's nocturnal, diurnal, and seasonal variations over a period of several months. In addition, the low point of the orbit will be about 1,200 miles as compared with the nominal 1,800 mile closest approach distance of the Mariner Mars 1969 fly-by. This closer distance to the surface will allow higher resolution measurements from all instruments, and will increase the value of the occultation and celestial mechanics experiments.

The Mariner Mars 1971 orbiter design is based on existing Mariner technology which resulted in successful planetary investigations of Venus during 1962 and 1967, and of Mars during 1965, and was used to develop the spacecraft which will be launched to Mars in early 1969. The actual hardware to be used for the 1971 orbital missions will make maximum use of spare hardware and test equipment from the Mariner Mars 1969 program. Because the Mariner Mars 1969 mission was not an orbital mission, an orbital insertion propulsion subsystem will be developed and integrated with the modified Mariner Mars 1969 hardware to make up the 1971 orbiter.

The Mariner Mars 1971 orbiter will weigh about 2,100 pounds total when launched. Of this total weight, about 975 pounds will be propellants expended during mid-course corrections and orbital insertion; about 150 pounds will be the dry weight of the propulsion subsystem; and about 975 pounds will remain as useful weight in orbit about Mars. Of the 975 pounds of useful weight, about 100 to 150 pounds will be devoted to the science subsystem.

The Office of Space Science and Applications, NASA Headquarters, is responsible for overall management of the Mariner program. The responsibility for project management is assigned to the Jet Propulsion Laboratory. The Jet Propulsion Laboratory will perform the systems integration function of the prime contractor for Mariner Mars 1969, but subcontracting will be for complete subsystems. Subcontracting will be more extensive in the Mariner Mars 1971 project, with perhaps a system prime contractor for the spacecraft.

During the current fiscal year, the Mariner Mars 1969 project has been completing the design of the spacecraft subsystem and the fabrication of both test and flight hardware. These funds are also being used to initiate testing of the Proof Test Model Spacecraft which will extend through the remainder of this fiscal year. Fiscal Year 1969 funds will be used for the completion of flight spacecraft testing, launch operations, and the conduct of in-flight mission operations.

The funds requested for Mariner Mars 1971 in FY 1969 will provide for the completion of detailed system design, procurement of Mariner Mars 1969 follow-on subsystems, modification of Mariner Mars 1969 hardware, and development and testing of prototypes of critical subsystems.

Titan Mars 1973

	1967	1968	1969
Titan Mars 1973....................	---	---	$20,000,000

The orbital reconnaissance of Mars initiated in 1971 will be continued in 1973. In addition, the initial direct measurements of the atmosphere and on the Martian surface will be made by means of a small survivable lander. The objective of the Titan Mars 1973 program is to conduct exploration of Mars with spacecraft sized to the Titan and designed to orbit and land small scientific payloads on the planet, thereby utilizing the technologies and experience developed by the Lunar Orbiter, Surveyor, Mariner, and the Phase B Voyager programs. This program represents an intermediate step to achieving the objectives established for the 1973 Voyager mission.

The 1973 missions will make scientific measurements of the physical and chemical properties of Mars, advance the state-of-the-art of the technology required to accomplish advanced Mars orbital missions and to develop the technology for landing a survivable instrument package on the planet's surface.

The orbiter spacecraft design will be based upon the Mariner 1969/Mariner 1971 family. However, modest increases in scientific capability are contemplated. The survivable lander will weigh on the order of 800 pounds, will use aerodynamic drag and parachutes for deceleration in the Martian atmosphere, and will be designed to land a small instrument package on the surface by the use of impact limiter material to absorb the final impact loads.

The orbiter science subsystem, as currently planned, will include instruments to perform surface reconnaissance, obtain information on the surface and atmospheric composition, and to measure thermal radiation emitted from the surface, the atmospheric structure and density, the magnetic field trapped radiation; and the micrometeoroid flux of Mars.

In addition, the S-band occultation and celestial mechanics experiments, similar to those performed on previous planetary missions, will be continued. The instrument complement, plus the increased data storage and transmission capability, will permit up to 10 or 12 times higher data return from the 1973 orbiter mission than the data return from the Mariner Mars 1971 orbiter mission.

The lander science subsystem, as currently planned, will include instruments to directly measure the density profile; and atmospheric temperature, pressure, and composition, during entry and make surface measurements including pictures and soil composition water content and wind velocity.

The lander may be released from out of orbit or through direct descent prior to orbital insertion and will make its measurements during entry and after landing on the surface. The data collected will be relayed to the orbiter for subsequent transmission to the earth.

Current year funds budgeted under the Advanced Planetary Missions Technology program are being used to conduct mission studies and to define feasible variations from the baseline design described above. Variations being studied include the use of spacecraft propulsion subsystem for combined interplanetary injection and orbital insertion, thus potentially increasing the useful weight in orbit to about 2,500 pounds; the feasibility of deploying landers by direct descent versus out of orbit; and the evaluation of scientific gains as a function of the required performance for probes and landers. The FY 1969 funds requested will provide for the establishment of functional specifications, award of a systems prime contract, initiate detailed system designs, and provide for the development, fabrication, and testing of engineering models for both the orbiter and the landers. During FY 1969, the science payload will be selected and principal investigators supported in the development of scientific instrumentation.

OFFICE OF SPACE SCIENCE AND APPLICATIONS LAUNCH VEHICLE DEVELOPMENT PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Launch Vehicle Development program provided for the development of new vehicles and vehicle stages to support mission requirements. In FY 1967 the Launch Vehicle Development program consisted of Supporting Research and Technology/Advanced Studies and Centaur Development. Through Supporting Research and Technology new technological developments were investigated where their potential application to future missions and future launch vehicles were determined. Advanced Studies were performed to identify and analyze future mission requirements and to define methods of achieving desired performance characteristics. Under the Centaur Development project the Centaur high energy upper stage was developed and made available for launching automated earth orbital spacecraft and high velocity missions to lunar and planetary destinations. Development of the Centaur was completed during FY 1967. Other vehicles developed by NASA include the Scout and Delta which became operational in 1963 after undergoing similar development programs.

Since no major new vehicle development was conducted in FY 1968 and none is anticipated for FY 1969, the Supporting Research and Technology/Advanced Studies efforts are being budgeted in Launch Vehicle Procurement for these two fiscal years.

SUMMARY OF RESOURCES REQUIREMENTS:

	1967	1968	1969
Supporting research and technology/advanced studies	$4,000,000	---	---
Centaur development..........	27,200,000	---	---
Total....................	$31,200,000	---	---

Distribution of Program Amount by Installation:

	1967	1968	1969
Goddard Space Flight Center	$75,000	---	---
Electronics Research Center	$2,214,000	---	---
Langley Research Center....	650,000	---	---
Lewis Research Center......	27,761,000	---	---
NASA Headquarters..........	500,000	---	---

BASIS OF FUND REQUIREMENTS:

No funds are being requested in FY 1969 for Launch Vehicle Development.

OFFICE OF SPACE SCIENCE AND APPLICATIONS — LAUNCH VEHICLE PROCUREMENT PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objective of the Launch Vehicle Procurement program is to provide for the purchase of launch vehicles for space missions. The program includes the procurement of vehicle hardware, launch services, and other supporting activities in addition to providing for a Sustaining Engineering and Maintenance effort at the launch sites and the contractor plants. The program also includes an Advanced Studies/Supporting Research and Technology effort to analyze future mission requirements and investigate new technological developments. Those vehicles currently being procured are: Scout, Delta, Thor Agena, Atlas Agena, and Centaur.

The Launch Vehicle Procurement program is presented as a separate program, but vehicle funding associated with specific flight projects is also shown parenthetically with these projects. Sustaining Engineering and Maintenance costs are not included in the parenthetical notations shown with each mission project as effort is general in nature and benefits all projects associated with a particular launch vehicle system.

NASA's goal is to purchase launch vehicles in the most efficient and economical manner possible. One of the most important considerations in the management of this program is that of trying to determine the optimum number of vehicles to be ordered on each production contract. Before such an order is placed, the following factors are considered: (1) current and projected inventories, (2) launch schedules, (3) procurement lead times required for vehicle delivery, and (4) the most economical production rates of NASA's vehicle contractors.

Prior to the FY 1968 submission, Launch Vehicle Development was presented as a separate program. Since no major development is proposed for FY 1969, the remaining development activities - Supporting Research and Technology and Advanced Studies - are again shown in the Launch Vehicle Procurement program.

SUMMARY OF RESOURCES REQUIREMENTS:

	1967	1968	1969
Supporting research and technology/ advanced studies................	---	$4,000,000	$4,000,000
Scout............................	$9,400,000	10,200,000	16,500,000
Delta............................	23,835,000	30,300,000	30,800,000

	1967	1968	1969
Structures and materials.........	---	$700,000	$600,000
Vehicle engineering.............	---	100,000	200,000
Total....................	---	$4,000,000	$4,000,000

The objective of Advanced Studies is to define vehicle requirements for future missions and to establish the methods by which performance in excess of current capabilities can best be developed. Through these studies, areas of research and new technology development, which may be most fruitful in terms of mission benefits, are indicated. Supporting Research and Technology efforts are directed toward developing the new technology for which a need has been demonstrated by Advanced Studies.

The FY 1967 and FY 1968 Advanced Studies have been directed toward mission and technology requirements for very high velocity launch vehicles. Particular efforts in technology were directed toward high energy and storable upper stages to be used with existing lower stages. FY 1969 studies will be concerned with mission analyses, investigation of vehicle and stage alternatives, and program planning.

Supporting Research and Technology tasks being conducted in the FY 1968 program include computation of performance of low-thrust propulsion systems, alignment and calibration of strapdown guidance systems, test program preparation for strapdown system evaluation, trajectory analysis support for the advanced kick stage, gyro test and evaluation, development of a guidance roll and yaw compensation system, S-band antenna studies, pressurization and dynamics of cryogenic tanks, tests of insulated liquid hydrogen tanks, storage of hydrogen in space vehicles, and other tasks important to the future of the launch vehicle program.

In FY 1969, Supporting Research and Technology work will continue on the development of strapdown guidance systems for small and medium class launch vehicles for science and applications missions. Effort will also be directed toward propulsion system/mission analysis research, investigation of advanced pressurization systems, oxidizer tank and system fabrication, fuel tank and system fabrication, spacecraft prototype engine development, throttling techniques for hydrazine reactors, improvement of a solid propellant motor for use on the Scout velocity package, solid stage switching for use in space vehicles, investigation of a large heat shield for use with launch vehicles, glass-fiber conical cryogenic tank support, and propulsion module integration studies.

	1967	1968	1969
Agena	$29,396,000	$14,400,000	$14,000,000
Centaur	55,019,000	68,200,000	63,000,000
Total	$117,650,000	$127,100,000	$128,300,000

Distribution of Program Amount by Installation:

	1967	1968	1969
John F. Kennedy Space Center	$2,387,000	$5,200,000	$5,800,000
Marshall Space Flight Center	---	500,000	500,000
Goddard Space Flight Center	15,743,000	18,000,000	28,300,000
Jet Propulsion Laboratory	---	100,000	100,000
Electronics Research Center	---	1,600,000	1,700,000
Langley Research Center	9,400,000	10,600,000	16,800,000
Lewis Research Center	81,889,000	78,400,000	74,400,000
Headquarters	---	900,000	700,000
Western Support Office	8,231,000	11,800,000	---

The overall plan for launches during this period is:

Vehicle	Calendar Year 1967	Calendar Year 1968	Calendar Year 1969
Scout	4	7	5(+1 B/U)
Delta	6	6	6
Agena	7	2	3
Centaur	4	3	4
Total	21	18	18(+1 B/U)

Above table includes Advanced Research and Technology missions but excludes reimbursable launches and vehicles procured for other agencies.

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology
Advanced Studies

	1967	1968	1969
Advanced studies	---	$1,000,000	$1,000,000
Propulsion	---	100,000	300,000
Guidance, control and navigation	---	1,600,000	1,700,000
Instrumentation and electronics	---	500,000	200,000

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Scout Procurement

	1967	1968	1969
Vehicles	$2,047,000	$3,500,000	$7,000,000
Motors	3,263,000	1,200,000	3,500,000
Logistics and spares	90,000	500,000	1,000,000
Sustaining engineering and maintenance	4,000,000	5,000,000	5,000,000
Total	$9,400,000	$10,200,000	$16,500,000

Scout is the smallest and the only all solid-propellant launch vehicle in the NASA vehicle family. It is used for a variety of small scientific payloads such as small satellites, atmospheric and space probes, and high speed re-entry experiments. Between the launching of the first Scout vehicle on July 1, 1960, and December 1967, there have been 58 launches. Although NASA has primary responsibility for the management of the Scout program, this vehicle has been utilized by DOD, AEC, foreign countries, and international organizations.

The Langley Research Center has managed the Scout project for NASA since its inception. The prime contractor for the production, checkout, and launch of Scout vehicles is Ling-Temco-Vought (LTV), Dallas, Texas. Scout vehicles are normally launched from the Western Test Range, California or Wallops Station, Virginia. In 1967, a Scout vehicle was successfully launched for the first time from the Italian San Marco platform in the Indian Ocean off the coast of Africa. Thus, there are now three sites capable of launching Scout vehicles.

In FY 1969 funds for Scout Procurement will be utilized for the production, assembly, checkout, and launch of the Scout vehicle. In addition, funds will also be required to support LTV systems management, for logistics, and for vehicle adaptation for individual missions.

FY 1969 funds for Scout Sustaining Engineering and Maintenance will be utilized for maintenance of ground support equipment at the two American launch sites, logistics, transportation, management and engineering support, minor improvements in the Scout vehicle, and other support activities.

Delta Procurement

	1967	1968	1969
Delta production	$8,544,000	$14,700,000	$12,000,000
Thor boosters	7,000,000	6,900,000	9,500,000
Propellants	500,000	700,000	700,000

	1967	1968	1969
Third stages....................	$490,000	$1,000,000	$1,000,000
Sustaining engineering and maintenance..................	7,301,000	7,000,000	7,600,000
Total.........................	$23,835,000	$30,300,000	$30,800,000

The Delta vehicle family has proven to be one of the most economical, versatile, and reliable members of the NASA launch vehicle stable. Its flight configuration consists of the Thor booster, the Delta second stage, and a third stage if necessary. If the third stage is required, an FW-4 or TE-364 motor may be utilized depending upon mission requirements. These configurations are capable of lifting a wide variety of medium-sized payloads into earth orbit or launching small spacecraft into lunar orbit or deep space. To date the Delta vehicle has successfully launched more meteorological, communications, and scientific spacecraft than any other NASA vehicle. Through December 1967 there have been 55 Delta vehicle launches of which 51 have been scored as successful, and Delta has achieved for the second time 22 consecutive successful launches.

NASA has assigned primary management responsibility for the Delta project to the Goddard Space Flight Center. The prime contractor for the Delta vehicle is the McDonnell-Douglas Corporation, Santa Monica, California. NASA procures the first stage Thor boosters through the Air Force, which has the primary responsibility for the production of this vehicle stage. The Delta vehicle is launched from the Eastern Test Range, Cape Kennedy, Florida and the Western Test Range, California.

FY 1969 funds for Delta Procurement will be used to complete the purchase of fourteen first and second stage vehicles initially funded in FY 1968, and to procure associated vehicle hardware, launch services, and other supporting services at the launch sites and production facilities. Initial funding for the production of ten additional vehicles is planned for FY 1969.

During FY 1969, Delta Sustaining Engineering and Maintenance funds are required for the maintenance of ground support equipment at the two launch sites, for vehicle-related engineering support, and for minor product improvement efforts. Improvements planned for FY 1969 include the modification of the FW-4 motor nozzle and conversion to S-band telemetry. Major improvement efforts initiated in FY 1968, such as the adaptation of the Long Tank Thor booster and the TE-364 third stage to Delta, will be completed in FY 1969.

Agena Procurement

	1967	1968	1969
Agena production................	$3,564,000	$1,400,000	$2,500,000
Agena mission modifications......	9,354,000	7,700,000	5,000,000
Thor procurement................	4,257,000	2,000,000	4,400,000
Atlas procurement................	7,176,000	1,900,000	---
Propellants......................	310,000	200,000	100,000
Sustaining engineering and maintenance..................	4,735,000	1,200,000	2,000,000
Total........................	$29,396,000	$14,400,000	$14,000,000

The Agena project includes the Thor Agena and the Atlas Agena launch vehicle systems. The Thor Agena has been utilized for polar orbital missions which exceed the capability of the Delta vehicle. The Atlas Agena has been used for a wide variety of missions including lifting relatively heavy automated payloads into earth orbit and launching several medium-sized spacecraft on lunar and planetary missions.

During 1967 the Thor Agena vehicle successfully launched the Orbiting Geophysical Observatory IV into earth orbit. Missions launched by the Atlas Agena in 1967 included Mariner Venus '67, Lunar Orbiters III, IV, and V and Applications Technology Satellites II and III. Of these missions, all but the ATS II were successful.

In view of the demonstrated operational success of the more powerful Atlas Centaur and the low projected launch rate of heavy automated missions, NASA intends to phase out the Atlas Agena during FY 1968. The last currently planned launch of a NASA Atlas Agena is early in CY 1968, when the OGO E mission is scheduled. Following this launch NASA plans to close down its Agena facility at the Eastern Test Range. Thor Agena vehicles will continue to be launched from the Western Test Range.

Within NASA the management of the Agena project has been assigned to the Lewis Research Center. Lockheed Missiles and Space Corporation, Sunnyvale, California is the prime contractor for the Agena stage. McDonnell-Douglas Corporation, Santa Monica, California and General Dynamics/Convair, San Diego, California, are prime contractors for the Thor and Atlas boosters, respectively. The Agena and the booster stages are purchased from these contractors through the U.S. Air Force, which has primary management responsibility of these vehicles.

FY 1969 funds for Agena Procurement are required for the purchase of Agena upper stages and Thor boosters. In addition, it will be necessary to fund mission-peculiar adaptation, launch services, and other support activities.

Funds for Agena Sustaining Engineering and Maintenance in FY 1969 are required for maintenance of ground support equipment, engineering services, and minor improvements in support of the continued utilization of the Thor Agena launch vehicle.

Centaur Procurement

	1967	1968	1969
Vehicle production................	$30,755,000	$44,700,000	$38,000,000
Atlas booster procurement.........	9,231,000	8,400,000	7,000,000
RL-10 engine procurement..........	3,875,000	500,000	2,400,000
Propellants.......................	678,000	1,400,000	1,500,000
Sustaining engineering and maintenance....................	10,480,000	13,200,000	14,100,000
Total.........................	$55,019,000	$68,200,000	$63,000,000

The Atlas Centaur is the largest launch vehicle currently employed by NASA exclusively for automated space missions. It consists of the Atlas booster and the recently developed Centaur upper stage which was the first rocket in the national launch vehicle family to utilize liquid hydrogen/liquid oxygen propellants. These high energy propellants and the Centaur's capability to restart in space make this vehicle uniquely qualified to perform a variety of high velocity deep space missions as well as relatively large earth orbit and lunar missions. Since development was completed in 1966, the Centaur has been launched seven times in support of Surveyor missions and all launches have been successful. In the future, NASA plans to launch a variety of missions on the Atlas Centaur including Mariner Mars, Orbiting Astronomical Observatories, Advanced Technology Satellites, and Pioneer space probes.

The Lewis Research Center has primary management responsibility of the Centaur Project. The prime contractor for both the Atlas booster and the Centaur stage is General Dynamics/Convair, San Diego, California. The Pratt and Whitney Division of United Aircraft, West Palm Beach, Florida is an associate contractor for Centaur's liquid hydrogen engines. Honeywell, Inc., St. Petersburg, Florida is an associate contractor for the Centaur guidance system. The Atlas Centaur is launched from the Eastern Test Range, Cape Kennedy, Florida.

During FY 1969 funds are required to continue funding for OAO, ATS and Mariner Mars 1969 vehicles. Funds are also required to initiate procurement of vehicles for the Mariner Mars 1971 and ATS F and G missions. In addition to procurement of Atlas and Centaur hardware for these missions, funding support for procurement of RL-10 engines, inertial guidance systems, launch services, management and engineering services at the contractor plant, and for a variety of supporting services is necessary.

Fiscal year 1969 Centaur Sustaining Engineering and Maintenance funds are required for maintenance ground support equipment, engineering analysis, other miscellaneous engineering support activities, and Centaur improvements. Centaur components to be improved include the guidance computer, pulse code modulation telemetry equipment, forward adapter, fixed insulation, and others. This is necessary to enhance the reliability and flexibility of this vehicle, which NASA plans to make the mainstay for launching heavy and high energy missions.

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Bioscience program has two principal objectives. The first objective is the attainment of a thorough understanding of the effects of the space environment on terrestrial organisms. Its implementation includes ground-based research, the Biosatellite project, and development of flight experiments for other missions.

The flights of Biosatellite I and II have thoroughly checked out the engineering design and integrated operation of the spacecraft systems. The system deficiencies encountered with the first flight were corrected and Biosatellite II was recovered satisfactorily. The objective of the experiments carried in Biosatellite II was to determine the effects of the space environment on simple forms of life such as amoeba and frog eggs, seedlings, and plants, especially with reference to interaction of weightlessness with a known intensity of ionizing radiation. The subsequent flights, with more complex forms of life and flight durations up to 30 days, will be utilized to determine the effects of weightlessness on mammalian systems and the effects of an environment disassociated from the normal 24 hour day/night cycle related to the earth's rotation. Two flights are planned for the 30 day mission and two for the 21 day mission.

The second objective of the Bioscience program is the search for extraterrestrial life, with the primary emphasis directed initially to the moon and nearest planets. The specific aims of this objective include: (a) physical and chemical evaluation of planetary surfaces as a possible environment for life; (b) determination of whether or not life exists, or has existed; (c) if life in some form exists, determination of its characteristics; and (d) if no life exists, investigation of the pattern of chemical evolution in order to evaluate the probability of its future occurrence either spontaneously or by contamination. The planetary quarantine program has the objective of minimizing the possibility that terrestrial organisms could contaminate a planet and thus destroy its scientific value as a means of testing the various hypotheses regarding the existence of extraterrestrial life. Continuous effort will be made before initiation of planetary flights to assure an adequate understanding of and solution to the very complex problems associated with this planetary quarantine effort.

A supporting program of basic and applied research is being conducted in conjunction with and in support of the Bioscience program objectives. This effort includes such work as developing techniques for identifying organic molecules and fossils from Pre-Cambrian rocks which will be applied to extraterrestrial samples either in situ or on returned samples, studies on the probability of growth of viable organisms on the planets, and the probability of release from space flight hardware that impacts at high velocity. Studies are being conducted on the use of electron microscopes to magnify or demagnify images several thousand fold to use in collection and storage of information in extraterrestrial studies. Evaluation of the results of the Biosatellite II flight data as compared to ground based SR&T is in process. Studies on the effects of acceleration and weightlessness are continuing, and flight studies of gravity level preference are being accomplished.

SUMMARY OF RESOURCES REQUIREMENTS:

	1967	1968	1969
Supporting research and technology..	$10,050,000	$11,800,000	$16,000,000
Biosatellite........................	31,950,000	30,000,000	32,500,000
Total...............................	$42,000,000	$41,800,000	$48,500,000

Distribution of Program Amount by Installation:

	1967	1968	1969
Marshall Space Flight Center......	$100,000	$55,000	$105,000
Goddard Space Flight Center.......	369,000	134,000	156,000
Jet Propulsion Laboratory.........	954,000	1,342,000	1,448,000
Wallops Station...................	25,000	40,000	185,000
Ames Research Center..............	32,941,000	30,963,000	33,530,000
Langley Research Center...........	160,000	85,000	85,000
NASA Headquarters.................	7,451,000	9,181,000	12,991,000

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

	1967	1968	1969
Exobiology.........................	$2,350,000	$3,500,000	$4,000,000
Environmental biology..............	1,627,000	1,965,000	3,265,000
Behavioral biology.................	1,621,000	1,948,000	3,248,000
Physical biology...................	1,842,000	1,687,000	2,587,000
Planetary quarantine...............	1,810,000	1,800,000	2,000,000
Bio-communications.................	800,000	900,000	900,000
Total..............................	$10,050,000	$11,800,000	$16,000,000

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Exobiology

An integral and perhaps inevitable event in the origin and evolution of the universe was the origin of life. An understanding of the controlling factors in the origin of life and a determination of the uniqueness of life on the earth are the primary objectives of the Exobiology program. The research areas considered basic to the program area are:

1. Chemical Evolution - a study of the chemical events on the primitive earth or on any primitive planet with a similar history which preceded and led to the origin of life. There are two approaches to chemical evolution: (a) abiogenesis is the synthesis of biologically significant organic molecules by the application of energy (electrical discharge, ultra violet radiation, heat, etc.) to the simple components (methane, ammonium, water) of the primitive atmosphere, and (b) organic geochemistry which includes analysis of ancient rocks and sediments of the Earth, Moon and other planets, for fossils (both chemical and biological), providing a record of the events taking place at the time of the origin of life. Extraterrestrial analyses can be done _in situ_ or on returned samples.

2. Biological Adaptation - a study of the response of terrestrial organisms (primarily microorganisms) to extremes of environment (temperature, radiation, pressure, atmospheric composition, water availability, etc.) likely to be characteristic of extraterrestrial environments. Two basic problems are being explored - survival and growth. Are terrestrial organisms accidently landed on an extraterrestrial surface likely to survive and be detected inadvertently by our life detection experiments, and are terrestrial organisms likely to grow and destroy an indigenous life form. What are the limits of environmental extremes which carbon-based life can tolerate, so that we may estimate the likelihood of life on any given planet? Are there other chemistries which could produce a "living" system capable of tolerating quite different environments than we ordinarily consider?

3. Life Detection - the development of techniques which will allow us to determine the presence or absence of past, present or future life elsewhere in the universe. The emphasis is on automated systems performing relevant environmental measurements and chemical analyses early in the program, evolving to more complex payloads making more integrated and sophisticated measurements and ultimately to unmanned and even manned laboratories. The most likely techniques are those which seek the more basic attributes of terrestrial life - organic chemical, metabolic, and growth analyses, as well as imaging systems for visual detection and morphology. Ultimately, data on all of these basic attributes will be required, hopefully on a single sample.

Environmental Biology

The Environmental Biology program deals with those fundamental research projects seeking to understand the effects of various aspects of the space environment, such as weightlessness, acceleration, vibration, radiation, and magnetism, on living systems ranging from the microorganism to man. The approach deals with investigations at the molecular, cellular, system, and organism level of development.

There is little systematic information available concerning the effects of mechanical forces on complete biologic systems. One of the greatest scientific challenges of today is an understanding of gravity as an environmental factor and the role it plays in the origin, nature, and function of highly organized life.

Accurate information is required concerning the availability of earth organisms to live, grow, and repopulate in planetary environments. Ways of adaptation that were adequate under given circumstances here in the earth environment may no longer be adequate when circumstances change in the space and planetary environment.

With the extension of space missions to the planets, regenerative life support systems will be needed. Research on hydrogen-fixing bacteria indicates an ability to supplement current systems with living or bio-regenerative organisms that can utilize animal wastes and carbon dioxide to synthesize protein, fat, and other nutrients. This bacterium, known as hydrogenomonas, fulfills its energy requirements with hydrogen from the electrolysis of water.

The microflora or bacteria associated with man are vital to his well being and normal function. Confinement of man for prolonged periods in closed environments (for example, a space capsule) could conceivably cause abnormal situations which may be either beneficial or detrimental to him. To study the interactions of man and microbes under conditions of confinement, the germfree animal provides a unique baseline for the establishment of model systems which are considered prerequisite to control measures, in contrast to conventional animals with their diversity of ill-defined, and unpredictable, indigenous microflora.

Behavioral Biology

The role of behavioral biology in space bioscience is twofold: (1) to explore the ways in which the extreme conditions of space flight affect the behavior of organisms, and (2) to use the unique features of the space environment to advance the analysis of behavior. In addition to weightlessness, which represents the principal unique factor in space, important effects upon behavior include drastic reductions in familiar modes of sensory stimulation, the removal or alteration of ordinary day-night cycles and, particularly for higher forms, a rather severe kind of social isolation.

A major area of endeavor is the border region between perception and control of movement. The origin and maintenance of eye-hand coodination is an extremely promising topic for current research in behavioral biology. The various feed-back and feed-forward mechanisms involved in manipulatory behavior have become susceptible to laboratory experimentation. If there is any deterioration in the performance of high-level motor skills it is important to learn about this from the standpoints of astronaut safety and a deeper understanding of mechanisms in sensorimotor coordination.

Orientation in space is engaging the attention of investigators interested in understanding and controlling those functions which are essential to extravehicular activity and those other maneuvers in space which require complex behavior. Both ground-based and inflight studies on the sensation of gravity such as the determination of thresholds for angular and linear acceleration and responsiveness of the otoliths, semicircular canals, and other gravi-receptors to both transient and prolonged stimulation will contribute to this understanding.

Absence of the day-night cycle and other periodic aspects of the earth environment make space an ideal laboratory for learning about the origin and nature of circadian rhythms. Interest in this subject extends to a concern for behavioral and other biological events, observed in man, with a periodicity of approximately twenty-four hours, exemplified by the cycle of sleep and wakefulness. Studies of various stages of sleep, particularly those dealing with neurophysiological and biochemical changes during that stage associated with rapid eye movement promises new knowledge equally relevant to man in space and in his normal environment. The relationships between the requirements for sleep, the process of fatigue, and the effects of gravity remain almost totally unexplored.

Physical Biology

The Physical Biology program supports research in comparative physiology, bio-instrumentation, biophysics, and theoretical biology. Research in comparative physiology includes studies on living organisms which specifically lend themselves to investigations in orbiting biological vehicles, on the nutritional requirements of living organisms for prolonged space travel, and on the physical dynamics of various physiological and behavioral systems.

The dynamics of the body temperature regulatory system, the blood flow (cardiovascular system), and the hormonal system are being studied by physical modeling and analysis in an attempt to understand the mechanics of these systems under normal conditions as well as in stress situation.

Various types of biological instrumentation are being developed to measure and analyze biological, biochemical, and biophysical phenomena. In biological telemetry, work is proceeding on the development of a multichannel sensing implantable device in order to measure, simultaneously, a number of biological and behavioral activities, and to enable measurement of normally inaccessible physiological activities under a variety of conditions. This is especially important in space flight experimentation where data have to be telemetered and acquired under conditions not normally found in earth laboratories. Electron microscopic techniques are being used to develop a method of storing data accumulated during space flight. These techniques may allow storage of data by miniaturizing the information to 1/100,000 their usual size.

In the area of biophysics, research is being conducted on biological systems at the molecular and cellular levels. It has been shown that some proteins carry their ancestral type to some degree in cells as far removed in relationship as spinach, bacteria, and human heart muscle. In theoretical biology, work is proceeding on determinations of what organic and life-related molecules can exist under the atmospheric conditions of pressure and heat that are found on other planets.

Planetary Quarantine

The search for extraterrestrial life cannot be successfully prosecuted unless planetary spacecraft are kept free of terrestrial contamination until the exploration is completed. With the successful accomplishment of each flight, knowledge is added that makes it possible to improve the design of succeeding missions. Thus the knowledge gained by both Venus fly-bys in 1967 has permitted a reassessment of the possibility of contaminating that planet. Early fly-bys of Mars will assist in the design of later landing missions, particularly in the design of effective planetary quarantine measures. No mission has either confirmed or denied the possibility of the existence of life in the outer atmosphere of Venus, on Mars, or below the surface of the moon.

Both major launching nations have accepted the criterion that there must not be more than one chance in a thousand of contaminating a planet during the period of biological exploration. This level of safety has required rather rigorous sterilization of the spacecraft by dry heat before launch and protection of the sterile capsule from recontamination during launch. These requirements have had a severe impact on the reliability of the spacecraft.

Up to the past year it was not believed to be possible to achieve high reliability of sterilization and mission reliability. Recent developments, however, suggest that it may be possible to substantially reduce the heat requirements. Intensification of investigations in FY 1969 should result in reduction of the sterilization requirements and substantial reduction in costs.

In the operational area all lunar flights have been monitored to provide an inventory of the microorganisms landed on the moon. These operations are being extended to Apollo in order that life on the returned lunar samples may be more quickly identified and the quarantine period for returned astronauts and lunar material be shortened.

Bioscience Communications

The Bioscience Communications program was established to meet the growing need for effective and timely communication between NASA program scientists and administrators, scientists in universities, industry, and other government agencies. Its activities are designed to meet the information needs of each area of the Bioscience program in directing and coordinating its activities with a maximum of efficiency and foresight, and to provide the scientific community with access to information on the scientific products of these programs.

The Bioscience Communications program provides (1) partial support of the Space Science Board of the National Academy of Sciences and its subcommittees, (2) training of scientists through research associateships and summer institutes, (3) consultation to administrative program scientists, (4) supplemental cross-disciplinary communication between various interfaces of the physical and biological sciences, (5) research literature and report analyses, current status reports, etc., (6) conferences, symposia, and informal meetings.

Biosatellite

	1967	1968	1969
Spacecraft	$24,544,000	$23,842,000	$20,478,000
Experiments	6,861,000	5,894,000	11,028,000
Operations	545,000	264,000	994,000
Total Spacecraft Operations	$31,950,000	$30,000,000	$32,500,000
Thor-Delta (Launch Vehicle Procurement Program)	(---)	(3,900,000)	(5,900,000)
Total (including Launch Vehicles)	($31,950,000)	($33,900,000)	($38,400,000)

The first two Biosatellite flights (3 days duration) investigated the biological effects on a variety of cells, plants, and simple forms of life and the effects of weightlessness combined with radiation on plants, animal cells, and insects. Biosatellite I was successfully launched on December 14, 1966, but was not recovered due to failure of the retro-rocket system. Biosatellite II was launched on September 7, 1967, and recovered on September 9, 1967. The third and fourth flights, of 30 days duration, will investigate the effects of weightlessness on a primate's general metabolic behavior and performance, and cardiovascular and nervous systems. The fifth and sixth flights, of 21 days duration will consist of experiments to determine the effects of weightlessness on plant growth and development, growth of isolated human cells, gross body composition and function in mammals, and circadian (24 hour) rhythms.

Management responsibility for the Biosatellite program has been assigned to the Ames Research Center. Spacecraft development and fabrication is under contract to the General Electric Company, Re-entry Systems Division, located at Philadelphia, Pennsylvania.

The Biosatellites are launched from Cape Kennedy by two-stage, thrust-augmented Thor Delta launch vehicles. The experiments are contained in the re-entry vehicle while other supporting equipment is located in the adapter section. The adapter is separated from the re-entry vehicle prior to the retro maneuver. Recovery of the spacecraft is accomplished by the United States Air Force using aerial recovery.

The Biosatellite flights are providing data which has a wide range of applicability. The testing of biological hypotheses in the areas of genetics, developmental biology, environmental physiology, and general metabolism is one result of these flights. The Biosatellites should also provide valuable data pertaining to biological requirements for prolonged manned space flight, and the possibility of delayed effects appearing in later life or subsequent generations of animal subjects, with possible applications to man. Also, these flights should result in the development and test of new instrumentation techniques, surgical preparations, and other procedures and devices which may have medical and other applications to human beings.

FY 1966 and prior years funding for this six flight program, including launch vehicles, amounted to $61,711,000. Funding for FY 1967 provided for the subsystem and system qualification testing of the 3 day mission prototype spacecraft, assembly and system acceptance testing of the 3 day flight spacecraft, launch and operations support of Biosatellite I and the design and test effort to correct the Biosatellite I deficiencies. Also, it provided for the fabrication and qualification of the 30 day mission major subsystems and the functional testing of the 30 day developmental spacecraft model. Funding for FY 1968 provided for the launch operations of Biosatellite II, but emphasized the fabrication, systems functional testing and qualification testing of the 30 day spacecraft as well as continued funding for experiment development for the 30 day and 21 day missions. Funding for FY 1969 will provide for the flight operations of the two 30 day missions, data processing, and analysis and for the procurement of the 21 day experiment flight hardware. Funding requirements subsequent to FY 1969 for completion of this effort, including launch vehicles are estimated to be $25,360,000.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1969 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR

ADVANCED RESEARCH AND TECHNOLOGY PROGRAMS

Program	Fiscal Year 1967	Fiscal Year 1968	Fiscal Year 1969
Basic research............	$21,401,000	$21,465,000	$22,000,000
Space vehicle systems.....	33,909,000	35,000,000	35,300,000
Electronics systems.......	33,597,000	39,200,000	39,400,000
Human factor systems......	16,265,000	20,985,000	21,700,000
Space power and electric propulsion systems......	40,440,000	44,000,000	44,800,000
Nuclear rockets...........	53,000,000	54,000,000	60,000,000
Chemical propulsion.......	33,638,000	37,250,000	36,700,000
Aeronautical vehicles.....	35,900,000	66,800,000	76,900,000
Total................	$268,150,000	$318,700,000	$336,800,000

FISCAL YEAR 1969 ESTIMATES

The Advanced Research and Technology programs shown in the preceeding table supports research in two major technological areas, Space Technology and Aircraft Technology. The division of effort between these two areas is shown below:

	1967	1968	1969
SPACE TECHNOLOGY			
Program			
Basic Research..................	$17,801,000	$17,165,000	$17,200,000
Space Vehicle Systems...........	33,909,000	35,000,000	35,300,000
Electronics Systems.............	29,597,000	31,400,000	32,000,000
Human Factor Systems............	14,065,000	18,485,000	19,500,000
Space Power and Electric Propulsion Systems............	40,440,000	44,000,000	44,800,000
Nuclear Rockets.................	53,000,000	54,000,000	60,000,000
Chemical Propulsion.............	33,638,000	37,250,000	36,700,000
Total........................	$222,450,000	$237,300,000	$245,500,000
AIRCRAFT TECHNOLOGY			
Program			
Basic Research..................	$3,600,000	$4,300,000	$4,800,000
Electronics Systems.............	4,000,000	7,800,000	7,400,000
Human Factor Systems............	2,200,000	2,500,000	2,200,000
Aeronautical Vehicles...........	35,900,000	66,800,000	76,900,000
Total........................	$45,700,000	$81,400,000	$91,300,000
TOTAL, ADVANCED RESEARCH AND TECHNOLOGY............	$268,150,000	$318,700,000	$336,800,000

Aircraft technology includes supporting research and technology effort conducted under Basic Research, Electronics Systems and Human Factor Systems programs related to aeronautics, in addition to all projects itemized under the Aeronautical Vehicles program.

OFFICE OF SPACE SCIENCE AND APPLICATIONS — SPACE APPLICATIONS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objectives of the Space Applications Program are to: (1) expand the knowledge of atmospheric and space phenomena; (2) conduct a broad program of research and technical development oriented toward the application of space techniques for the benefit of mankind; (3) develop and test procedures, instruments, subsystems, spacecraft, and interpretive techniques for the various applications; (4) fulfill NASA's responsibilities under the Communications Satellite Act of 1962; (5) develop and implement for the Environmental Science Services Administration (ESSA), Department of Commerce, the operational meteorological satellite system; and (6) cooperate with other government agencies in the study and development of space technology related to the early realization of practical benefits, such as earth resources survey endeavors in areas of agriculture/forestry, hydrology/oceanography, geography/cartography and geology/mineralogy through periodic systematic surveys of earth resources.

Many countries throughout the world have traditionally looked to the United States for economic, scientific, and technological leadership. One of the significant ways in which this leadership can be demonstrated is through a comprehensive space applications program. The Space Applications Program effort is directed toward research, development, and flight test in the discipline areas of: applications technology, communications, earth resources, geodesy, meteorology, and navigation and includes implementation of operational systems, as appropriate. Current satellite flight projects include TIROS, Nimbus, Applications Technology and Geodetic Satellites. Fiscal Year 1969 effort includes feasibility, definition, and design studies for an Earth Resources Technology Satellite. Applications Technology Satellites offer great potential to mankind by developing and extending technology commonly required for all types of applications. Communications Satellites offer the possibility of broadcast to all or parts of the world by economical means. Geodetic Satellites offer the means to determine the size and shape of the earth and the vector properties of its gravitational field. Meteorological Satellites provide the capability to improve weather prediction on a global basis, and increase our knowledge of the atmosphere. Earth Resources Satellites provide the means to obtain valuable data in such areas as agriculture/forestry, geology/mineralogy, hydrology/oceanography, and geography/cartography. Navigation Satellites provide location, traffic control, search and rescue, and communications systems for aircraft and ships.

SUMMARY OF RESOURCES REQUIREMENTS:

	1967	1968	1969
Supporting Research and Technology/ Advanced Studies	$11,030,000	$19,300,000	$23,800,000
TIROS/TOS Improvements	1,292,000	9,100,000	5,800,000
Nimbus	24,410,000	33,700,000	32,100,000
Meteorological Soundings	2,855,000	3,000,000	3,000,000
International Applications Satellite	100,000	100,000	100,000
Applications Technology Satellites	30,013,000	25,600,000	31,200,000
Geodetic Satellites	1,600,000	3,400,000	4,000,000
Earth Resources Survey	---	5,300,000	12,200,000
Aircraft Program	---	(5,300,000)	(10,200,000)
Earth Resources Technology Satellite	---	---	(2,000,000)
Total	$71,300,000	$99,500,000	$112,200,000

Distribution of Program Amount by Installation:

	1967	1968	1969
Manned Spacecraft Center	---	$6,100,000	$11,400,000
Marshall Space Flight Center	$280,000	300,000	400,000
Goddard Space Flight Center	65,210,000	78,300,000	79,500,000
Jet Propulsion Laboratory	321,000	100,000	---
Wallops Station	240,000	400,000	200,000
Ames Research Center	100,000	100,000	100,000
Electronics Research Center	1,230,000	1,800,000	2,600,000
Langley Research Center	905,000	800,000	700,000
Lewis Research Center	312,000	1,400,000	1,400,000
NASA Headquarters	2,702,000	10,200,000	15,900,000

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology/
Advanced Studies

	1967	1968	1969
Applications Technology	$1,226,000	$1,400,000	$1,900,000
Communications	2,618,000	3,200,000	4,200,000
Earth Resources	---	7,700,000	8,700,000
Geodesy	450,000	1,000,000	1,800,000
Meteorology	5,761,000	5,000,000	5,800,000
Navigation	975,000	1,000,000	1,400,000
Total	$11,030,000	$19,300,000	$23,800,000

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Supporting Research and Technology in Space Applications covers an extremely wide range of activity from the broad spacecraft technology focusing on advancement in spacecraft stabilization methods, high pointing accuracy, higher power, long lifetime, and data handling capability to the more specific items such as sensors and instrumentation study and design. These efforts form the scientific and technological basis for present and future applications and missions.

The discipline areas of applications are: applications technology, communications, earth resources, geodesy, meteorology, and navigation.

Efforts in FY 1967 for applications technology continued in the area of attitude measurement such as starfield readers, radio frequency (RF) sensors, and non-RF sensors; and control devices such as gravity gradient components, momentum wheels and small thrusters. Effort also continued on the design and preliminary development of a spaceborne millimeter propagation experiment. Funds in FY 1968 are being used for control systems studies directed at stabilization of spacecraft in orbit; spacecraft equipment developments to improve RF amplification and antenna system capabilities and to increase the reliability and useful lifetime of satellite elements. Studies will be continued on long-life fully stabilized spacecraft having improved large space erectable antenna with greater pointing accuracy. Active and hybrid gravity gradient stabilization control systems analysis will be continued. A feasibility study is planned on a unified space applications mission satellite, which will examine multi-disciplinary applications missions in terms of the trade-offs relative to type of sensors and experiments, orbital characteristics, and spacecraft technology. In FY 1969, efforts will continue in the development of new control systems and initiation of effort on a hydrazine control system. Development of components and subsystems will continue with new effort being initiated on a unified S-band transponder. Also, it is planned to initiate studies for the evaluation of educational TV satellite potential and the definition of industry requirements of satellite applications.

In communications, FY 1967 and prior year investigations had been conducted on satellite systems capable of linking terminals of greatly reduced size, making possible communications with low capacity mobile and fixed stations. Investigations continued on the effect of scattering electromagnetic waves by earth's atmosphere and space environment and the determination of mutual interference between space and terrestrial communications systems. Fiscal Year 1968 effort is primarily in the active satellite area, including evaluation and assessments of components and subsystems required for broadcast applications; propagation studies and component development in the frequency region between 10 to 100 GHz where frequencies are more available for space communications, but much less understood; and interference analysis and prediction methods needed for developing frequency sharing criteria. A feasibility study will be conducted to determine satellite system concepts and approaches to provide wide-band communications between orbiting spacecraft and earth terminals via satellite relays. Efforts in FY 1969 will continue the evaluation and development of components and subsystems for communications satellites. Continued efforts will be made to optimize the utilization of the frequency spectrum. Systems analysis and technological studies will be conducted on: data dissemination by satellite, the potential of TV broadcast satellites, and the relationship of communication satellites to common carrier systems for mass communications dissemination.

Earth resources effort in FY 1967 was funded from the Apollo Applications program. Feasibility studies were conducted to define the potential for using remote sensing technology in detecting, measuring, and mapping earth resource phenomena from space. Studies have been conducted in coordination with user agencies to determine the capability of remote sensing devices for obtaining data relevant to the fields of agriculture, forestry, geography, cartography, geology, hydrology, and oceanography. Two NASA aircraft equipped with experimental sensors gathered data over selected test sites in support of feasibility studies to assess potential space applications. The aircraft acquired data, as well as data from Gemini, TIROS, and Nimbus were distributed to the investigators for analysis. The Departments of Agriculture, Interior, Commerce, and Navy are participating in this multi-discipline research. Fiscal Year 1968 funds are being used for studies to define earth resources sensor configurations for space flights. In addition, in coordination with user agencies, studies are being conducted on processing and dissemination of space acquired data, ground truth investigations and space mapping, in oceanography and in the development of agricultural signatures for identification and analysis of crop species. In FY 1969, participating agencies will continue their efforts to define requirements for space missions. Development of interdisciplinary instrumentation will continue with emphasis on the determination of requirements for future instruments beyond those presently required by user agencies. Additional studies will be performed to assess the relationship and requirements of earth resources satellites for the areas of oceanography, forestry, urban and rural development, agriculture, petroleum and mining, water resources, and other earth resources program potential.

Geodesy efforts in FY 1967 and FY 1968 consisted of (1) conceptual studies, feasibility analysis, and configuration definition of geodetic spacecraft, (2) analysis of geodetic requirements in terms of spacecraft mission and instrumentation configuration, (3) analysis of feasibility and effectiveness of accurately located ground-based spacecraft observation systems, and of data analysis techniques for active and passive geodetic satellites, and (4) research into geodetic effectiveness and feasibility of techniques, to calibrate geodetic observation methods intended for extraterrestrial use. In FY 1969, existing studies will be continued and new effort initiated to determine the data requirements for ship positioning, continental drift, and the relationship of satellite and surface gravity measurements. Investigations will also be conducted to determine the potential of using satellites for marine geodesy and to assess advanced geodetic satellite applications.

In meteorology, FY 1967 and prior year funds were utilized for developing and evaluating components for potential meteorological satellite system applications: design and development of satellite sensors for the detection and controlled acquisition of meteorological data directly from the atmosphere, investigation of scientific techniques for the systematic observation, analysis and interpretation of meteorological atmospheric phenomena; and system analysis and exploration of the atmosphere. Fiscal Year 1968 funds are being used primarily for the development of improved satellite subsystems and components and the identification and development of advanced sensors. Improvement efforts include the spaceborne medium size memory, on-board data processing systems, interferometer development, power and attitude control systems, tape recorder optimization, and solar array drive and positioning. Identification and development of advanced sensors include the test and evaluation of various meteorological experiments on rockets and aircraft, advanced studies on radiation data, the development of radiometric inversion techniques for inferring atmospheric structure, and research in millimeter techniques for remote sounding. In FY 1969, the effort will be continued in the area of improved subsystems and components and advanced sensors for synchronous and non-synchronous altitude satellites. In addition, studies will be conducted on the utilization of meteorological data obtained from synchronous satellites, determination of the requirements for air and water pollution sensors and subsystems, and the quantitative data requirements for advanced atmospheric models.

Navigation and traffic control satellite system conceptual studies conducted in FY 1967 and prior years indicated that satellites could assist over-ocean aircraft and ships to obtain more precise position information under all weather conditions, and could aid air-sea traffic control and coordination of rescue operations. In FY 1968, navigation and traffic control effort included studies and experiment development on data and voice transmission via satellite to ships, aircraft, and other mobile platforms; position determination techniques; and studies of future navigation and traffic control satellite concepts. In FY 1969, effort on these studies and experiment development will continue. Studies will also be initiated to assess the socio-economic-political implications of navigational satellites; to determine user agency requirements for navigational aids, search and rescue techniques, and data on transportation hazards.

TIROS/TOS Improvements

	1967	1968	1969
TIROS M Spacecraft..............	$847,000	$7,400,000	$3,300,000
TOS Improvements................	445,000	1,700,000	2,500,000
Total Spacecraft and Support.	$1,292,000	$9,100,000	$5,800,000
Delta (Launch Vehicle Procurement Program)	(---)	(800,000)	(---)
Total (including launch vehicles)...................	($1,292,000)	($9,900,000)	($5,800,000)

Nine TIROS research and development spacecraft funded by NASA, and seven operational spacecraft, based on the TIROS configuration, funded by ESSA, have been successfully launched. In response to the requirements of ESSA for an early day-night capability in a single spacecraft, NASA initiated design study effort in FY 1966 for a spacecraft designated TIROS M. This spacecraft, scheduled for launch in 1969, will contain two advanced vidicon camera systems (AVCS), two automatic picture transmission (APT) systems, two high resolution radiometer (HRR) systems and secondary sensors, which consist of a flat plate radiometer to map the earth's heat budget and a solar proton monitoring instrument. TIROS operational system (TOS) acquisition stations at Wallops Island, Virginia, and Gilmore Creek, Alaska, will be used. Data will be utilized by the Goddard Space Flight Center (GSFC), ESSA and cooperating government and non-government meteorological organizations. The configuration flight tested by TIROS M will be used in the future improved TOS spacecraft funded by ESSA. The TOS Improvement program provides for the research and development of components and subsystems for meeting the evolutionary requirements of the TOS system. These requirements are increased reliability, extended life, expanded sensor capability, and improved operational capability. Efforts currently being undertaken include the improvement of vidicon cameras, radiometers for higher resolution day-night coverage, sensors for vertical profile measurements, improved attitude determination subsystems, on-board orbit correction subsystems, and improved ground station systems.

The Office of Space Science and Applications is responsible for the overall management of this project. Responsibility for project management is assigned to the Goddard Space Flight Center. The major spacecraft contractor is Radio Corporation of America.

Fiscal Year 1966 and prior year NASA funds for TIROS I through IX, TIROS M, and TOS improvements, including launch vehicles, amounted to $56.6 million. Fiscal Year 1967 funds were utilized to initiate hardware procurement for the TIROS M spacecraft and for TOS sensors development. Fiscal Year 1968 funds are being used to continue these efforts. Fiscal Year 1969 funds are required to complete the TIROS M spacecraft and sensors; for integration, test, and launch of the TIROS M spacecraft; and to continue funding the TOS improvement efforts. Subsequent funding requirements for TIROS M are estimated at $1.5 million for completion of funding on the prime spacecraft contract. TOS improvement effort will continue at the level of about $2.5 million per year.

Nimbus

	1967	1968	1969
Nimbus			
Spacecraft........................	$14,152,000	$18,100,000	$18,000,000
Experiments........................	8,261,000	13,400,000	12,100,000

	1967	1968	1969
Ground Operations and Support......	$1,997,000	$2,200,000	$2,000,000
Total..........................	$24,410,000	$33,700,000	$32,100,000
TAT-Agena (Launch Vehicle Procurement Program)..........................	(2,330,000)	(3,036,000)	(3,638,000)
Total (including launch vehicles)	($26,740,000)	($36,736,000)	($35,738,000)

The objectives of Nimbus are: (1) to develop an improved meteorological satellite to provide data for use by the scientific community, (2) to carry out flight tests to prove the applicability of the instrumentation, (3) 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 (4) to provide the basis for further significant technological advances in meteorological satellites for scientific and operational uses. The Nimbus concept features (1) orientation--the spacecraft stabilized in three axes and pointing to the earth at all times, (2) coverage--the polar orbit enables the spacecraft sensors to provide daily global coverage, and (3) capacity--the spacecraft configuration allows for test of a sizeable number of relatively advanced observational sensors and experiments.

The project consists of six spacecraft of which two have been launched, Nimbus I, August 28, 1964, and Nimbus II, May 15, 1966. These launches have validated the Nimbus concept of testing a variety of advanced sensors on a stabilized earth oriented spacecraft. Nimbus B and D are currently under development for launch in 1968 and 1970, respectively, to test a variety of additional advanced meteorological experiments.

Nimbus B will test such sensors as: (a) infrared interferometer spectrometer (IRIS), (b) interrogation, recording, location system (IRLS), (c) medium resolution and high resolution infrared radiometer (HRIR), (d) a satellite infrared spectrometer (SIRS), (e) an image dissector camera system (IDCS) to provide daytime TV pictures of cloud cover. Nimbus D will test such sensors as (1) an improved infrared interferometer spectrometer (IRIS), (2) an improved satellite infrared spectrometer (SIRS), (3) a filter wedge spectrometer (FWS) to monitor water content of the atmosphere, (4) a temperature/humidity infrared radiometer (THIR), and (5) an improved interrogation, recording and location system (IRLS). Effort is being initiated in FY 1968 on development of Nimbus E and F scheduled for launch in 1972 and 1973, respectively, to test additional experiments to further extend the technology advancements in meteorological satellites for scientific and operational purposes utilizing spacecraft of greater weight and power capability.

The Office of Space Science and Applications is responsible for overall management of the Nimbus project. Responsibility for project management is assigned to Goddard Space Flight Center. The major contractors for the Nimbus A-D missions are General Electric for integration and test of the spacecraft and for the controls subsystems and the Radio Corporation of America for camera, power, and data storage subsystems. Major contractors for the Nimbus E and F spacecraft, experiments, and subsystems have not yet been selected.

Fiscal Year 1966 and prior years funds, including launch vehicles, amounted to $156.5 million. Fiscal Year 1967 funds were utilized to continue development of Nimbus B spacecraft and experiments, initial procurement on long lead hardware items for Nimbus D and continued data handling of Nimbus II. Fiscal Year 1968 funds are being utilized for completion, integration, and launch of the Nimbus B spacecraft, continued development of Nimbus D spacecraft and experiments, and for final definition and initial experiment development effort for Nimbus E and F, and continued data handling for Nimbus II and for Nimbus B after launch. Fiscal Year 1969 funds are required to continue the development of Nimbus D, E, and F spacecraft and experiments and continued data handling from missions in orbit. Subsequent years funding requirements for this project, including launch vehicles are estimated to be $82.3 million.

Meteorological Soundings

	1967	1968	1969
Large research sounding rockets......	$1,920,000	$2,020,000	$2,070,000
Sounding rocket system development...	630,000	750,000	700,000
Field experiment support............	305,000	230,000	230,000
Total..........................	$2,855,000	$3,000,000	$3,000,000

The objectives of the Meteorological Sounding project are: (1) to determine the structure and characteristics of the atmosphere in the region 20 to 60 miles above the earth through the use of research and development type sounding rockets, and (2) to develop a meteorological sounding rocket system amenable to research, range support, and supporting operational requirements. To accomplish these objectives, three areas of effort are involved: (1) development and use of large sounding rockets to explore atmospheric characteristics in the region of 30-60 miles above the earth, (2) design and test of small sounding rocket systems to obtain data from the region 20-40 miles above the earth, and (3) participate in conducting sounding rocket experiments in cooperation with other countries on a cost-sharing basis.

The Office of Space Science and Applications is responsible for the overall management of the project. Project management for large research rockets is assigned to Goddard Space Flight Center, for small developmental rockets to Langley Research Center, and for the field experiment support to Goddard Space Flight Center and Wallops Station.

Fiscal Year 1966 and prior year funding amounted to $9.2 million of which $7.4 million was utilized for large research rockets, $1.6 million for small rocket development, and $.2 million for field experiment support. Approximately 50 large research rockets and 100-150 small developmental sounding rockets are launched each year. Funds for FY 1967 were utilized for launch of large research and small developmental sounding rockets, flight test of various payload components, research for system improvements and for initiation of the international cooperative field experiment project with Argentina. Funds for FY 1968 are being utilized to launch additional large research rockets and small developmental sounding rockets; development and improvement of sounding rocket systems; continuation, extension, and development of field experiment projects jointly with countries in South America, Europe, and Asia, to study and observe the upper atmosphere through the coordinated launches of small developmental sounding rockets.

Fiscal Year 1969 funds are required to provide for the launch of approximately 50 large research rockets to continue study of the relationship of the atmospheric structure in the arctic, sub-arctic, mid-latitudes, and the tropics during various seasons; for launch of about 150 small development sounding rockets; flight test of various payload components; research to improve rocket performance; and the continuation and development of the field experiment projects with other cooperating countries. Subsequent year funding requirements will continue at about the level of $3.0 million per year.

International Applications Satellite

	1967	1968	1969
Spacecraft and support....................	$100,000	$100,000	$100,000
Scout (Launch Vehicle Procurement Program)	(---)	(---)	(3,000,000)
Total (including launch vehicles).......	($100,000)	($100,000)	($3,100,000)

This project was entitled French Satellite in the FY 1968 budget. It is a cooperative project with France and consists of a space meteorology experiment involving the use of free-floating balloons and an earth orbiting satellite. The experimental data will provide the velocity of air masses at various altitudes, and assist in gaining a better understanding of the atmospheric structure.

France will: (a) design, develop, and launch balloon payloads equipped to gather meteorological data in conjunction with an earth orbiting spacecraft, (b) design, and develop the spacecraft, and (c) provide ground operational support including spacecraft checkout, tracking, data acquisition and analysis. NASA will: (a) provide the launch vehicle, backup vehicle if required, and launch services, (b) provide technical assistance, and (c) assist in data acquisition and analysis.

The Office of Space Science and Applications is responsible for the overall management. Responsibility for project management is assigned to Goddard Space Flight Center.

This project was initiated in FY 1967. Fiscal Year 1967 funds were utilized for spacecraft and balloon subsystems studies. Fiscal Year 1968 funds are being used to continue this effort including the analysis of balloon and spacecraft antenna, electronics, balloon position fixing techniques, and general project support. Fiscal Year 1969 funds will be required to continue this effort and for procurement of the launch vehicles and services. Funding requirements for future years for this project are estimated to be about $.2 million.

Applications Technology Satellites

	1967	1968	1969
Spacecraft......................	$15,413,000	$10,900,000	$15,300,000
Experiments.....................	13,400,000	13,200,000	13,100,000
Operational support............	1,200,000	1,500,000	2,800,000
Total..........................	$30,013,000	$25,600,000	$31,200,000
Atlas Agena and Atlas Centaur (Launch Vehicle Procurement Program).....................	(17,856,000)	(10,301,000)	(4,200,000)
Total (including launch vehicles)..................	($47,869,000)	($35,901,000)	($35,400,000)

The objectives of the Applications Technology Satellites project are to design, develop, flight test, and evaluate a variety of experiments in the space applications disciplines by use of a series of spacecraft, most of which are launched into synchronous orbits. Seven spacecraft are in the series, of which three have been launched to date, one into medium altitude and two spin stabilized spacecraft into synchronous orbit. Four additional spacecraft are scheduled for launch in the 1968-1973 period utilizing Atlas Centaur launch vehicles. The launch of ATS-A into medium altitude was largely unsuccessful due to failure to obtain the circular orbit required. Applications Technology Satellites B and C have successfully demonstrated the feasibility of a variety of experiments at synchronous altitude such as black and white and color cloud cover pictures from synchronous altitude, very high frequency communication experiments with aircraft, and a number of environmental measurement experiments. Applications Technology Satellites D and E scheduled for launch in 1968 and 1969 respectively will test new and additional space applications experiments at synchronous altitude using gravity gradient stabilized spacecraft. Applications Technology

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Satellites F and G are scheduled for launch in the 1972-73 period to flight test a 30 foot space erectable parabolic antenna; accurate, long life stabilized system; precision radio-interferometer; and other applications and scientific experiments which are to be selected.

Included in this project are efforts on development of additional advanced applications flight experiments in the discipline areas of meteorology, broadcast and program distribution, data collection and relay, navigation and traffic control, and geodesy. These experiments will be incorporated into the appropriate ATS spacecraft for flight testing.

The Office of Space Science and Applications is responsible for overall management. Responsibility for project management is assigned to Goddard Space Flight Center. The major contractors for the first five ATS missions are Hughes Aircraft Company for spacecraft development, and General Electric Corporation for gravity gradient stabilization system development. Contractors for the F and G are being selected in FY 1968.

Fiscal Year 1966 and prior year funding for this project, including launch vehicles and meteorological flight experiments, amounted to $90.1 million. Fiscal Year 1967 funds were used to cover the first two launches and continued development on the subsequent three spacecraft and experiments. Fiscal Year 1968 funds are being utilized to launch the third spacecraft and continue the development of ATS D and E and initiate the development of ATS F and G. Fiscal Year 1969 funds are required to continue development of the four spacecraft (D through G), experiments, and ground operational support of the missions in orbit, and several advanced applications experiments. Subsequent funding for this project, including launch vehicles is estimated to be $118.5 million.

Geodetic Satellites

	1967	1968	1969
Spacecraft and support...............	$1,600,000	$3,400,000	$4,000,000
Thor Agena and Delta (Launch Vehicle Procurement Program)...............	(---)	(700,000)	(4,300,000)
Total (including Launch Vehicles)..	($1,600,000)	($4,100,000)	($8,300,000)

The objectives of this program are to conduct geodetic satellite measurements on a global scale. This, in conjunction with astrogeodetic, surface base-line, and gravity data available from other sources, will result in: the establishment of a unified world datum in a geocentric coordinate system to which the major world datums will be connected; the definition of the structure of the earth's gravitational field and refinement of the locations and magnitudes of large gravity anomalies; the improvement of the positioning accuracy of tracking sites and the location of isolated islands; and an evaluation and correlation of the results obtained from the geodetic instrumentation and techniques utilized.

The Geodetic Satellite Project consists of four flight missions, namely: (1) GEOS-I (GEOS-A) successfully launched on November 6, 1965, (2) PAGEOS-I successfully launched on June 23, 1966, (3) GEOS-B, scheduled for flight in early 1968, which is structurally similar to GEOS-I and will contain flashing lights, minitrack beacon, doppler beacon transmitters, range and range rate, SECOR and C-band transponders, and optical reflectors for laser tracking and (4) GEOS-C, scheduled for flight in 1969. GEOS-C, structurally similar to both GEOS-I and GEOS-B, is the back-up spacecraft for GEOS-B, and will be flown at an inclination and altitude required for supplying the data to complete a unified world datum and improve the location of the tracking stations if GEOS-B is successful. GEOS-C will carry the same basic instrumentation as GEOS-I and B plus instrumentation designed to obtain highly precise data measurements.

The Office of Space Science and Applications is responsible for the overall management of GEOS.

FY 66 and prior year funding including launch vehicles, amounted to $23.5 million. FY 67 funds were utilized for continued development of GEOS-B spacecraft and for continued data acquisition and analysis from GEOS-I. FY 68 funds are being utilized to complete GEOS-B spacecraft data acquisition and analysis, provide systems engineering, and ground support for GEOS-B launch and commencement of development of GEOS-C. FY 69 funds are for continued GEOS-B data acquisition and analysis, GEOS-C (GEOS-B back-up) spacecraft development, and ground operational support. Funding requirements for future years, including launch vehicles are estimated to be $7.4 million.

Earth Resources Survey

	1967	1968	1969
Aircraft Program................	$ ---	$ 5,300,000	$10,200,000
Earth Resources Technology Satellite....................	---	---	2,000,000
Total........................	$ ---	$ 5,300,000	$12,200,000

This project consists of two activities in the earth resources discipline, as follows (1) an aircraft program to develop and test remote sensing techniques, sensors, and data handling systems, and (2) feasibility, definition, and design studies pertaining to an earth resources technology satellite.

The objectives of the aircraft program are: (1) to conduct feasibility studies and program definitions on testing of sensors and data collecting techniques for earth resources, (2) to design, develop, and flight test these equipments, and (3) to conduct aircraft flights over selected test sites to evaluate the performance of the sensing equipment and to obtain significant data in the discipline areas of agriculture/forestry, geography/cartography, oceanography/hydrology, and geology/mineralogy.

This effort was conducted in FY 1967 in Supporting Research and Technology (SR&T) funded from Apollo Applications and included in the Space Applications program effective with FY 1968. The FY 1967 and 1968 effort consisted of studies in the areas of program definition, feasibility, and potential benefits to the national interest and mankind in the disciplines cited above. This effort also included instrumentation development, and integration of experiments and sensors into a Convair 240A and a Lockheed P-3A aircraft for flight over specified test sites to gather fundamental data in the various earth resources disciplines. In Fiscal Year 1968, the Convair 240A is being replaced with another P-3A. These instrumented aircraft gather, for example, such basic data as (1) soil types, crop conditions, environmental conditions, etc., in the case of agriculture; (2) tree identification, forest density, forest conditions, etc., in the case of forestry; and (3) water densities, temperatures, currents, etc., in the case of oceanography. In addition to gathering significant data, the aircraft program serves as a test bed for acquiring the skills in handling and interpreting the data obtained and in gaining valuable design experience in the pursuit of more sophisticated instrumentation required for future satellite missions.

The objectives of the Earth Resources Technology Satellite (ERTS) effort are to conduct feasibility, definition, and design studies of a satellite containing a variety of sensors capable of obtaining fundamental experimental data in the earth resources disciplines. Analysis of these data would locate, identify, and assess many earth resource phenomena. In agriculture and forestry for example, crop growth area, forest area, brush/range land interface, crop yield, and damage assessment data could be obtained by an Earth Resources Technology Satellite. The Departments of Agriculture, Commerce, Interior, and the U.S. Naval Oceanographic Office have participated in a cooperative program with NASA to identify uses and assess the value of space acquired data when applied as improvements to functions for which they have responsibility.

The Office of Space Science and Applications is responsible for the overall management of this project. Responsibility for project management of the Aircraft Program is assigned to Manned Spacecraft Center. A field center has not yet been designated for the Earth Resources Technology Satellite study effort.

Fiscal Year 1969 funds are required for instrumentation development for a high-altitude aircraft; operational support for two P-3A's and the high altitude aircraft; and for data acquisition, analysis, and utilization, in the Aircraft Program; and in Earth Resources Technology Satellite activity to conduct feasibility, definition, and design studies for a satellite system. These endeavors will be coordinated with user government agencies. Funding requirements for future years for the Aircraft Program are estimated to be about $5.5 million per year.

OFFICE OF UNIVERSITY AFFAIRS | SUSTAINING UNIVERSITY PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

Since the beginning of the national space program, NASA has depended upon universities to supply expertise and competence that is essential to the space effort and is available only in universities. University scientists conceive and develop satellite experiments which contribute directly to new scientific knowledge; they do research in university laboratories on communication and meteorological satellites and manned flight operations; they serve on advisory groups which plan and evaluate space activities; they train the thousands of scientists, engineers, and managers who run the space program. This is not a one-way benefit; participating universities gain new knowledge and experience necessary to their continued scientific, technical and academic advancement. NASA also deals with universities to feed back knowledge gained from space exploration into useful nonspace applications and to help preserve the role of the United States as a leader in aeronautics and space science and technology as required by the Space Act of 1958. The nature of NASA's relationships with universities changes somewhat from time to time to meet changing needs, but regardless of the level or direction of the nation's space program, universities must be an essential part of it.

Most of NASA support to universities is through the agency program offices and centers which deal directly with university scientists and engineers in carrying out specific research and development projects. However, many needs fall outside the cognizance of these offices and must be met by the Sustaining University Program. These include sustaining research on subjects broader in scope than the responsibilities of any other NASA office, training of graduate students in disciplines which represent particular NASA needs, special training for senior faculty members in space research and engineering systems design. The investment in universities has been responsible for a major contribution toward making this nation a leader in space exploration, especially in space science.

In the early years, NASA needed to increase the number of university trained experts to develop scientific experiments and spacecraft. In FY 1968 and FY 1969, the flight program is being cut back and the need is for preserving to the greatest extent possible, the scientific and technical base that has been developed and for concentrating research efforts on more complex space programs which might be undertaken in the future. That is, if the United States hopes to retain a position of leadership in space exploration, it must compensate for the lack of flight programs through more intense laboratory research aimed at developing the science and technology needed for whatever flights might be undertaken in the future. NASA also needs the best minds available in universities to study the social and economic implications of various future flight options; and to concentrate on studies in sophisticated systems engineering design, to encourage the utilization of knowledge, development of talents and apply the vast amount of information emanating from the total space research and technology program.

SUMMARY OF RESOURCES REQUIREMENTS:

	1967	1968	1969
Training	$16,000,000	$3,000,000	$3,000,000
Research	11,000,000	7,000,000	7,000,000
Research facilities	4,000,000	---	---
Total	$31,000,000	$10,000,000	$10,000,000
Distribution of Program Amount by Installation:			
NASA Headquarters	$31,000,000	$10,000,000	$10,000,000

BASIS OF FUND REQUIREMENTS:

Training

Training	$16,000,000	$3,000,000	$3,000,000

As the national space effort proceeds towards attainment of its mission objectives, training activities conducted under NASA's Sustaining University Program are continuously being reviewed and reassessed to insure harmony with the new conditions and tasks the Agency will encounter in the years ahead.

In FY 1969, $3 million is requested for training, $1.5 million of which will be allocated to predoctoral training in systems engineering design and public administration and the other $1.5 million to special summer training programs.

NASA's effectiveness has been limited by a critical shortage of well trained persons who can conceive, design, and develop complex boosters, spacecraft, aircraft, and ground facilities which represent the main thrust in the country's space and aeronautics effort, and for persons who understand the administrative and management problems involved with the expanding dimensions of science and technology within the social and economic structure of the nation. The special predoctoral training program in systems engineering design and public administration has been established so that senior faculty members and graduate students may use NASA installations as laboratories in which to study problems which are relevant to NASA needs while helping to strengthen the graduate programs at their universities. The $1.5 million would support about 75 predoctoral students in these two areas.

The other $1.5 million will be allocated to special summer training activities which are described below.

The summer faculty fellowship program, emphasizing individual research activities, was started to help young faculty members keep up with the latest technical developments in engineering and science. Originally established with the assistance of the American Society for Engineering Education (ASEE), these 10 week summer sessions are cooperative endeavors undertaken in conjunction with one or more universities located near NASA research centers. Participants spend about three quarters of their time in the laboratory and the balance of the time in seminars or symposia, mainly on the university campus. During the summer of 1968, it is estimated that between 225 and 250 young faculty members will participate in the program at one of eight locations involving eight NASA centers and twelve universities. A program of similar magnitude is planned for FY 1969.

A faculty fellowship program in systems engineering design was started during the summer of 1966. Under this program, faculty members from different engineering disciplines are brought together to work on broad space related problems requiring an integrated or team approach. Usually, at least two faculty members from the same university participate in order to introduce new techniques in the teaching of systems engineering design when they return to their home institutions. These activities are also carried on in cooperation with one or more universities, located near NASA centers, with center personnel, having special competence in systems engineering design, lending strong support. During the summer of 1968, it is estimated that between 75 and 100 young faculty members will participate in the program involving four NASA centers and seven universities. Programs at the same locations are planned for FY 1969.

The other special training programs include the summer institutes for upper division undergraduates and the post-M.D. training in aerospace medicine. The summer institutes for undergraduates are designed to acquaint junior and senior level undergraduates with some of the substantive problems of space science and engineering. As in previous years, the students are selected from a national competition and will be especially talented young men and women who show promise of continuing their studies at the graduate level. During the summers of 1968 and 1969, it is planned to conduct four of these institutes.

The post-M.D. training program is designed to help provide a few very select medical doctors with special advanced training to work in direct or supporting roles in manned space flight efforts. In FY 1968 and FY 1969, the level of effort will be the same as in previous years.

Research

	1967	1968	1969
Research........................	$11,000,000	$7,000,000	$7,000,000

NASA, through the research element of the Sustaining University Program, supports university research which is broader in scope and longer range than program or project oriented research. Sustaining research grants have been awarded to about 50 universities throughout the country and are designed to permit universities to develop and strengthen their own faculties and curricula while contributing directly to NASA's space and aeronautics research needs. In addition to further development of the universities scientific and technical competence, particular emphasis is placed on multidisciplinary studies which consider social, economic, and public policy aspects of advancing science and technology. Research supported by these grants has a significance beyond the immediate research accomplishments in that participating universities, at the same time, enhance their capabilities to contribute to other technical, engineering, scientific, social, and economic needs of their regions and the nation.

Research supported by the Sustaining University Program balances and complements the Agency's project research and flight experiment activities and provides stable funding for university research and training. Typical research efforts will include:

1. Multidisciplinary research grants which provide a stable base of support for space related science and engineering at the universities best able to contribute to the research needs of the national space program.

2. Strengthening of the nation's university research in areas where specific agency needs have been identified but adequate capability does not exist in universities.

3. Research on more complex, longer duration missions of the future (e.g. planetary exploration).

4. Multidisciplinary study of future technical needs and implications of the space program including social and economic aspects: e.g., world-wide communications, long-term weather pattern analysis, improvements in speed and safety of aircraft, and better development of earth resources.

5. Research on management and administration of complex scientific and technical programs supported by public funds.

6. Study of experience and knowledge from the space program which might be beneficial in dealing with other national problems such as pollution, transportation, housing, and crime control.

Research programs are individually tailored to the strength of the participating institutions. The grants typically bring together the most able minds on the campus interested in space and aeronautics research. This group, in consultation with NASA, determines the most opportune ways in which available resources may be utilized to achieve the objectives of the grant and the research needs of the space program.

With a budget of $7 million in FY 1969, the research element of the Sustaining University Program will support multidisciplinary programs at 35 universities. This number is down from the 44 institutions funded in FY 1968 and 50 universities in the program in FY 1967.

Research Facilities

	1967	1968	1969
Research facilities........	$4,000,000	---	---

NASA has in previous years funded the construction of laboratory facilities at about 35 universities. The money provided space which is being used for the conduct of research and training in space related science and technology. Under a period of declining budget, NASA is not requesting FY 1969 funds for the construction of major laboratory facilities on university campuses.

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OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY — BASIC RESEARCH PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Basic Research program supports fundamental research in the physical and mathematical sciences. It is aimed at providing an understanding of the physical phenomena pertinent to other NASA programs concerned with current and future aircraft and space activities. This basic research is carried out principally in NASA's Research and 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 of determining the best materials for the supersonic transport airplane.

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

Fluid dynamics research covers the three general areas of aeronautical fluid dynamics, entry fluid physics, and internal fluid mechanics of propulsion and power systems including the problems of clear air turbulence, sonic boom, aerodynamic heating and aerodynamic control of high speed aircraft. Reentry research focuses on improved understanding of the parameters which influence heating, the ablative response of the heat shield, and on the three dimensional flow fields about maneuverable bodies. Fluid dynamic principles were applied to study blood circulation. Existing test data were analyzed in an attempt to develop simple and more precise circulatory diagnostic procedures.

The objective of the electrophysics program is to obtain new knowledge of the effects of acoustic, gravitational, electric and magnetic forces on the electronic, nuclear, atomic and molecular constituents of matter. New information in this area is the source not only for advances in the technology programs of electronics, space power and space propulsion, but also for the exploration and understanding of complex phenomena in space; for example, the interaction of the charged particles of the solar wind with the magnetosphere, and the determination of the motion of the earth's magnetic field.

Materials research has as its objective the understanding of the characteristics and behavior of materials. It ranges from studies into the fundamental properties of solids to investigations of how and why engineering materials fail. Increasing emphasis is being placed on the behavior of electrons in solids and the effect of corrosive environments on metals and polymers over a wide range of temperatures. Research on mechanisms for improving the strength of composite and ceramic materials is continuing. The understanding of all such materials will enable advances to be made in the utilization of both currently available as well as newly developed materials to advanced aircraft and more sophisticated spacecraft.

The research program in applied mathematics is concerned with the improvement of mathematical techniques required for problems in aerospace science and technology. A mathematical approach is often the most feasible and economical for planning experiments. It is also a necessary basis for precise and reliable designing of the complicated and expensive pieces of hardware needed for various NASA operations. For example, mathematical research in numerical analysis, by developing faster and more effective computation procedures, has reduced the cost of digital simulation mission studies necessary for the successful design of such items as the Saturn V vehicle.

SUMMARY OF RESOURCES REQUIREMENTS:

	1967	1968	1969
Supporting research and technology	$21,401,000	$21,465,000	$22,000,000
Total	$21,401,000	$21,465,000	$22,000,000
Distribution of Program Amount by Installation:			
Marshall Space Flight Center	$888,000	$824,000	$840,000
Goddard Space Flight Center	145,000	161,000	160,000
Jet Propulsion Laboratory	4,757,000	4,089,000	4,000,000
Ames Research Center	2,126,000	2,006,000	2,050,000
Electronics Research Center	1,231,000	1,805,000	1,900,000
Langley Research Center	2,360,000	2,793,000	2,900,000
Lewis Research Center	2,775,000	2,677,000	2,930,000
NASA Headquarters	6,584,000	6,884,000	7,220,000
Western Support Office	535,000	226,000	---

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

	1967	1968	1969
Fluid physics	$4,875,000	$4,910,000	$5,050,000
Electrophysics	7,290,000	7,315,000	7,320,000
Materials	7,811,000	7,800,000	8,170,000
Applied mathematics	1,425,000	1,440,000	1,460,000
Total	$21,401,000	$21,465,000	$22,000,000

Fluid Physics

The Fluid Dynamics program specifically applicable to aeronautics is being expanded. A program of research on the sonic boom has begun. Studies will be initiated on aerodynamic noise associated with turbulent jets, internal flows, and combustion processes. The important operational problem of clear air turbulence is also being studied.

Aerodynamic studies in the rarefied gas dynamic regime, simulating satellite conditions, are providing new understanding of the orbital characteristics of satellites.

Aerodynamic heating is particularly severe at the nose of the entry vehicle during entry into the atmosphere at speeds greater than that for Apollo. The problem is one of heat shield survival. There is a need for either a significant improvement of heat shield performance or a means of significantly reducing the heating rate. Both approaches are being pursued. Three dimensional analysis of the flow fields about maneuverable entry configurations will begin.

The problem of the detailed boundary layer behavior relating to rocket nozzle throat heat transfer is being studied. The possibility of inducing laminar flow in the throat region to reduce heat transfer rates is also being investigated.

Fluid dynamic analysis techniques were applied to experimental data on blood flow through animal organs to provide information on flow rate, blood volume and transit time. Theoretical results agree with the measured values. Hopefully, the technique will be modified for human applications to provide a safe positive test of the condition of cerebral circulation for possible use in selecting astronauts.

Electrophysics

The Electrophysics program is conducted within the research laboratories of NASA, at universities, and at industrial and other Government laboratories. Specifically, the work includes a number of new investigations such as the use of laser beams for information storage purposes. High density (10^7 bits per square inch) information can be obtained on a thin film of manganese bismuth by using a very fine laser beam in a magnetic field to produce discrete one micron size spots on the thin film. In comparison, about ten cubic feet are needed to store the same number of bits in a modern computer. Also, a new advance in superconductivity promises to raise the critical temperature below which superconductivity occurs. At present, the highest critical temperature is $20^{o}K$ ($-423^{o}F$) which means that liquid helium must be used for cooling. This is a serious disadvantage to the possible uses of superconducting magnets in space applications, such as shielding against energetic charged particles. The new advance covers theoretical prediction and experimental verification that in a composite structure of two thin-film superconductors separated by an insulating film, the critical temperature can be increased.

Investigations of plasma acceleration and plasma-energy generation are being carried out which involve fundamental phenomena such as ionization, excitation, and radiation of atoms and molecules. Because results from theory and experiment do not agree very well in some cases, the research will include the collisional interactions of atoms such as cesium, argon and xenon so that the energy transfer in these processes may be understood. Both plasma power devices and thermionic diode power converters will benefit from these studies.

Magnetoplasmadynamic arcs require substantial improvement in efficiency to be useful in space propulsion and power systems. The problems are that the electrical discharge is not uniform enough as it spreads out into the exhaust, the ionization rate does not reach optimum values, and plasma instabilities cause an undesirable dissipation of electrical power. Continued research is expected to solve these problems.

Materials

The scope of the materials program includes the understanding of the behavior and properties of solid materials, metals, ceramics, polymers, composites of these materials, minerals, and lubricants. Studies of the effects of a wide range of environments on material behavior are increasingly being emphasized. Particularly the effects of cryogenic and very high temperatures, and those of corrosive and embrittling fluids are under investigation. Studies of the physics and chemistry of solids emphasize the interrelationship between the electronic, atomic, molecular and macroscopic structures of materials and their electronic, mechanical, and chemical properties. Methods for controlling these structures are of particular interest in order to obtain desired combinations of properties. These fundamental studies are expected to provide new capabilities for predicting and controlling material properties and in developing new materials. For example, fundamental studies on the nature of the bonding in carbides are indicating what means might be taken to produce materials having high strengths above 4000°F.

Other high temperature materials are also receiving continuing emphasis. The strengthening of nickel-base superalloys with dispersions of fine refractory particles and with fibers is providing new insight into strengthening mechanisms as well as improved alloys. Because the refractory metals, tungsten and chromium, are known for their brittleness as well as their high temperature strength, our research metallurgists are also studying how to improve their ductility.

Premature failures in metallic structures due to corrosive or embrittling environments continue to attract our attention. By studying the mechanisms which cause cracking in metals while being subjected to loads and corrosive fluids, the means may be provided by which gas storage vessels and high performance aircraft structures will be improved.

Another problem area in high speed aircraft that requires particular attention is that of sealants for fuel tanks. For such applications, elastomeric materials are required having long-time stability at high temperatures and at the same time being compatible with the aircraft structural materials and the fuel. Research is being initiated to synthesize new types of elastomers having improved high temperature properties.

Applied Mathematics

The applied mathematics program promotes the formulation of mathematical models and computer programs for more effective and economical treatment of problems in aeronautics and space technology. Research is carried on in various relevant mathematical fields such as analysis, calculus of variations, mechanics and numerical methods.

Gravitational and orbital mathematics needs research in differential equations and celestial mechanics relevant to design and motion of spacecraft. Further research is required on solutions of partial differential equations arising in electromagnetic and radiation theory and in heat conduction problems of hypersonic vehicles.

Mathematics research will continue on aeronautical problems such as the use of the calculus of variations in optimization of aircraft trajectories and in the mechanics of thin shells, approximation methods for solving control equations, and on the stability of systems of non-linear differential equations.

Geophysical and planetary mathematics requires continuing research in analytical mechanics and relativity theory as well as numerical analysis and data processing methods for best exploiting the vast amounts of data received at NASA tracking stations. The latter fields of research are also being pursued in the area of tracking and data processing mathematics, along with the widely applicable topics of error analysis matrix inversion and statistical estimation theory.

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY — SPACE VEHICLE SYSTEMS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Space Vehicle Systems program is a broad-base research and technology program in aerothermodynamics, structures, and space environmental factors of importance to the design of spacecraft and launch vehicles. It also provides for the formulation and documentation of authoritative space vehicle design criteria based on operational experience and the latest research information. The objectives of the program are to identify and solve the technical problems of launch vehicle stages, manned and unmanned spacecraft, and the overall integrated space vehicle during flight through the atmosphere and in space. The program seeks to provide the advanced technology base for the conception and design of future vehicles and to support current space vehicles and missions of NASA and the military services.

SUMMARY OF RESOURCES REQUIREMENTS:

	1967	1968	1969
Supporting research and technology	$26,777,000	$30,258,000	$31,300,000
Lifting-body program	1,000,000	1,200,000	1,200,000
Reentry heating flight experiments	1,800,000	2,206,000	1,500,000
Project Pegasus	70,000	---	---
Small space vehicle flight experiments	4,262,000	1,336,000	1,300,000
Total	$33,909,000	$35,000,000	$35,300,000

Distribution of Program Amount by Installation:

	1967	1968	1969
Manned Spacecraft Center	$537,000	$650,000	$600,000
Marshall Space Flight Center	3,692,000	3,981,000	3,950,000
Goddard Space Flight Center	1,935,000	2,215,000	2,325,000
Jet Propulsion Laboratory	2,426,000	2,125,000	1,825,000
Ames Research Center	3,198,000	2,984,000	3,250,000
Electronics Research Center	320,000	385,000	400,000
Flight Research Center	1,010,000	1,350,000	1,500,000
Langley Research Center	16,145,000	15,661,000	15,905,000
Lewis Research Center	2,288,000	3,115,000	3,225,000
NASA Headquarters	1,899,000	2,434,000	2,320,000
Western Support Office	459,000	100,000	---

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BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

	1967	1968	1969
Space vehicle aerothermo-dynamics....................	$5,936,000	$7,441,000	$7,750,000
Space vehicle structures.....	9,467,000	9,853,000	9,950,000
Space environmental factors..	10,269,000	11,254,000	11,200,000
Space vehicle design criteria	1,105,000	1,710,000	2,400,000
Total....................	$26,777,000	$30,258,000	$31,300,000

Space Vehicle Aerothermodynamics

The Space Vehicle Aerothermodynamics program is concerned with the design problems associated with flight of launch vehicles and spacecraft through the atmosphere. In FY 1969 particular attention will be given to advanced reentry vehicles for manned flight near the earth, including methods for recovery on land, and to the entry and terminal descent of unmanned probes on other planets.

With earth atmosphere entry, interest is centered on hypersonic vehicles of increasing slenderness. Work currently in the exploratory stage dealing with a number of new configurations will be more closely focused during FY 1969, and the most promising configurations will be investigated in greater depth.

Investigation of the M2-F2 and HL-10 flight research vehicles has already revealed several important problems in flight control. These have been investigated in the laboratory. Solutions resulting from this work have been incorporated in the HL-10 for verification in flight. This close interplay between flight and laboratory research will continue.

Research on specialized parachutes and other decelerators for application to Mars entry probes has indicated that these devices are also attractive for other applications, such as stabilization and deceleration of manned spacecraft at high speeds and altitudes. This ground-based and flight research will be continued in the coming year.

A substantially augmented program was instituted in FY 1968 to develop the technology of gliding flexible-wing descent systems for application to the recovery on land of manned spacecraft. The parawing research and technology program, which will continue in FY 1969, will involve a combined analytical, ground-based, and flight test program to investigate problems of deployment, air loads, and flight control with parawings of large size appropriate to spacecraft recovery.

Space Vehicle Structures

Major objectives of this subprogram are to develop advanced structures, exploit new structural materials, and provide advanced structures technology needed to improve the efficiency and cost effectiveness of space vehicles. The subprogram encompasses the areas of advanced structural concepts and materials applications, structural mechanics, structural loads, structural dynamics, high temperature structures, cryogenic storage and large orbiting antenna structures.

Substantial progress has been made in previous years to alleviate the low-frequency dynamic problems resulting from ground winds, in-flight winds, and other related conditions causing overall structural responses. A concerted attack has now been initiated on the critical problems caused by high frequency dynamic conditions. Emphasis will be given to improved techniques of analysis and better ground test simulation to reduce the necessity for overdesign and overtesting.

The general purpose structural analysis computer program for space vehicles should become operational during FY 1969. This program will permit more uniform and effective structural design analysis of the integrated space vehicle and the interactions of stages and subsystems. It will also accommodate new technologies, such as those related to high frequency dynamics. The program may also find application to other structures such as buildings, bridges, ships and aircraft.

Analysis and small-scale experiments are under way on large antenna structures for orbiting radio telescopes. Critical technical problem areas of structures are being identified. Small-scale laboratory experiments will be continued to the extent possible.

Emphasis will continue in advanced research and technology for prolonged space storage of cryogenic fluids. Progress is being made in developing improved tanks and materials and more effective insulation systems for storing liquid hydrogen.

Space Environmental Factors

This subprogram is concerned with the effects of the space environment on space vehicle design and operation and the development of the related technologies required for design. The principal areas of concern are space radiation, meteoroids, reduced gravity and thermal radiation. Continuing research in these areas is required as missions and spacecraft become more complicated and involve longer exposure times in space.

Exposure to high-energy space radiation can degrade the performance of spacecraft materials and components and necessitate shielding for man. Research is continuing on radiation-sensitive materials and components with emphasis on the understanding of basic damage mechanisms. Research is also continuing to obtain data for use in shielding design as well as on the development of improved shielding methods. The recently completed NASA Space Radiation Effects Laboratory is now in full operation.

Advances have been made in determining the meteoroid penetration hazard in near-earth space, but additional data are still needed. Studies of natural meteors entering the earth's atmosphere will be continued to obtain the additional data on the near-earth environment. Also, emphasis will be placed on studies of new detection concepts for use in obtaining future flight data on the hazard in both the near-earth and asteroid regions. Simulation of meteoroids in the laboratory is still not adequate, and work is continuing on techniques to obtain the desired particle masses and velocities in ground test facilities.

The maintenance of desired temperatures under varying thermal inputs is essential to reliable spacecraft operation. Continuing research includes development of stable coatings having desired radiative characteristics, heat transfer analysis techniques, and advanced thermal control concepts. Attention will be given in FY 1969 to the problem of degradation of radiative properties of surface coatings resulting from exposure to the space environment and to the problem of properly simulating that environment in the laboratory.

Space Vehicle Design Criteria

The objective of this program is to develop, document, and publish design criteria, including models of the environments, that are applicable to the design of space vehicle structures, propulsion systems, and guidance and control systems. Research results and experience gained from the design and operation of space vehicles are being utilized to formulate and update the criteria in order to insure the development of more reliable and efficient space vehicles.

To date, eight documents have been completed and have been circulated to NASA centers and throughout the aerospace industry. Several more documents, including those dealing with the meteoroid environment, the atmospheric winds, and the albedo and reflected radiation from the earth are nearing completion. In addition, a number of documents are now in various stages of development and approximately 20 of these should be completed and issued during FY 1969.

The program in FY 1969 will encompass the areas of structures, chemical rocket propulsion, guidance and control, and environments as in prior years and will also include some initial effort on electromechanical mechanisms. The program is being carried out in various NASA centers with the assistance of technical experts from the aerospace industry and universities.

Fiscal year 1969 funds will be used to contract for the services of technical experts outside of the Federal Government who have the knowledge and experience in critical areas of space vehicle design.

Lifting-Body Program

	1967	1968	1969
Flight vehicles and support services..................	$1,000,000	$1,200,000	$1,200,000

FY 1969 funding is required for this continuing program to investigate in flight with manned research vehicles the piloting and control problems of lifting-body configurations at transonic speeds and during terminal approach and landing.

Seventeen flights have been made to date. Substantial data on flying qualities and performance have been obtained, problem areas uncovered, and means for improvement found, all in keeping with the objectives of the research program.

Flight tests of the M2-F2 vehicle were halted in May 1967 when it was damaged in landing. The HL-10 is in flight status. A third test vehicle, the X-24A, developed under USAF auspices has been added to the program. The X-24A is undergoing extensive preflight tests preparatory to flight during FY 1969.

Some increase in funding was necessary in FY 1968 and will also be required in FY 1969 as a consequence of the M2-F2 accident, modifications that were found to be necessary for the HL-10, and the addition of the X-24A.

Reentry Heating Flight Experiments

	1967	1968	1969
Spacecraft and support........	$1,800,000	$2,206,000	$1,500,000
Scout (launch vehicle procurement program)...........	(100,000)	(2,150,000)	(1,200,000)
Total (including launch vehicles)...............	($1,900,000)	($4,356,000)	($2,700,000)

Two reentry experiment payloads are being fabricated for launch with Scout vehicles to obtain anchor-point data on the heating rates associated with turbulent boundary layers on clean, nonablating surfaces at high Mach numbers and on the conditions related to transition from laminar to turbulent flow. Results from these experiments will permit correlation of laboratory data and assist in the solution of the general problem of turbulent flow heating.

The first experiment will be flown in the first half of CY 1968. FY 1969 will provide for completion of the second payload and launching of the second experiment.

Funds will also provide for the definition of critical follow-on experiments on configurations with ablative heat shields to determine the effects of roughened, charred surfaces and outgassing on boundary layer transition and to investigate the interactions between the high-temperature flow field and the ablating heat shields as they affect heat shield performance and vehicle motions.

Small Space Vehicle Flight Experiments

	1967	1968	1969
Spacecraft and support........	$4,262,000	$1,336,000	$1,300,000

Planetary Entry Parachute Technology - During FY 1967 and FY 1968, intermediate and large scale parachute tests were conducted at transonic and low supersonic speeds to evaluate promising parachute concepts for terminal descent of unmanned Mars instrumented capsules. It was found that deployment and canopy inflation could be accomplished in the wake of a large bluff aeroshell structure representative of a typical Mars entry probe. Two types of large-porosity parachutes, the disc-gap-band and ringsail, were shown to have satisfactory characteristics to Mach 1.6.

If deployment and stable flight can be accomplished with assurance at higher Mach numbers, the weight of the payload to be landed on the Mars surface could be increased. Flight tests will be conducted in FY 1969 to extend the range of investigation.

Heat Shield Materials Technology - Small scale flight tests of heat shield materials closely coupled with arc-jet tests in the laboratory have increased our knowledge of heat shield performance. A recent Pacemaker flight made a significant contribution to the Apollo program by obtaining data on simulated protuberances. The program will continue in FY 1969.

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY — ELECTRONICS SYSTEMS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objective of the Electronics Systems program is to provide the knowledge and technology which will satisfy the requirements of future space and aeronautical systems in the most effective and efficient manner. Research activities include all elements of electronics and control functions from conceptual studies through the development and evaluation of new or improved components and subsystems. The program efforts center on: (1) support of future space missions, (2) improved avionics systems for all types of aircraft, and (3) general research on new or advanced techniques in the functional areas of instrumentation, data processing, communications, guidance, control and component technology. Achievement of program goals is sought through analytical and experimental studies performed in industrial, academic and government laboratories. Flight experiments are employed to collect data, confirm research results, and verify predicted performance in those areas which cannot be adequately studied in the laboratory.

SUMMARY OF RESOURCES REQUIREMENTS:

	1967	1968	1969
Supporting research and technology....................	$32,302,000	$38,700,000	$38,900,000
Flight projects.................	1,295,000	500,000	500,000
Total.........................	$33,597,000	$39,200,000	$39,400,000

Distribution of Program Amount by Installation:

	1967	1968	1969
Manned Spacecraft Center......	$292,000	$150,000	$150,000
Marshall Space Flight Center..	4,049,000	2,655,000	2,600,000
Goddard Space Flight Center...	3,306,000	2,660,000	2,700,000
Jet Propulsion Laboratory.....	2,282,000	3,305,000	3,300,000
Ames Research Center..........	3,735,000	3,815,000	3,815,000
Electronics Research Center...	9,716,000	15,935,000	16,100,000
Flight Research Center........	845,000	890,000	890,000
Langley Research Center.......	7,156,000	5,320,000	5,500,000
Lewis Research Center.........	450,000	400,000	400,000
NASA Headquarters.............	1,761,000	4,070,000	3,945,000
Western Support Office........	5,000	---	---

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

	1967	1968	1969
Advanced concepts..................	$1,071,000	$3,820,000	$3,735,000
Guidance systems...................	7,368,000	8,200,000	7,890,000
Control systems....................	6,444,000	5,900,000	6,275,000
Communications.....................	4,615,000	4,775,000	4,730,000
Tracking and data acquisition.....	3,060,000	3,625,000	3,640,000
Data handling and processing......	3,140,000	4,010,000	4,025,000
Instrumentation....................	3,609,000	3,810,000	4,055,000
Electronic techniques and components......................	2,995,000	4,560,000	4,550,000
Total........................	$32,302,000	$38,700,000	$38,900,000

Advanced Concepts

Research in the advanced concepts subprogram is comprised of studies to define technical requirements of future aerospace systems, the development of methods and techniques for performing system analyses, and large system efforts which encompass several functional areas.

Efficient operation of supersonic aircraft requires the use of the most advanced technology available. To meet this requirement in those functions performed electronically, the Electronics Research Center has begun development of an integrated electronics system for supersonic aircraft. Current efforts are centered on the analysis of system requirements. In FY 1969, these efforts will continue and development of system components will begin.

Earth orbiting spacecraft provide outstanding opportunities to study and evaluate the earth's natural and man-made characteristics through the use of on-board sensors. Principal constraints on this technology are the resolution of available sensors and methods for efficient analysis and reduction of accumulated data. Studies of typical data obtained in past space missions have begun and will continue in FY 1969 to identify useful features of that data, and determine areas where improved sensors or data handling techniques can improve the quality and efficiency with which useful results can be obtained.

Guidance Systems

Guidance system research has the objective of providing improved sensors and techniques for determining the position and flight path of aerospace vehicles. Principal efforts include the development of advanced inertial and electromagnetic sensors, high reliability computers, and simplified equations for guidance and navigation.

Prior year efforts on strapdown (fixed-nongimballed) inertial guidance systems using electrostatic gyros will culminate in laboratory tests of the complete system during FY 1969. Flight tests on test aircraft will follow. Research on long-life, highly accurate gyros and accelerometers for gimballed systems will continue. Laboratory tests of developmental models will begin in FY 1969.

Research in electromagnetic sensors will center on continued development of solid state detectors to provide increased reliability and accuracy in horizon sensing and star tracking applications. Study of holographic imaging techniques as a means for determining attitude in space will be initiated. A laser radar for space rendezvous has been successfully developed and tested in ground simulations. Follow-on efforts in FY 1969 will focus on development of a space experiment to confirm ground test results.

Computers are essential to the guidance and navigation of manned aerospace vehicles. A concept which provides for self testing and repair by the computer has been developed and is now being implemented. Laboratory tests will be conducted in FY 1969. Studies of techniques for integrating computer functions with the guidance sensors will continue.

Trajectory analysis provides mathematical tools for developing guidance equations and simplified techniques for accomplishing guidance and navigation functions. This work is fundamental to the guidance research and will continue.

Control Systems

Control and stabilization research and development leads to improvements in space and aeronautical control systems. Areas of emphasis are precise pointing controls for astronomical telescopes, long life spacecraft attitude controls, flight controls for vertical/short takeoff and landing (V/STOL) aircraft and general aviation use, and display and other component devices.

Efforts on control moment gyros (CMG) control techniques for precision pointing applications have been previously reported. This work is being extended to study control systems for large, flexible manned spacecraft. Simulation and test equipment for this purpose have been procured. Component tests are completed. Full scale CMG system tests will be initiated in FY 1969.

A versatile facility for long life attitude control system development has been installed at Ames Research Center. Sensor logic and actuator design will be studied in this facility during FY 1969 to obtain optimized control systems for unmanned observatory and earth resources satellites.

Flight controls for V/STOL aircraft are being studied to develop systems which can provide stable, possibly automatic, vertical take-offs and landing. A display generator, developed in prior year efforts, is being used to study

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short take off and landing displays for low-noise approaches. This will lead to display development in FY 1969. Improved flight controls for general aviation aircraft are being developed. Research on proximity warning indicators (PWI) seeks to reduce the danger of mid-air collisions in civil aircraft. Flight tests will occur in FY 1969. Display devices which operate in bright light are being developed and will be improved in the coming year.

Components such as a new variable-field brushless direct current motor, are being developed for general use in control systems. Contributing to all control system development is a program of basic and applied control theory research.

Communications, Tracking and Data Acquisition

Earth resources satellites and orbiting astronomical telescopes must transmit high resolution images back to earth in quantities which will exceed the capability of our present technology. Future deep space missions also require greatly increased data rates to make the greatest use of their capabilities as they pass other planets and endeavor to map their surfaces. Each mission has specific requirements which influence the techniques and frequency to be used so studies are continually performed to determine the optimum systems. Research is continuing in the improvement of components such as high-power, high-efficiency tubes and large space-erectable antennas. Since large reductions in size and weight can be attained by the use of higher frequencies, both submillimeter and optical techniques are being explored. The technology of optical communications has progressed sufficiently during the past three years to give savings in size and weight of 50% or more over conventional microwave systems and, at the same time, to increase the communication margin of safety by a factor of 30. In FY 1969, work will continue on the development of laser light sources, modulators, detectors and telescopes. In all of these communication systems, improved performance can be obtained at minimum cost by the use of advanced coding techniques. A recent development in this area will be used in the Pioneer D mission. Other promising techniques will be explored and developed with university grants in FY 1969.

To improve the quality or resolution of astronomical telescopes, it is extremely desirable to place the telescope outside the earth's atmosphere. A telescope in space could see celestial objects with 200 times the detail available to earth telescopes. However, to build and operate a large space telescope, new mirror materials must be found and tested, and a method must be developed for determining the accuracy of mirror surfaces and for continually correcting the detected errors. Research on these problems is underway and will continue in FY 1969.

The availability of lasers furnishes a valuable tool for attaining increased accuracy in tracking satellites. Pulsed ruby laser systems have already achieved an accuracy of 1.5 meters. The use of argon lasers and doppler techniques should yield an improvement to approximately 15 centimeters. Development of a tracking system employing these techniques will continue in FY 1969.

Data Processing

To keep pace with the increasing needs of aerospace missions, continuing advances in both ground-based data processing and spacecraft computing capability are needed.

Prior year funds have provided computer programs and equipment which permit more effective communications between experimenters and large ground-based computers in the solution of complex problems. Techniques are being developed to facilitate the extraction of useful information from data obtained in space experiments. In FY 1969, continued improvements in these techniques will be sought, with particular emphasis on methods for expediting the analysis of data from spacecraft, wind tunnel tests, pilot/control and physiological experiments.

Research efforts in previous years have resulted in the development of basic components and conceptual circuit arrangements which have exhibited major performance improvements in laboratory demonstrations of spaceborne computers. Fiscal year 1969 work will be directed toward system refinement and development of engineering models for additional testing. Further development is expected to result in spacecraft computers equal in performance to current large scale ground-based computers.

Research will also continue on techniques for pre-processing data on board spacecraft to minimize the quantity of data transmitted and processed on the ground.

Instrumentation

Aerospace missions of the future will continue to be heavily dependent on the availability of measurement techniques to obtain scientific data, and instruments for obtaining test and engineering measurements.

Development of techniques which provide visual and optical information is particularly important. Prior year research efforts have advanced our capability to measure and provide information related to launch vehicle and spacecraft design and testing, space operations and ground simulation facilities. Application of microelectronic technology, developed under other programs, has been of considerable benefit to instrumentation research. Fiscal year 1969 efforts are planned to continue the application of such related technologies and develop additional capability to measure and sense physical phenomena in parts of the electromagnetic spectrum which are still relatively unexplored (particularly in the Infrared and Ultraviolet regions).

Lasers are receiving more and more attention in the field of instrument research because of their unique properties. One particularly interesting development is a ground based laser system which measures density of the earth's atmosphere in a vertical direction. In addition to the unique capability of making measurements from the ground which were previously only available from balloons or rockets, this development has provided a possible technique for detection of clear air turbulence (CAT), a problem of serious importance in jet aircraft operations. Fiscal year 1969 funds are planned to continue the original development program and to investigate feasibility of airborne CAT detector systems using lasers. Other research efforts will continue to study the application of lasers to instrumentation problems.

Electronic Techniques and Components

Research in electronic techniques and components seeks to develop improved electronic devices with increased versatility, higher initial quality and longer useful lifetimes, and to establish principles and practices for testing and using these devices more effectively.

Recent advances in electronic component technology have led from discrete parts to integrated circuits and currently to large scale integration (LSI) in the equivalent of hundreds of parts formed and interconnected automatically on a single device. The potential utility of this technology to provide complex electronic functions with minimum space and weight requirements makes continued research and development essential. During FY 1969, research efforts will seek better materials for making large scale integrated circuit devices and improved fabrication techniques. The tiny size of the parts arranged on each device requires development of new tools and techniques for inspecting and testing finished products. Since many parts are located on a single device, efficient circuit design requires the development of computer techniques which can quickly examine all possible combinations of circuit elements and enable the designer to select the best arrangement for a particular application.

Research will continue on methods for making interconnections and cables which join the electronic components into systems, and on improved packaging and assembly techniques. Efforts to develop parts that will withstand the variations of the space environment, particularly temperature extremes, will receive increased emphasis in FY 1969.

Flight Projects

	1967	1968	1969
Radio Attenuation Measurements (RAM-C)........................	$1,000,000	$500,000	$500,000
Small Flight Project (SCANNER)...	295,000	---	---
Total Flight Projects..........	$1,295,000	$500,000	$500,000

	1967	1968	1969
Scout (Launch Vehicle Procurement Program)..........	($700,000)	($900,000)	(---)
Total (including Launch Vehicles)...........	($1,995,000)	($1,400,000)	($500,000)

Flight projects provide verification of laboratory investigations and acquire data on natural phenomena which are essential to the development of advanced sensors and systems. Brief descriptions of these projects are provided in the following paragraphs.

Radio Attenuation Measurements (RAM)

Project RAM is concerned with alleviating the communication blackout caused by the plasma which surrounds a spacecraft as it reenters the atmosphere. RAM C-1 was successfully flown in October 1967 and demonstrated the partial effectiveness of the use of higher frequencies and of the injection of water into the plasma in overcoming the blackout problem in the 25,000 foot per second velocity range. RAM C-B will be flown in calendar year 1968 to determine with greater accuracy the characteristics of the reentry plasma sheath in the 28,000 foot per second velocity range.

Several materials have shown an ability in laboratory tests for further alleviating the blackout problem. If further investigation indicates their superiority over water, a flight test using an existing backup spacecraft will be considered for FY 1969.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1969 ESTIMATES

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY HUMAN FACTOR SYSTEMS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objective of the Human Factor Systems Program is to provide the research and technology to (1) qualify, (2) support, and (3) utilize man in advanced aeronautical and space missions. This is accomplished by: (1) determining man's reactions to the unique environments of space and aeronautical flight; (2) defining the essential requirements for sustaining and protecting man in these environments; (3) developing the technology necessary to provide suitable life support and protective systems; and (4) integrating man's capabilities with those of machines to obtain composite systems of superior performance. In this manner we can ensure the optimum utilization of man in space as an observer, as a mechanic, and as a decision maker.

This is accomplished through timely ground based research in human factors validated by critical flight experiments in air and space. This will provide the confidence necessary for the use of man in the future spectrum of missions. The technological tasks to be accomplished include assessment of the physiological and psychological effects on man, human engineering, extravehicular engineering, personal protection and life support. Understanding of the physiological effects on man as he responds to future aeronautical and space stresses is necessary for his effective integration with the total system. Human engineering is essential for the development of design data and procedures for aviation, maintainability in space, and for the appropriate integration of man in the man-machine complex. Extravehicular engineering will provide the astronaut with work aids, translation devices, and other augmentation systems for use in free space as well as in extraterrestrial surface environments. Life support is one of the most difficult technology areas because of the many sub-system capabilities that must be integrated as a functional system. Space suits and astronaut protection devices are life saving devices which must be fail safe, but must provide a functional capacity for work with a minimum of decrement.

The Human Factor Systems Program is accomplished through a multi-disciplined approach including researchers in nearly every field of medicine, biology, psychology, engineering, physics, and electronics, located in NASA installations, Department of Defense aerospace medical facilities, universities, and industry.

SUMMARY OF RESOURCES REQUIREMENTS:

	1967	1968	1969
Supporting research and technology	$14,765,000	$19,385,000	$20,200,000
Small biotechnology flight projects...........	1,500,000	1,600,000	1,500,000
Total..................	$16,265,000	$20,985,000	$21,700,000

Distribution of Program Amount by Installation:

	1967	1968	1969
Manned Spacecraft Center.....	$ 1,160,000	$ 2,300,000	$ 2,600,000
Marshall Space Flight Center.	100,000	300,000	300,000
Jet Propulsion Laboratory....	---	50,000	---
Wallops Station..............	---	535,000	500,000
Ames Research Center.........	5,498,000	6,225,000	6,250,000
Electronics Research Center..	610,000	980,000	1,250,000
Flight Research Center.......	1,300,000	1,000,000	1,100,000
Langley Research Center......	4,516,000	5,955,000	6,850,000
Lewis Research Center........	66,000	150,000	150,000
NASA Headquarters............	2,979,000	3,390,000	2,700,000
Western Support Office.......	36,000	100,000	---

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

	1967	1968	1969
Human research and performance	$ 6,595,000	$ 5,985,000	$ 6,250,000
Life support and protective systems..................	5,262,000	9,000,000	9,250,000
Man-systems integration......	2,492,000	3,900,000	4,200,000
Advanced concepts............	416,000	500,000	500,000
Total..................	$14,765,000	$19,385,000	$20,200,000

Human Research and Performance

The President's Scientific Advisory Committee Report on this program emphasized the necessity to qualify man for possible future space exploits. The expertise of the Space Science Board's summer study groups and committees provides the plan of attack on these problems. In fiscal year 1969, a systems analysis approach will be used to determine how the adaptive mechanisms of the cardiovascular system perform their function of limiting the deleterious effects of stresses. Computerized mathematical models will be used to study these mechanisms based on data obtained from instrumented animals. A key element in these studies is the provision of bioinstrumentation to measure the dynamic response of living systems to various stresses. Instrumentation techniques include the use of ultrasonics to measure blood flow and microminiature implanted sensors to measure pressures, volumes, and accelerations. Ames Research Center has developed implantable multichannel telemetry sensors, which have been active for five months in animals.

The toxicity of oxygen at various pressures is being determined in several species of animals preliminary to human tests in fiscal year 1969. Experiments have shown that excessive oxygen pressure must be avoided since it can cause damage to lungs, kidneys, and other organs.

Hormones and their control of stress reactions are being studied in animals at the cellular level, as well as in humans under stress. Of fourteen men tramping 110 miles in 10 days in the arctic cold at Fairbanks, Alaska, two collapsed on the seventh day. There had been no warning signs, except for a low level of one hormone, aldosterone. Further tests are necessary to establish whether a low level of this hormone is a warning of trouble to come. In the course of these space oriented studies, there sometimes are very worthwhile discoveries with other medical applications. For example, studies at Ames on hormones from the pituitary gland have resulted in the discovery of an enzyme which possibly may be used to produce human growth hormones from bovine growth hormones. Many people suffer from lack of this hormone and there is presently no adequate source of supply.

In fiscal year 1969, extensive studies of the effects of solar flares on mammalian tissue will be possible as a result of the development of a solar flare simulator for NASA by the AEC's Donner Laboratory, University of California, Berkeley. Monkeys are being exposed to determine the effects of solar flares similar to those astronauts may experience in long missions. In a collaborative study with the Navy at Pensacola, Berkeley is studying radiation effects on the physiological balance mechanisms using monkeys, and at the NASA Langley Research Center cyclotron, a USAF team of radiobiologists is studying the effects of protracted low dose exposures. Another area of increasing research effort in fiscal year 1969 will be the bacteriological aspects of long term space flight. Environmental factors in such flights could possibly cause non-pathogenic organisms to become pathogenic, alter the mechanisms of infection and the immunological mechanisms, and result in cross-infection of space crew members.

In aviation, major effort will continue on studies of the psychoacoustic effects of aircraft noise and sonic boom. The second year of a study on defining the annoyance parameters of this pollutant is underway. The physical characteristics of aircraft noise are being measured while families residing near eight major airports in the U. S. are questioned regarding their reactions to this noise. The results will be analyzed to determine if the noise would be less objectionable, if, for example, certain frequencies were suppressed.

Life Support and Protective Systems

The most critical technology problem area is life support. The logistics saving by recycling water and oxygen is most desirable, but limited ground studies have indicated that available techniques for achieving this do not live up to expectations when they are embodied in a total life support system where each unit depends on the output of another. A manned environmental chamber test is planned in fiscal year 1968 to close the water loop for an unprecedented sixty day period. Four men will consume water regenerated from their liquid wastes. Of particular interest will be inventory and control of bacteria during such a run. Based on what is learned from this and other research, new sub-systems must be developed with emphasis on maintainability and reliability. Such equipment will be developed in fiscal year 1969 for future manned tests on an advanced life support system. The National Academy of Sciences has furnished NASA with interim water standards for recycled water and final standards are to be determined for both water and air. The sensing and control elements of life support systems are most important and are receiving increased **emphasis**, as is the difficult problem of handling human waste. Advancements in this technology are applicable to problems of air and water pollution on earth, and close liaison is being maintained with the Federal Water Pollution Control Administration and the Office of Saline Water.

The developments in new protective space suit concepts are most exciting, particularly new hard suit concepts in which man can operate with very little performance decrement because of easier mobility of the joints when the suit is pressurized. These are so promising that increased effort will include studies of application of these concepts to soft clothsuits to improve donning, and increase mobility and performance so that their operating pressure can be increased to that of the spacecraft. Personal life support back packs will include advanced cooling and controlling systems with some using long shelf life solid chemical oxygen rather than gaseous oxygen. In aviation a new aircraft seat design is being developed which will absorb energy and provide the occupant more crash injury protection.

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Man-Systems Integration

To ensure man's effectiveness in advanced aircraft and space systems, extensive studies are underway on the utilization of man in complex systems---as an operator and as a manager. In flight management, man has an increasingly complex role in assessment of the flight situation, the judgment of the significance of unscheduled events, and exercise of command-control functions. Emphasis will increase on methods of improving habitability of working and living areas of manned spacecraft for long duration flight times. The Space Science Board has an active committee to assist in the requirements for research on this problem.

The development of extravehicular technology is a pacing item for man's work in space on astronomical telescopes, structures assembly, and crew and cargo transfer. Recommendations of the Astronomy Missions Board will influence study efforts in fiscal year 1969 on manned engineering operations in orbit including maintenance, repair, and equipment refurbishment and the development of worksite technology, tools, and work support systems. Conventional earth type tools have been relatively ineffective. Our simulation techniques have proven so effective that the development of tools and work techniques in the weightlessness of orbital flight is now possible. Large structures such as S-band antennae are assembled in a simulated weightless environment. In aviation, the air crew work-load is being studied in order to reduce stress and fatigue and increase safety.

Advanced Concepts

Research on advanced concepts is essential to solving the next generation of problems in any particular field. Noteworthy is a non invasive technique for measuring velocity of blood in man by ultrasonics. It promises to have many clinical applications, as well as being a useful monitoring device in space.

Biotechnology Flight Projects

	1967	1968	1969
Biotechnology flight projects..........	$1,500,000	$1,600,000	$1,500,000
Scout (Launch vehicle procurement program).....	(-)	(-)	(1,500,000)
Total	($1,500,000)	($1,600,000)	($3,000,000)

In fiscal year 1969, a Scout launch of a vestibular experiment is planned to permit study of the action in weightlessness of the basic cells in the frog's balance mechanism that is similar to man's inner ear (otolith). These tiny cells detect the presence of gravity and send coded messages to the brain centers of control. It is important to measure these effects in gaining an understanding of this tiny, but very effective sensor so necessary to man's well being in space as well as on earth. Other physiological experiments are being defined by the Ames Research Center, as an outgrowth of their human and animal research. Similarly, the Langley and Electronics Research Centers, and Manned Spacecraft Center are developing life support and protection equipment experiments.

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

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objective of the Space Power and Electric Propulsion Systems program is to determine the technologies required to adequately support potential future missions; and by application of effective research and exploratory development to improve or establish these technologies to the degree required to ensure eventual successful development and application by future mission program offices.

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 (Space Electric Rocket Test) flight, the continuing ATS program and the ground technology program are essential steps toward the goal of early application.

SUMMARY OF RESOURCES REQUIREMENTS:

	1967	1968	1969
Supporting research and technology.................	$34,940,000	$35,400,000	$35,800,000
Space electric rocket test (SERT).................	---	1,100,000	1,500,000
SNAP-8 development............	5,500,000	7,500,000	7,500,000
Total.....................	$40,440,000	$44,000,000	$44,800,000

Distribution of Program Amount by Installation:

	1967	1968	1969
Manned Spacecraft Center......	$ 267,000	$ 200,000	$ 600,000
Marshall Space Flight Center..	1,748,000	960,000	1,200,000
Goddard Space Flight Center...	5,078,000	3,430,000	3,933,000
Jet Propulsion Laboratory.....	6,579,000	9,159,000	9,950,000
Ames Research Center..........	145,000	270,000	265,000
Electronics Research Center...	853,000	1,550,000	1,549,000
Langley Research Center.......	970,000	745,000	850,000
Lewis Research Center.........	21,559,000	24,855,000	24,186,000
NASA Headquarters.............	1,808,000	2,270,000	2,267,000
Western Support Office........	1,433,000	561,000	---

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

	1967	1968	1969
Nuclear flight safety.........	$ 110,000	$ 150,000	$ 165,000
Electric propulsion...........	8,990,000	7,800,000	7,496,000
Nuclear power generation......	13,160,000	14,650,000	15,080,000
Solar power generation........	7,584,000	7,700,000	7,849,000
Chemical power generation.....	5,096,000	5,100,000	5,210,000
Total......................	$34,940,000	$35,400,000	$35,800,000

Nuclear Flight Safety

Although AEC development and safety offices and NASA mission program offices have basic responsibility for safe design and development, it is necessary to do a limited amount of testing and evaluation in certain fields such as atmospheric reentry in which NASA centers have special competence. These funds are used to pay for necessary hardware and equipment at the centers to accomplish this supporting effort. This work is conducted, usually on a cooperative basis, with AEC, DOD and other participating organizations.

Electric Propulsion

The prime objective of this program is the advancement of electric thruster system technology for mission use. These thruster systems offer potential significant advantages for both prime and auxiliary propulsion missions. For example, reduced launch vehicle requirements for a required mission payload can be achieved for interplanetary spacecraft. In addition, flight time for certain difficult missions can be reduced, and missions totally impractical by chemical rockets can be accomplished by electric propulsion. Satellite station keeping, manuevering and attitude control can also be performed with reduced system weight relative to conventional chemical techniques. Propellant economy resulting from high specific impulse is the basis for these indicated performance advantages of electric thrusters. However, the propellant weight saving must more than compensate for the weight of the necessary electric power source. Since power supply weight is dependent on thruster system efficiency, a major program goal is to increase this efficiency. In addition, the thruster system must operate reliably for thousands of hours in order to realize these advantages.

Electrostatic thruster systems will continue to receive the major emphasis in FY 1969. Such thrusters are characterized by the acceleration of ions or charged particles by applied electrostatic force fields. The ion engine uses two processes for ion formation; electron bombardment and contact ionization. These two types of electrostatic thruster have received the most attention in FY 1968.

Endurance testing in FY 1967 of 1 KW electron bombardment ion thrusters has demonstrated that operating lifetimes (about 1 year) adequate for early solar array powered prime propulsion missions are achievable. During FY 1968 emphasis has been placed on further improvements in thruster and overall thruster system efficiency. The 500 hour test of a single thruster system conducted in FY 1967 was a precursor for a more complex system test to simulate, in a reasonably realistic manner, operation for a typical solar electric mission. Work to date on this upcoming test has progressed to the point in FY 1968 where four 2.5 KW electron bombardment thrusters have been clustered and preliminary thruster performance tests have been conducted. Based on these tests the subsystems which condition the power supplied by a solar array simulator and control thruster operation have been specified. Since thruster control includes the programmed switching off of individual thrusters, a translation mechanism is necessary to position the thruster array so that the resultant thrust vector will not alter the attitude of the simulated spacecraft. The design of such a translation mechanism is currently under study. The complete system test is scheduled to start in FY 1969, and it is intended to demonstrate the technology of a basic propulsion system design and to evaluate its capability to perform the required operational functions of solar powered missions.

Research into possible interactions resulting from ion thruster operation, such as thruster exhaust effects on the spacecraft and on the ambient space environment, are planned to continue into FY 1969. SERT II, the orbital test of a 1 KW electron bombardment thruster to be launched in CY 1969, will augment these studies by furnishing information on possible radio frequency interference due to thruster operation and propellant exhaust deposition on spacecraft structures.

The contact ion engine appears more suitable for auxiliary propulsion applications such as satellite station keeping. Development of a 10^{-5} pound thrust system, capable of vectoring the thrust electrically instead of mechanically, is being completed in FY 1968 and will be experimentally flight tested on the Applications Technology Satellite (ATS) D&E, the first of which is to be launched in CY 1968. Effort on a higher thrust system (10^{-3} pounds) suitable for north-south station keeping of a large communication type satellite will be continued in FY 1969. In addition, work on colloidal particle electrostatic thrusters for auxiliary propulsion will begin in FY 1969. This type of thruster may greatly reduce power requirements.

Resistojet thrusters which produce thrust by the expansion of an electrically heated gas through a nozzle have been experimentally flight tested. The ATS-I flight experiment reported on last year did not result in a satisfactory test because of undetected damage sustained during installation. Preliminary telemetry data obtained from a second flight experiment on ATS-III indicate that thrust has been successfully produced. Additional data are presently being studied to completely evaluate the operation of the flight experiment. This type of resistojet is planned for operational use on both the ATS D&E synchronous attitude spacecraft for east-west station keeping.

System studies have shown that resistojets operating at higher temperatures are of interest for drag cancellation of large orbiting space stations. It is planned to continue life testing of these high temperature resistojets in FY 1969. Also, research efforts in FY 1969 will be directed toward the utilization of biowaste products as propellant for these thruster types.

The third category of electric thruster is the electromagnetic device which differs from other types in that the interaction between high currents and magnetic fields is used in the production of thrust. These thruster types offer potential size advantages relative to ion engines. The major problems limiting development are in acquiring a basic understanding and verifying the performance of laboratory devices. Progress in FY 1968 was marked by the discovery of a rapidly rotating current sheet in steady state MPD (Magneto-Plasma Dynamic) arcs and the completion of a fiberglas testing chamber which will eliminate electrical interaction with vacuum tank walls, one source of uncertainty in performance determination. Research presently in progress will continue in FY 1969.

Nuclear Power Generation

The objective of the nuclear electric power technology program is to provide a broad option and design basis for the selection and evaluation of energy conversion equipment to be used in advanced nuclear electric power systems for future space missions. These systems will utilize nuclear energy generated by isotope or reactor heat sources, and therefore, an understanding of and close cooperation and coordination with AEC isotope and reactor programs are maintained. The program covers the power range from watts to megawatts with system endurance goals of one to five years. Primary efforts include the Brayton gas cycle turbo-electric system, the Rankine cycle alkali-metal turboelectric system, and the thermionic direct conversion system. Other concepts such as thermo-electric and magnetohydrodynamic conversion cycles are also being examined. The technology underlying these systems is a long-range effort requiring the establishment of engineering data relating to new materials, working fluids and components at temperatures never before used in power systems.

The Rankine cycle and thermionic conversion systems in combination with reactor heat sources under development by AEC offer the potential of achieving the lightest power system weights at high power levels for both auxiliary electric power and electric propulsion systems. The Brayton system, with its inherent high cycle efficiency and inert gas working fluid, offers an attractive power source in the 2-10 kilowatt range for manned applications, especially if coupled with isotope heat sources, provided the high inherent efficiencies can be demonstrated in such small units operating on gas bearings.

The Rankine turbogenerator program in FY 1968 made significant progress in design, fabrication and tests of major components, and in characterization of the system as a whole. Among the significant advances were the following: comprehensive analyses and preliminary designs were completed for the full scale turbine, generator and turbogenerator package, thereby providing a basis for the design of the turbogenerator which is the critical component of the power conversion system. A detailed design was completed on a high temperature (2200^{o}F) electromagnetic lithium pump. During FY 1969 the design of the turbogenerator will be developed in greater detail. The lithium pump and a high temperature test facility will be built for tests of the lithium pump's performance and endurance.

Fabrication was completed and tests were started on an advanced potassium turbine, electromagnetic boiler feed pump and lithium heated boiler. Experimental investigations were also initiated on corrosion resistance of advanced high temperature tantalum alloys, high temperature alkali metal valves and high temperature electrical switchgear capable of operating in alkali metal systems at temperatures in excess of 1000^{o}F.

These first are important milestones of engineering ingenuity. As part of these successful component fabrication programs, major advances were made in the forging, broaching and brazing of advanced molybdenum-based and tantalum-based alloys, and in the application of nonrefractory super-alloys. Such technology advances are essential if we are to be able to use the liquid metal resistant and strong, but brittle, and oxidation susceptible refractory metals which are capable of operation at the high temperatures of interest.

During FY 1969 endurance tests will be performed on a three-stage potassium turbine, potassium boiler feed pump, potassium corrosion loop, high temperature valves and high temperature electrical switchgear. Performance tests will be run on a single tube tantalum boiler equipped to study the boiling and vapor drying processes. In addition, turbine moisture removal techniques, boiler stability characteristics and the simulation of liquid metals with conventional fluids will be investigated.

An 8000 hour test on a newly developed advanced tantalum-based alloy, ASTAR 811C, showed that this new material at 2100^{o}F has 4 to 5 times the strength of the currently selected tantalum alloy and exhibits suitably low creep under operating stresses at temperatures up to 2600^{o}F. A 6000 hour endurance test of an approximately half-scale model of an alternator stator showed that the electrical, magnetic and insulating materials, and the bore seal, can successfully operate for very long periods at 1350^{o}F in ultra-high vacuum without degradation in properties or performance. During FY 1969 the development and testing of high performance structural and electrical materials will be continued.

System steady-and-transient-state stability tests were performed for the first time in a small scale two-loop lithium-to-potassium Rankine cycle system with good results. Analytical system studies were performed with the objective of identifying suitable design point operating conditions. During FY 1969 the small scale two-loop lithium-to-potassium Rankine cycle system will be subjected to a series of transient state tests with an analog reactor simulator slaved to the lithium heater. System design studies will be continued. Advanced concepts aimed at providing technology for lightweight components will be investigated.

Research is continuing on the technology programs associated with thermionic reactor electric power systems. The main parts of the program include: (1) analytical studies of thermionic reactor systems and their associated system components; (2) experimental test programs on current life and performance limiting problems and their improvement under high temperature and radiation flux such as electrical insulators, materials properties changes, high temperature fuel stability, gas released and cesium reservoir control. This research will be continued in FY 1969.

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As part of a coordinated insulator test program, NASA will provide in FY 1969 special thermionic insulators to Oak Ridge National Laboratory for inclusion in AEC's irradiation test program aimed at providing ceramic insulators satisfactory for use with in-core thermionic converters. Development testing of the components of an externally-fueled converter will be accelerated. A test-rig for investigating the control and stability aspects of a multiple-converter (liquid-metal-cooled) array will begin operation at JPL during FY 1969 and investigation of problems associated with fission product venting of multiple-converter arrays will be started.

As a combined in-house and contractual effort, the Brayton cycle power conversion system technology program continues to be directed at the demonstration of the high component, subsystem and system performance needed for isotopic power. The present power conversion system utilizes the inert cycle gas fluid in gas bearings for simplicity of operation in a sealed system. However, long time operation of gas bearings in this hot environment must still be demonstrated.

During FY 1968 a gas bearing equipped turbocompressor was operated for over 10 hours at design conditions of high temperature and speed. The gas bearings operated quite stably. Improvements to the bearing components have been incorporated to avoid bearing pivot rub noted during one of the tests. A compact gas bearing equipped 5.5 KWe turboalternator-compressor package will be delivered and placed on test during the latter part of this fiscal year.

During FY 1968 other subsystem assemblies and components have been designed and fabricated. It is expected that subsystem and hot closed-loop system testing will be initiated during FY 1969. Coordination with AEC on the high temperature isotope heat source has continued, and steps are being taken with their assistance for an isotope-Brayton power system demonstration test.

The major effort on isotope-thermoelectric power for space applications continues to be conducted by AEC which is developing the SNAP-19 and SNAP-27 generators for the Nimbus B and Apollo missions. NASA is continuing to evaluate isotope-thermoelectric and isotope-thermionic systems for potential space use. During FY 1968 environmental tests, including shocks equivalent to 1000 g's were successfully conducted at JPL with tubular lead telluride compact thermoelectric converters. The good properties and performance of these converters will be further examined in FY 1969, particularly with respect to cascading with silicon-germanium for higher performance coupled with high reliability. Life testing of typical SNAP units and components will be continued during FY 1969.

Solar Power Generation

Major goals of the solar power generation subprogram are: (a) to devise radiation resistant solar cells, (b) to develop improved metal to solar cell electrical contacts, (c) to devise compact methods for stowing large solar cell arrays for launch and to develop reliable techniques for automatically deploying these large, lightweight arrays, (d) to devise new solar cells having greatly improved efficiency and reduced cost and (e) to develop advanced electrical components and circuits for battery charging, voltage regulation, processing, distribution and control of electric power on spacecraft and aircraft.

During FY 1968 the first phase of a three phase program to achieve technology readiness of an advanced 20 watt per pound (20 w/lb), 50 KW folding solar cell array was completed and work on the second phase was initiated. In FY 1969 work on the second phase will be completed and the third phase will be initiated. Phase three will consist of the assembly and test of a significant part of a 1250 ft^2 wing (the 50 KW array is composed of four identical 1250 ft^2 wings) of the solar cell array. Structural and deployment tests will be performed. The goal of 20 w/lb is a five-fold advance over the solar cell arrays currently planned for use on the Apollo Applications workshop and telescope cluster in the early 1970's. These significant weight reductions require the use of new structural concepts and materials. Beryllium is being investigated to provide the needed increase in stiffness to weight ratio. Methods for forming, milling, cutting and joining large beryllium structures are being developed.

In FY 1968 research was continued toward a more radiation resistant silicon solar cell. The beneficial effect of lithium added as a trace impurity was first discovered in 1965. The action of lithium has been described as a "self-healing" process. Research is underway to determine whether the healing rate can be made sufficiently fast so that damage in space would be annealed as rapidly as it occurs. Laboratory tests have shown that certain lithium cells recover rapidly from intense doses of radiation, but subsequently deteriorate under room storage conditions. Substantial further work in FY 1969 and subsequent years is needed to adequately explore the potential of this promising discovery.

During FY 1969 research on new solar cell concepts will be continued with a view toward increasing efficiency, improving temperature tolerance and reducing manufacturing costs of large arrays. Work will continue on large area cadmium sulfide solar cells which show a potential for greatly reduced manufacturing cost. At the present time these thin film cells are only one-third to one-half as efficient as silicon cells and have not been able to withstand thermal cycling without degradation.

While notable progress has been made in the performance and reliability of spacecraft electrical power systems, a continuing need exists for improvements in the efficiency, weight, life and reliability of power conditioning, distribution and control equipment.

In FY 1969 further research is needed on a versatile circuit for stable control of pulse modulated power oscillators, on a new concept for overload protection of electrical circuits and on an approach to solar array orientation and power transfer that would eliminate slip rings, brushes, gears and high speed bearings which are trouble spots with existing designs.

Chemical Power Generation

Electrochemical devices -- batteries and fuel cells -- are used as primary power sources and as energy storage systems for launch vehicle and spacecraft power. The wide range of storage, frequency of use, rate of discharge and recharge, high-g impact, biological sterilization and temperature lead to several different types of batteries to better meet these requirements.

Research has continued toward batteries that can provide five year service life in 90 minute orbits. In this service the battery must survive 30 to 40,000 charge-discharge cycles. Substantial improvements in such battery components as seals and separators are needed. There is a critical need for valid methods of accelerating battery testing. Methods for accumulating the equivalent of five year service with actual test times of days or weeks must be devised to shorten the time and cost that will otherwise be required to develop such batteries. Continued investigation of accelerated test methods will be an important part of the FY 1969 program in this area.

The energy storage problems of long lived synchronous satellites (24 hour orbit) are quite different from low orbit applications. In this case, only hundreds of charge-discharge cycles occur per year, but the energy storage device must retain its charge for longer periods. To satisfy these demands, work will continue in FY 1969 on electrically rechargeable fuel cells, using hydrogen and oxygen as the means of energy storage. A "breadboard" assembly of rechargeable fuel cells will be fabricated and tested for performance and service life.

Preliminary results in FY 1968 with rechargeable metal-gas batteries have been encouraging. Several dozen cycles were obtained with zinc anodes and oxygen-using cathodes. The metal-gas devices combine battery (zinc) and fuel cell (gaseous oxygen) technologies to give useful performance not available from batteries or fuel cells separately. Further work is needed in FY 1969 on these metal-gas electrochemical systems.

The major effort on primary (essentially non-rechargeable) batteries is on sterilizable and impact resistant silver-zinc cells. An organic membrane, sterilizable battery separator was improved in its chemical and physical properties during the past year and evaluated in single cells for sterilizability. Having passed these tests, it will be incorporated in experimental batteries in FY 1969 and evaluated. A new battery case material was found last year, which can survive the rigors of heat sterilization. This will be used in the evaluation program with epoxy sealant, while better methods of sealing the battery case to the top will be explored at the same time. A shock resistant battery design was found to be unsatisfactory; better designs are being sought.

Research on a free-electrolyte fuel cell will continue in FY 1969. The free electrolyte is circulated outside the cell and can be cooled more effectively opening the way for larger fuel cell stacks and modules. Impurities swept out by the electrolyte can be removed with expected improvements in system life. More work is needed on this device, including improved methods of wet-proofing the electrodes.

Electrochemical research has ranged from the compilation of critically evaluated electrochemical data (continuing) through exploration of gaseous electrolytes (completed) and electrode-less plating (continuing) to a study of electrolysis for regenerating reactants for lunar-based fuel cells. A university thesis on a novel construction of fuel cells that may lead to more compact systems will be investigated further in FY 1969. An analysis of heat transfer in fuel cells was successfully applied to batteries and is expected to be broadened and generalized. Single-crystal alloy catalysts have been found that promise to be better than the best fuel cell catalysts available thus far.

Space Electric Rocket Test (SERT)

	1967	1968	1969
Spacecraft and experiments development................	---	$ 1,100,000	$ 1,500,000
Agena (Launch Vehicle Procurement Program).............	$(2,420,000)	(1,640,000)	(2,640,000)
Total (Including Launch Vehicle)..........	$(2,420,000)	$(2,740,000)	$(4,140,000)

SERT II is an extension of the SERT project which was initiated by SERT I launched in July 1964. SERT I was a suborbital flight to demonstrate ion beam neutralization in space. SERT II is planned as an orbital flight for a minimum of six months to evaluate ion thruster characteristics and performance during extended space operation and to investigate possible interactions with the spacecraft. SERT II represents the next major step in the development and acceptance of electric thrusters for prime propulsion of interplanetary spacecraft. Not only will a successful flight provide additional confidence for the adoption of electric thrusters for actual mission use, but much valuable information will be derived to assist in the designing of electrically propelled spacecraft.

Planned to be launched by a THORAD-Agena from Western Test Range during CY 1969, the SERT spacecraft with experiments will be orbited together with the Agena vehicle. The Agena will provide the necessary electric power from a 1.5 KW solar array and $1,000,000 of FY 1969 funds is required for the procurement of this solar array. A spacecraft support unit has been introduced into the design to simplify the interface between the spacecraft and the Agena vehicle. In addition, a gimbaling system has been adopted to vector the ion engine thrust to maintain spacecraft stability. Fiscal Year 1969 resources amounting to another $500,000 are necessary for the spacecraft support unit and the thrust vectoring gimbal system.

SNAP-8 Development

	1967	1968	1969
Development..................	$ 5,500,000	$ 7,500,000	$ 7,500,000

The objective of this technology project is to conduct the ground development of a 10,000 hour, 35 electrical kilowatt nuclear electric generating system suitable for space applications in the 1970's and beyond. Principal potential applications for SNAP-8 are large earth orbiting space stations, lunar exploration, direct TV broadcast satellites and ultimately manned interplanetary missions.

SNAP-8 is a joint NASA-AEC development with AEC responsible for reactor development and NASA responsible for the power conversion system and eventually for full system integration. SNAP-8 utilizes a mercury Rankine conversion loop to convert thermal power developed by a compact reactor into electrical power. The design approach places emphasis on maximum use of current state-of-the-art and provides flexibility to adapt to a range of potential missions with a minimum of changes in the system.

In CY 1966 the program was reoriented toward emphasizing component life development and system technology testing using the breadboarded power conversion system in order to solve the component problems encountered, particularly in the boiler and turbine. Hardware commitments for more advanced system testing were, therefore, deferred.

In the past year priority has been placed on developing solutions to the major life-limiting problems found in the boiler and turbine from previous development testing and on endurance testing in small component loops of the other major components of the power conversion system. During CY 1967 total test hours on major SNAP-8 components increased from about 23,000 hours for all previous years to over 80,000 hours, indicating a significant acceleration for the year in testing progress.

This achievement reflected more component test loops brought on the line as well as better on-test experience. During this period the first SNAP-8 component, the lube/coolant pump, passed the 10,000 hour endurance test milestone.

The principal change made to the boiler and turbine to correct observed life problems was to substitute a more ductile material in the turbine rotors and stators and to replace the iron-based alloy in the boiler tube with tantalum. Tantalum has been found to have no measurable solubility in mercury and is expected to reduce the previously experienced corrosion problem. Testing of a modified turbine and a new boiler built with these new materials has been initiated and verification of the design is being obtained. In modifying the turbine the efficiency was also improved to assure a 35 KWe power conversion system output, and the improved performance has also been verified in test.

During the **remainder** of FY 1968 it is planned to complete a long duration test of the modified turbine and new boiler and to perform a post-test inspection of these components to assess progress in developing solutions to the life problems of these two components. Endurance testing of the other major components will continue and periodic examinations made of these components to assess their development status. Supporting investigations of scaled-down experimental boilers will be continued toward improving the understanding of full-scale boiler capabilities and limitations. AEC is expected to complete fabrication of the next SNAP-8 reactor in FY 1968 and a long-duration power test of this reactor is scheduled to begin in FY 1969.

The budget request for FY 1969 provides primarily for the continued life development of the power conversion system components toward the 10,000 hour mark in component loops, and it is planned to complete a 2500 hour demonstration of the life capability of all the major components in the breadboarded SNAP-8 power conversion system. Development of secondary components related to system start-up and electrical control initiated in FY 1968 will be continued. In addition, the existing breadboarded power conversion system will be used to perform transient tests of system start-up, shutdown, and restart. Analytical studies will also be performed of a SNAP-8 power conversion system in a more compact configuration to provide guidelines for component development and system transient testing more nearly representing the conditions expected in future applications.

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objective of the Nuclear Rockets program is to provide rocket propulsion systems for application to high-energy, high-payload missions of the future. In carrying out this objective, the AEC-NASA Space Nuclear Propulsion Office is conducting a detailed system-analysis, design, development and test program to provide an approximately 75,000 pound thrust NERVA engine of between 800-850 seconds specific impulse for flight status by approximately FY 1976. This work is proceeding on the basis of data, designs, and experience established in the technology phase of the program.

The specific NERVA activities to be conducted in FY 1969 include the completion of the technology phase of the NERVA program and continuation at an increased level of the design, development, procurement, and component testing of the approximately 75,000 pound thrust NERVA engine initiated in FY 1968. Included in FY 1969 will be the establishment of the NERVA engine detailed requirements and configuration, and facility modifications as needed.

In addition to NERVA, this program supports activities to advance the technology of nuclear rocketry with particular regard to specific impulse and duration. Effort will continue to be directed toward vehicle considerations, mission studies, and engine-vehicle interfaces. The activities in support of these advanced objectives are carried out primarily at NASA centers (Lewis and Marshall) and at the AEC's Los Alamos Scientific Laboratory.

The major justification for the development of the nuclear rocket engine is that it provides a major advancement in space propulsion capability. The NERVA engine in a nuclear stage could increase the payload and enhance the efficiency and operational characteristics in a variety of potential missions. Some of the missions for which a NERVA-powered stage would provide operational and payload advantages are: large-payload, orbital-transfer missions; manned or unmanned lunar missions; unmanned solar-system missions; and, eventually, heavy-payload manned missions beyond the moon.

The NERVA-powered stage applied as a third stage of the Saturn V launch vehicle improves significantly its payload and mission versatility. For example, a nuclear stage would increase the lunar-landed payload by approximately 60-70% and allow direct flights to the surface of the moon to be accomplished in a single Saturn V launching. In addition, the nuclear third-stage increases the payload capability of the Saturn V for deep space missions by 100% or more. The energy capability of the nuclear stage can be employed to reduce trip times to distant planets by hundreds of days. These improved capabilities provided by nuclear propulsion in the third-stage of Saturn V can be utilized to improve the effectiveness of missions, to increase mission or payload reliability, to reduce the number of required launches, or to extend the spectrum of potential missions in the late 1970's and the 1980's.

SUMMARY OF RESOURCES REQUIREMENTS:

	1967	1968	1969
Supporting research and technology	$16,506,000	$15,000,000	$15,000,000
NERVA	34,162,000	35,000,000	41,000,000
NRDS operations	2,332,000	4,000,000	4,000,000
Total	$53,000,000	$54,000,000	$60,000,000

Distribution of Program Amount by Installation:

	1967	1968	1969
Marshall Space Flight Center	$1,650,000	$2,100,000	$3,000,000
Lewis Research Center	3,515,000	2,200,000	2,400,000
Space Nuclear Propulsion Office	47,835,000	49,700,000	54,600,000

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

	1967	1968	1969
Rocket reactor research	$10,855,000	$9,800,000	$7,700,000
Nuclear rocket engine systems	3,901,000	2,600,000	3,800,000
Safety	150,000	500,000	500,000
Vehicle technology	1,600,000	2,100,000	3,000,000
Total	$16,506,000	$15,000,000	$15,000,000

The supporting research and technology effort (SR&T) supplies four basic needs: (1) general SR&T data for current projects; (2) advancing basic technology for nuclear rocket engines and vehicles; (3) feasibility effort on advanced nuclear propulsion concepts; and (4) studies of special flight safety considerations of nuclear rockets.

Rocket-Reactor Research

This activity supports work in two general areas: first, in the area of advanced concepts and in the design studies of reactor concepts of interest for future applications; secondly, these funds provide for nozzle and propellant feed systems for use in the advanced technology reactor ground test program at the Nuclear Rocket Development Station (NRDS).

Research will continue in FY 1969 on advanced nuclear propulsion concepts such as the gas core nuclear rocket propulsion concept in which the uranium fissionable material is in a gaseous rather than a solid form. Results of

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this work have indicated that extremely high specific impulse is potentially attainable with this fuel. In-house capability and research is centered at the Lewis Research Center. Most of the work in this area, however, is carried out using the capabilities of industry and universities through contracts and research grants.

In the past, NASA has funded the development of a liquid hydrogen turbopump feed system used to test the high-power Phoebus-2 and the NERVA reactors. During FY 1969, this system will be modified to meet the pressure and flow requirements of the test bed reactor experiments (PEWEE-1) to be conducted by the Los Alamos Scientific Laboratory in FY 1969 (under AEC funding). Propellants and pressurants in support of the research and development activities on turbopumps and nozzles for Phoebus reactor tests as well as the Phoebus and Pewee reactor tests themselves are provided by these funds.

Nuclear Rocket Engine Systems

This research provides information for specifying characteristics of future generations of nuclear rockets as well as establishing a general base of information on the design and operation of components and engines. Engine component technology is the responsibility of NASA; the in-house effort is conducted by the Lewis Research Center with other work being accomplished under Lewis' direction by contractors and universities.

The major effort currently being carried out in this program is on the effects of radiation on nuclear engine components, materials, and systems.

The purpose of this work is the definition of the behavior of materials in a combined radiation and cryogenics environment. Such information supports all phases of the nuclear rocket program and is essential for the design effort. Other important efforts are improved instrumentation, fluidic control system components and engine transient analysis.

Safety

Assuring the safety of all current and projected activities of the nuclear rockets program requires knowledge related to the new and unique problems encountered. Most required information stems directly from the main stream technological development activities. Frequently, however, specially directed research and analysis must be undertaken in areas outside the normal reactor and propulsion discipline. Examples of work in progress or planned for FY 1969 include exploration of the relation between propulsion requirements and astronaut safety; special problems of hydrogen safety; special facility requirements; and further analysis and conceptual design of measures to avoid or counter flight failures.

Vehicle Technology

This subprogram activity provides basic design information which will assist the development of nuclear rocket vehicles for flight mission applications.

General flight system technology activities which were underway in prior years will continue. Areas of particular interest where research investigations will be conducted are propellant heating, radiation effects and emergency propellant venting and reliquification of cryogenic propellants. This work is carefully coordinated with engine development.

NERVA

	1967	1968	1969
Technology.....................	$34,162,000	$23,000,000	$16,800,000
Development....................	---	12,000,000	24,200,000
Total.........................	$34,162,000	$35,000,000	$41,000,000

The NERVA program in FY 1969 includes the completion of the technology phase of the effort and increasing activities in the development of the flight-rated NERVA engine at a thrust level of approximately 75,000 pounds. These two elements of the program are discussed below.

Technology Phase

	1967	1968	1969
Engine system component and subsystem..............	$14,426,000	$7,700,000	$3,700,000
Ground test and operations support....................	17,357,000	13,300,000	10,300,000
Propellants..................	2,379,000	2,000,000	2,800,000
Total......................	$34,162,000	$23,000,000	$16,800,000

Engine System

During FY 1969, effort will be directed toward finishing the test activities concerned with ground-test experimental engines. It is planned that the last phases of XE-1 testing will be accomplished and disassembly of that engine will be concluded. The XE-2 will be tested later in the fiscal year. The objectives of these tests include: checkout of the test facility, Engine Test Stand No. 1 (ETS-1); evaluation of engine control systems; exploration of boot-strap startup data; mapping of engine performance at a variety of operating points; performance data on engine components at rated conditions; and determination of the requirements of engine after-heat removal.

Component and Subsystem

The remaining effort in technology will involve the completion of testing and delivery of the ground experimental engine components and subsystems.

Ground Test and Operations Support

This effort in FY 1969 will be largely directed to the technology phase of the NERVA program. Engine test facility operations at the Nuclear

Rocket Development Station are included in this heading. It also provides remote handling equipment, checkout and test equipment, and maintenance equipment for test operations. During FY 1969, the Engine Maintenance Assembly and Disassembly Facility (E-MAD) will be used to assemble the experimental engine assemblies and reactor experiments. Remote maintenance and disassembly operations will also be conducted. Engine Test Stand-1 will be used to conduct the experimental engine (XE) tests. Operation support also provides for instrumentation, safety and product assurance activities.

Propellants

Funds provided under this heading will be used for procurements of propellants, primarily liquid hydrogen, required in various parts of the NERVA test programs.

Flight Engine Development	1967	1968	1969
Engine system, component and subsystem.......................	---	$8,070,000	$15,700,000
Ground test and operations support	---	3,930,000	8,500,000
Total..........................	---	$12,000,000	$24,200,000

Engine System Development

Major effort will be underway on design and development of the flight-type NERVA engine system and its components. Engine systems analysis and optimization studies started in FY 1968 will be completed. Continuing studies will be made of the interactions and interfaces between the engine and vehicle. Areas of particular design interest include radiation shielding requirements for tank-heating and life-support; mode of after-heat and thrust removal; the effect of space environment on engine and vehicle; propellant storage and pumping modes; launch-site considerations, etc. In FY 1969, these design studies will be largely concluded. Direct input from Marshall Space Flight Center will support the contractor's activities in this area.

Component and Subsystem Development

Based on specifications developed for engine configurations and engine requirements, specific design, procurement and testing of components and subsystems will be underway in FY 1969. These include the following:

1. Reactor subsystem: This effort is largely funded by the AEC and will be carried out at Westinghouse Astronuclear Laboratory. The components vital to successful development of this subsystem include reactor fuel elements, reactor-support hardware, mechanical and electronic control components, radiation-shielding components, and ground-support equipment.

2. Turbopump assembly (TPA): The design, development and testing of this assembly will be underway in FY 1969. The facilities necessary to test components will be available during the course of the year, and testing of com-

ponents will be initiated. Weldments and forgings for the TPA will be procured during FY 1969 for component development testing as well as for the first engine, E-1. Machining and assembly of the TPA for initiating cold-drive, low-speed tests are also expected to be completed at the end of the year. Structural and dynamic testing will be initiated.

3. Thrust-chamber assembly: The U-tube nozzle developed under the NERVA technology program will be the basis for the NERVA nozzle design. The hot-bleed cycle will be used in NERVA, based on components and systems studies conducted during NERVA Technology phase. Additional nozzle design activities associated with nozzle extensions and a nozzle skirt will be conducted. Nuclear, thermal and stress analysis on the thrust chamber assembly components will be conducted. Forgings for development nozzles and for use in bleed-port development testing in chemical firings will be delivered, and contour machining of the nozzles completed. Nozzle bleed-ports will also be procured during the year.

4. Lines, valves and actuators: The components fabricated and tested in the NERVA technology program will be the basic starting point for qualification of these components. Included in this category are the turbine-power control valve, turbine block valve, discharge shutoff valve, emergency cooldown valve, and the propellant shutoff valve. These valves will be redesigned or upgraded from the XE engine to provide the necessary reliability and weight required for a flight engine. These redesigned valves will be fabricated in FY 1969 and leak, functional, timing response and cycle testing initiated. A new structural support coolant valve will be developed for the reactor support system to control coolant flow rate while maintaining a relatively constant bleed-flow rate off the pump discharge. Detailed design of this valve and fabrication will occur in FY 1969.

5. Thrust structure and attitude control: The design of these components, initiated in FY 1968, will be underway and long-lead procurement begun. The detailed design of the thrust vectoring system will be completed in FY 1969, and the components of the system will be fabricated to initiate development testing in early FY 1970. Components included in the system for which fabrication will be initiated in FY 1969 include gimbal bellows and remote joint, gimbal ring and ring bearings, remote structural connectors, and the thrust structure.

6. Engine control systems: The basic data for prototype control systems will be available from XE-1 testing, and systems requirements will be implemented by functional and detailed designs. Mechanical prototypes of flight-packed components will be fabricated and tested. Detailed design modifications to the existing ETS-1 facility engine control system and engine simulator will be completed in FY 1969 and fabrication of a modification kit initiated.

Ground Test Operation and Support

In FY 1969, necessary modifications of facilities will be initiated at Aerojet for full scale turbopump evaluation and for chemical test firings of nozzle bleed-ports. Modifications to ETS-1 for the NERVA engine will be in the design stage. Operational support also provides for instrumentation, safety and product assurance activities for NERVA development.

Nuclear Rocket Development Station Operations

	1967	1968	1969
General site support..............	$2,183,000	$3,600,000	$3,600,000
Capital equipment..................	149,000	400,000	400,000
Total..........................	$2,332,000	$4,000,000	$4,000,000

The mission of the Nuclear Rocket Development Station (NRDS) is to provide a site for ground static testing of the reactors, engines and eventually the propulsion modules or rocket stages associated with nuclear rocket development. The major users of the Station are Aerojet-General Corporation, Westinghouse Astronuclear Laboratory, and Los Alamos Scientific Laboratory, under the overall management of the AEC-NASA Space Nuclear Propulsion Office. The specific activities in FY 1969, as covered earlier, include completion of XE-1 testing and initiation of the XE-2 test series.

Maintenance, housekeeping and management functions must be provided at the site. These functions taken together constitute general site support. They include routine maintenance and operation of the facilities; for example, custodial services, maintenance of roads, grounds, and utility systems and furnishing of utilities, building operating supplies, fire protection, and cafeteria services. Included also are the services of a support contractor to maintain and operate plumbing, electrical, carpenter, welding and machine shops as well as support facilities and equipment.

These funds will continue to provide for NASA's share of the general site operations, the major part of which is funded by the AEC.

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY — CHEMICAL PROPULSION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objective of the Chemical Propulsion program is to establish science and engineering technology that will provide a basis for developing advanced chemical propulsion rocket systems for the Nation's future space missions. This program covers research examination of fundamental concepts, obtains pertinent engineering data, develops design, fabrication and testing techniques, and demonstrates improvements in propulsion machinery resulting from research examinations by performing experimental system tests.

Three basic propellant system types are covered. These are liquid propellant, solid propellant, and hybrid propellant systems. Thrust levels range from several million pounds to millipounds. A propulsion technology base is prepared for launch vehicle stages, lunar and planetary landing and ascent modules, orbit and de-orbit maneuver engines, midcourse correction engines, attitude control engines, rendezvous engines, propellant settling thrusters, and personnel transport devices. In addition to improving the performance and flexibility of chemical propulsion systems, lowering the cost and improving reliability and safety are principal objectives of this work. Propulsion processes, engine design, engine materials and fabrication techniques are studied along with measurements of propellant physical properties, combustion phenomena, a fundamental understanding of fluid mechanics processes, gas dynamics, solid mechanics and extremely high rates of heat transfer, and methods to control these are developed. The basic technological examinations are supported by complimentary system demonstration programs. The total process of developing the technological basis for advanced propulsion system designs requires many years.

The technical projects under the Chemical Propulsion program are managed by NASA field centers, using unique in-house capabilities and facilities to support their work. Work at the centers is augmented by extensive use of competent academic and industrial capabilities under contracted work arrangements.

SUMMARY OF RESOURCES REQUIREMENTS:

	1967	1968	1969
Supporting research and technology..................	$30,688,000	$33,750,000	$33,600,000
Large solid motor project.....	2,950,000	3,500,000	3,100,000
Total....................	$33,638,000	$37,250,000	$36,700,000

Distribution of Program Amount by Installation:

	1967	1968	1969
John F. Kennedy Space Center, NASA..............	$49,000	$175,000	$150,000
Manned Spacecraft Center....	514,000	1,120,000	900,000
Marshall Space Flight Center	5,200,000	5,890,000	5,800,000
Goddard Space Flight Center.	496,000	540,000	450,000
Jet Propulsion Laboratory...	3,923,000	4,774,000	9,645,000
Langley Research Center.....	2,316,000	2,553,000	2,658,000
Lewis Research Center.......	11,890,000	12,597,000	14,040,000
NASA Headquarters...........	2,816,000	4,082,000	3,057,000
Western Support Office......	6,434,000	5,519,000	---

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

	1967	1968	1969
Liquid Rocket Research and Advanced Technology.........	$11,687,000	$12,700,000	$12,600,000
Solid Rocket Propulsion Research and Technology.....	4,407,000	5,050,000	5,050,000
Liquid Rocket Experimental Engineering................	10,675,000	12,500,000	12,450,000
Solid Rocket Experimental Engineering................	3,919,000	3,500,000	3,500,000
Total....................	$30,688,000	$33,750,000	$33,600,000

Liquid Rocket Research and Advanced Technology

The Liquid Rocket Research and Advanced Technology project performs broadly based research applicable to advanced liquid rocket propulsion concepts. Half of the approximately 160 tasks is in applied research, generally applicable to all liquid rocket engines; roughly one third is applicable to spacecraft engines, the remainder is oriented towards launch vehicle problems. Forty-five per cent of the work is contracted with industry, forty-five per cent is done in-house and the remaining ten per cent is accomplished in universities.

The applied research effort for FY 1969 will include work in combustion, combustion stability, ignition, valve and seal technology, pump technology, materials of construction, and fabrication processes. The goals are to define the potential for increased rocket system performance, reduced weight and cost, extended mission duration, and improved reliability of components. Advancement specifically related to long duration space missions of the future is emphasized. The information generated is published as engineering reports and handbooks applicable to both the aerospace and non-aerospace industry.

The program in high-energy space storable propellants, such as mixtures of fluorine and oxygen or oxygen difluoride, with the light hydrocarbons or diborane serving as fuels, will include efforts in space ambient ignition, injector design for performance, chamber cooling, and nozzle altitude performance and analysis.

The programs examining the use of liquid hydrogen in rockets will augment work with subcooled and slush hydrogen, its handling and instrumentation applicable to it. These techniques will extend the time that hydrogen can be stored in space, or reduce insulation weight and spacecraft complexity.

Work will also assess the performance available from tripropellant combinations using liquid hydrogen, fluorine and lithium. Such tripropellant systems have demonstrated specific impulse performance in excess of 500 pound-seconds per pound. The continuing effort will be directed toward combustor simplification.

Work relating to launch vehicles will direct effort toward design and operating simplification of such equipment with a view to lowering future development and production costs. New reduced-cost methods of fabricating components will be examined. The transient thermal requirements of turbopump operation for starting engine systems that use cryogenic fluids will be determined and system design concepts will be developed to alleviate the operational and pre-conditioning constraints inherent in present equipment.

Solid Rocket Propulsion Research and Technology

The Solid Propellant Research and Technology program develops a base of data pertinent to the general application of solid propellant motors. It explores propulsion alternatives, tests performance and design, and resolves difficulties for solid propulsion systems.

The program in solid propulsion technology consists of 75 tasks. Forty per cent of the funds are contracted with industry, 13 per cent with universities and non-profit institutions, and 47 per cent is used within NASA.

The solid propellant research and technology effort has been structured to provide needed information on high performance solid propellant systems. This information covers kinetics of decomposition, chemical erosivity, combustion instability characteristics, physical properties of propellants

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and motor materials, sensitivity and hazards of propellants and their manufacture, processing procedures and characteristics. These data will permit evaluation of solid propellant systems for future mission development. Specific areas of concentrated effort are identified in the following paragraphs.

Controllable solid rockets now being tested under the experimental engineering program require extinguishable propellants, refinement in the knowledge of burning characteristics of such propellants, and improvement in hardware reliability, particularly for hot gas flow regulatory devices and ignition systems. The hybrid promises exceptionally high performance, restartability, and good space storability. Research on both these space rocket systems will be conducted.

Polymers are being developed to yield propellants with improved mechanical properties. The mechanical behavior investigation program is helping assure the structural integrity of solid rocket motors. Microwave technology will be investigated for use in nondestructive inspection of cast motors. Better knowledge of combustion processes and ignition transients in solid rocket motors will permit more reliable igniter design and control of combustion-induced instability.

Liquid Rocket Experimental Engineering

The Liquid Rocket Experimental Engineering work is largely system oriented. Improved components defined by the research and technology programs are designed, built, and assembled into working systems, usually "breadboard" models, so that component interactions may be studied under simulated operating conditions. New or unanticipated problems are often observed during these tests. These may require additional research effort at the component level. It is the purpose of such system tests to identify real performance potential, to define operating limits, to point up areas of technology which need further attention, and to assess the design methods, the fabrication processes, the test procedures, and the probable schedule, cost, and facility requirements of a potential hardware development project.

Launch Vehicle Systems - The need for reduced-cost propulsion capability is apparent. NASA and the DOD have been engaged in a coordinated program aimed at improved hydrogen peroxide rocket engines. DOD will proceed with a breadboard system demonstration of a high chamber pressure conventional nozzle engine configuration. NASA will support work on the combustion chamber of the aerospike engine with both small scale segments and at a nominal thrust level of 250,000 pounds to establish the performance to be expected of this configuration and to work out problems of combustion-induced instabilities. Additional work effort will be aimed specifically at encouraging new concepts for fabricating low cost propulsion equipment using the aerospike nozzle. Several new concepts in advanced turbomachinery will be investigated in model scale.

Space Propulsion Systems - In recent years emphasis in our spacecraft program has followed two principle tracks: 1) improvement in the technologies of thermal protection to extend the capabilities of hydrogen fueled rocket systems to perform deep space missions, and 2) development of a new class of high density high performance "space storable" propellants for use on long duration space missions where low density hydrogen use is impractical.

Oxygen-hydrogen systems are already operational as launch vehicles such as Atlas-Centaur and the Saturn vehicles. Technology needed to develop the capability for storing liquid hydrogen in space for extended durations is progressing rapidly. This work will greatly extend the usefulness of hydrogen-fueled propulsion stages. Significant progress has been made in demonstrating the operation and performance capability of fluorine-hydrogen engine systems, and in developing design criteria for liquid fluorine propellant system components.

The space storable propellant combinations offer a unique combination of attractive characteristics particularly suitable for deep space and planetary missions, both manned and unmanned. High performance, high bulk density, and suitable physical properties combine to render space storable propulsion systems strong contenders for planetary orbiters, landers, ascent vehicles and earth return stages. The principal propellant combinations of interest are oxygen-difluoride or mixtures of fluorine and oxygen with either liquified hydrocarbon gases or diborane as the fuel. Efficient combustion has been obtained and cooling limits have been established for transpiration, regenerative and ablative cooling techniques. Deliverable engine performance including expected kinetic losses during nozzle expansion of the exhaust under space conditions will be determined shortly. Pump technology for this class of propellants has also been initiated. In fiscal year 1969, efforts will be initiated to design, fabricate and test typical spacecraft engine systems, both pressure fed and pump fed. These engine systems will be "breadboarded" to provide the flexibility for making modifications, replacing components and evaluating alternate engine operational cycles, as improved designs are conceived.

Another critical area requiring attention is the actual storability potential of the space propellants. Simulated space environment chamber testing is planned to evaluate super-insulations, tank support and penetration design, shadow shield effectiveness, tank pressurization techniques, etc. The fiscal year 1969 work will determine those areas of insulation technology peculiar to the space storables and will lead to the eventual evaluation of complete propellant systems in simulated space chamber testing.

Auxiliary Propulsion - Sophisticated spacecraft require attitude stabilization; some also require small velocity changes for changing orbit or trajectory. Thrust requirements for auxiliary systems used to accomplish these purposes range from a fraction of a pound to several hundred pounds.

In the low thrust area, monopropellant hydrazine has seen widened application. The simplicity of the single propellant system, with performance several times that of a stored high pressure gas system, has led to its selection on a number of NASA and DOD stages and satellites. Work to improve the monopropellant state of the art through better understanding of the catalytic decomposition and improvement of catalyst materials will continue.

The low density, ammonia-hydrogen mixture resulting from hydrazine decomposition will be examined for use in pressurizing propellant tanks, driving auxiliary power turbogenerators, or for storage and later use to supply ultra-low-thrust attitude control nozzles.

Future large spacecraft and launch vehicle stages will utilize higher energy propellants for their main propulsion systems. Demonstration of auxiliary systems utilizing the higher energy propellants is underway. Materials to allow zero-g positive expulsion of cryogenic liquid oxygen and liquid hydrogen have been tested and work on small thrust chambers for these propellants continues. A breadboard system demonstration is planned. Investigations of small thrust chambers utilizing the "space storable" propellants are being planned.

Solid Rocket Experimental Engineering

The solid rocket experimental motor program supports tests of new motor configurations for launch vehicle, space, and auxiliary propulsion. Its goals and operations parallel the liquid rocket engine experimental program.

Launch Vehicle Propulsion - Large solid motors can greatly extend the capability of existing liquid stages and vehicles and can result in large reduction in effective cost of launch vehicle systems.

The solid motor launch vehicle engineering project will investigate low cost methods for applying materials or making motor parts. Specific examples are a trowel-on insulation for protecting large motor cases and roll-forging for making thick-wall, complex metal parts. Tough steel alloys, such as HY140, are being evaluated to increase reliability and reduce costs of large motor cases. These steels are tough enough to accommodate weld flaws and mismatches which normally would cause failure; hence cost of inspection and manufacture can be reduced, and test programs can be shorter.

Space Propulsion - The major advancements required for extending the use of solid motors for space propulsion are increased propellant energy content (specific impulse) and capability to be stopped and restarted. A restartable high energy solid motor has several cost attractive applications in unmanned missions based on small launch vehicles such as Scout, Delta, or Atlas. Experimental tests in fiscal years 1967 and 1968 established nozzle materials and insulation requirements for motors with restartable propellant. The program will continue into detailed design and initial prototype motor firings in fiscal year 1969.

A hybrid system based on a liquid oxidizer and a solid fuel (fluorine-oxygen and lithium hydride) has been analyzed for applicability in deep space missions such as planetary probes or planetary landings. The findings were that the controllability, high performance and space storability would make the hybrid motor a strong competitor for these missions. Accordingly the technology program was extended in fiscal year 1968 to design a prototype hybrid system. In fiscal year 1969 the work will test the nozzle, solid fuel charge and liquid oxidizer injectors. A heavy duty mock-up of the liquid tankage, valving, and other plumbing will be used initially. Following successful completion of these test combined flight weight elements will be designed and tested.

Auxiliary Propulsion - Solid auxiliary motors are widely used for retropropulsion to separate stages of vehicles, for astronaut escape systems, and for thrust to settle liquid propellants. Also included in this category are squibs, initiators and incendiaries, used for many starting and separating devices in vehicles and payload. Support of this project enhances reliability of these propulsion devices.

One low level thruster that appears useful is a solid wafer motor, which provides thrust on command in preset increments. It can provide midcourse correction of trajectory in a planetary probe mission at low cost. Testing of a prototype motor will be supported in fiscal year 1969.

Large Solid Motor Project

	1967	1968	1969
Large solid motor project...	$2,950,000	$3,500,000	$3,100,000

Three test firings of the 260 inch diameter, 75 foot long large motor were successfully completed by FY 1967, with peak thrust of 5.9 million pounds produced in the last test. In FY 1968 and FY 1969, the large motor project entered a sustaining phase to preserve a competitive option between solid and liquid rockets for the boost stage of an intermediate vehicle of about 100,000 pounds payload in the event there is established a requirement for such a payload.

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY — AERONAUTICAL VEHICLES PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The role of the Aeronautical Vehicles program is to provide through research in the disciplinary areas of aerodynamics, loads and structures, propulsion, operating environment and flight dynamics continued improvements in the safety, efficiency and utility of all classes of military and commercial aircraft. In order to supply industry with advanced data for the design of new aircraft, to seek the technological advances needed to develop safer and superior commercial and military aircraft and to provide the leadership in the generation of advanced aircraft concepts, the Aeronautical Vehicles program is organized with emphasis on the disciplines in the advanced research and technology category and supporting research in appropriate disciplines and proof-of-concept activities for general aviation, V/STOL, subsonic, supersonic and hypersonic aircraft. Proof of concept activity is system integration research whereby full scale operating systems are used to extend laboratory research in system elements. The programs in all 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.

As has been noted in previous program justifications, the XV-5A fan-in-wing aircraft, the tilt-wing XC-142A V/STOL transport and the variable-sweep wing for the F-111 all appeared several years ago as promising NASA research concepts. Now, these aircraft, developed by the military, are part of the NASA's continuing flight research programs aimed at further exploration of the characteristics of such vehicles and for correlation with earlier NASA test results.

The NASA also conducts extensive wind tunnel tests, simulator studies, analyses and flight investigations to aid in the solutions of problems of a developmental nature in support of military and civil aircraft procurement. This work is performed in cooperation with the Department of Defense and other government agencies and with government-sponsored contractors at the request of cognizant government agencies.

Research in the Aeronautical Vehicles program in FY 1969 will include studies directed to improved safety of general aviation aircraft; studies of lightweight propulsion systems for both general aviation and V/STOL aircraft; studies of advanced rotor and STOL concepts to increase the utility of helicopter and short-field aircraft; prototype developmental research directed toward minimizing fan-jet noise radiation and for quieter engines; studies of air-breathing propulsion cycles and engine components for advanced supersonic and hypersonic aircraft; and studies directed toward the overall improvement of flight safety through increasing operational flexibility including adverse or all-weather conditions.

Experimental research and development aircraft and engineering test-pilot proficiency aircraft necessary to carry out and support the aeronautics effort are included under this program.

SUMMARY OF RESOURCES REQUIREMENTS:

	1967	1968	1969
Advanced research and technology......	$3,730,000	$13,440,000	$16,080,000
General aviation aircraft technology supporting research.................	200,000	450,000	520,000
V/STOL aircraft technology supporting research.................	5,550,000	7,417,000	9,600,000
Subsonic aircraft technology supporting research.................	6,100,000	6,780,000	15,100,000
Supersonic aircraft technology supporting research.................	14,040,000	24,175,000	24,220,000
Hypersonic aircraft technology supporting research.................	6,280,000	14,538,000	11,380,000
Total.............................	$35,900,000	$66,800,000	$76,900,000

Distribution of Program Amount by Installation:

	1967	1968	1969
Marshall Space Flight Center........	---	$380,000	$450,000
Jet Propulsion Laboratory...........	$52,000	---	---
Ames Research Center................	6,230,000	8,202,000	10,520,000
Electronics Research Center.........	94,000	---	---
Flight Research Center..............	5,191,000	18,428,000	13,250,000
Langley Research Center.............	12,873,000	23,747,000	25,175,000
Lewis Research Center...............	10,109,000	13,269,000	23,435,000
NASA Headquarters...................	1,351,000	2,774,000	4,070,000

BASIS OF FUND REQUIREMENTS:

Advanced Research and Technology

	1967	1968	1969
Aircraft aerodynamics...............	$700,000	$1,390,000	$2,385,000
Aircraft loads and structures.......	600,000	1,070,000	2,000,000
Air breathing propulsion............	1,000,000	450,000	1,065,000
Aircraft operating environment......	1,430,000*	3,600,000	3,600,000
Aircraft flight dynamics............	---*	1,860,000	1,860,000
Aircraft support....................	---*	5,070,000	5,170,000
Total............................	$3,730,000	$13,440,000	$16,080,000

* Prior to FY 1968 Aircraft operating environment, Aircraft flight dynamics and Aircraft support were called Aircraft Operating Problems.

Aircraft Aerodynamics

Much of the research in aircraft aerodynamics is configuration - dependent and oriented toward a specific class of vehicles and is therefore programmed under the appropriate aircraft technology supporting research area. The balance, of a more fundamental nature or applicable to several aircraft classes, is carried out with aircraft aerodynamics funding under advanced research and technology. This research is a continuing effort on aircraft components and flow fields and associated boundary-layer phenomena throughout the aircraft speed range. It involves the formulation and refinement of applicable theories and calculative methods, the improvement of wind-tunnel capabilities and other experimental techniques and the application of these tools to advanced aircraft technology.

The funds required are for both small and large-scale models, wind-tunnel and model instrumentation and contracts for the operation of several wind tunnels and include the costs of NASA support of wind-tunnel tests for the Department of Defense and the Department of Transportation.

Aircraft Loads and Structures

The loads and structures program area is aimed at a broad spectrum of problems common to several or all types of aircraft since there is a common design goal of lightweight efficient airframes which will withstand the operating environment with reliability and safety. Gust and maneuver loads, acoustic response, wing and tail, and panel flutter, fatigue, composite materials, thermal stresses are all specific problem areas in which research will be conducted.

Atmospheric turbulence effects on structural loads using dynamically scaled models for comparison with analytical results will be determined to evaluate means of suppressing dynamic structural response to this turbulence.

The failure of aircraft structures due to fatigue is a problem of increasing magnitude with the use of higher strength aircraft materials without a corresponding increase in fatigue resistance. The solution of fatigue problems is compounded by the need for real time testing of aircraft materials and components. With the recent occupancy of the new Fatigue Laboratory at Langley, real time fatigue research may be conducted on structural components such as box beams of sufficient size to realistically represent the complexities of actual aircraft structures, funding is thus required for testing equipment, instrumentation and structural components.

Air Breathing Propulsion

The primary goals of this program area are to initiate and conduct investigations of propulsion components and system concepts, either not readily identified with a specific flight spectrum or else identified over a broad flight spectrum. Basic studies are conducted on inlets, compressors, combustors, turbines, nozzles and materials to provide higher ratios of thrust-to-engine weight, higher ratios of thrust-to-engine volume, and lower specific fuel consumption along with minimization of air pollution due to engine operation. Since substantial gains in specific fuel consumption and jet noise reduction are possible with very high bypass ratio engines, the application of methane fuel, which has a higher heating value and higher heat sink capability permitting high turbine inlet temperatures, to this class of engines will be studied.

Basic studies will be continued on lightweight, high speed shafting and gearing, techniques for reducing rotating machinery vibrations, aircraft/propulsion system integration and high frequency response instrumentation for the measurement of engine dynamic characteristics.

Aircraft Operating Environment

The research in this program area is aimed at solving general problems associated with flight environment, flight safety, noise, flight instrumentation and sonic boom. It involves theoretical analyses and laboratory and flight test experiments to validate current engineering procedures and to explore solutions to aircraft operational problems. The results provide the technological know how for safer and quieter aircraft operations and the basic environmental data for application to specific classes of aircraft (for example; V/STOL, subsonic, etc.).

Flight environmental research includes studies of warm air fog modification concepts, investigations of new means for detecting clear air turbulence, the analysis of turbulence data collected on test aircraft flown primarily for other program objectives, and support of National Severe Storms Laboratory programs related to electromagnetic characteristics of severe storms, turbulence intensity/radar reflectivity correlation.

In the flight safety area, the studies of turbine disk burst mechanisms being conducted at the Navy's Aeronautical Engineering Laboratory at Philadelphia using facilities assembled with prior fiscal year funds will be extended to include component part tests of large engines. Fuel ignition research as related to the problem of lightning strikes, the effects of lightning strikes on aluminum, stainless steel and titanium aircraft structural components and on aircraft electrical systems, the possibilities of new inerting systems and fireproofing materials, control of aircraft on wet runways including tire tread design, wheel braking, etc., will be studied.

NASA aircraft noise alleviation research is a continuing effort directed primarily at means of minimizing engine noise at its source. A better understanding of the fundamentals of compressor and fan noise generation will be sought. Fundamental information on the generation and propagation of noise from the exhaust jets of turbofan engines having high ratios of bypass to primary mass flows will be obtained. Particular emphasis will be placed on the low exhaust velocity range where the turbulence level of exhaust jets may be a dominant factor in noise generation, thus the experimental studies will be conducted under carefully controlled laboratory conditions with jet velocity and jet turbulence level as the main variables.

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Aircraft Flight Dynamics

Research in this area is directed toward obtaining a better understanding of the interrelationship between the pilot and the vehicle he controls. This includes improving methods for aircraft control, handling characteristics and the improvement in the capability of ground and flight piloted simulators for handling qualities investigations of all classes of aircraft.

Among the studies planned are investigations to determine the technical feasibility of modifying airplane operational procedures to alleviate noise during take off and landing, to determine airplane control and guidance requirements which could lead to improved operational procedures related to the effects of reduced ceilings in approach and landing, and the study and integration of display requirements and control system criteria for terminal area operations.

Aircraft Support

The NASA Research Centers use various aircraft in direct support of advanced research and technology programs. The maintenance, spare parts and ground support equipment for these R&D aircraft and chase and proficiency aircraft which are used for various missions are included in this funding category.

General Aviation Technology Supporting Research

	1967	1968	1969
Disciplinary research..............	$200,000	$450,000	$520,000
Total...........................	$200,000	$450,000	$520,000

General aviation aircraft are rapidly assuming a position of increasing importance to the economy and are no longer restricted to hobby type flying but include expanding air taxi and charter services which even fly U.S. mail. FAA projections are for a continuing rapid increase in this class of flying in the foreseeable future. The principal factors of concern in general aviation are first, safety and second, utility.

The problem of safety is being aggravated by the fact that, as these aircraft become more a key mode of transport and less a hobby, the typical operator is one who is inclined to spend less time flying just to maintain proficiency. As performance increases, the operator finds himself more often in unfamiliar operational circumstances. The consequences of this are seen in the increasing number of accidents involving aircraft far from home in poor weather and also the number of cases where the pilot cannot deal with power loss.

NASA has examined these problems with industry and with the FAA and agreement has been reached that most of the R&D effort should be directed at examining the flight dynamic characteristics best suited to the class of pilots who are becoming increasingly involved in this type of flying. Attention will be given to wind tunnel and spin tunnel studies in the stall, post-stall gyration and spin modes as well as improved lift systems to ease the approach and landing task in the high performance (executive jet) aircraft class and methods of achieving constant attitude landing flares. The correlation of flight data with wind tunnel data will provide the starting point for prediction of the handling qualities required for improved safety. Various stability and control parameters will be investigated including Dutch-roll damping, adverse yaw and trim compensation.

V/STOL Aircraft Technology Supporting Research

	1967	1968	1969
Disciplinary research..............	$5,550,000	$6,917,000	$9,150,000
Proof of concept:			
Rotating cylinder flap...........	---	500,000	450,000
Total...........................	$5,550,000	$7,417,000	$9,600,000

V/STOL aircraft have a great potential in an increasingly crowded and transportation dependent society. Their success, however, will depend on the ability to land and take off quickly, quietly and precisely from small areas with great regularity. The problem is one of flight dynamics of the aircraft, of matching the machine and the pilot and in providing proper integration of propulsion systems which are for this class of vehicle also a primary means of control. To be successful, a V/STOL machine must efficiently convert its thrust producing power into lift producing power; propulsion and aerodynamics interact strongly and must be accomplished properly to achieve this. The NASA V/STOL supporting research program is therefore defined with these problems as a primary focus. Three lines of endeavor are being followed. First, a very substantial effort, through analysis, simulation and flight test, is being directed at defining those aircraft characteristics which will enable the requirements to be met. Second, those V/STOL types which have been tried are being carefully reexamined in the light of the requirements to identify those having the potential of meeting them through further modification or development. Those concepts which show potential will be subjected to further wind tunnel and flight tests to determine the penalties in complexity and performance which might be incurred. Third, a number of previously untried concepts are to be reexamined in this light.

Disciplinary research in V/STOL aerodynamics will be aimed at providing information primarily through wind tunnel model studies of new or improved V/STOL concepts of interest to the military or for potential commercial use. Studies will continue to gain a better understanding of V/STOL jet interference effects, tunnel wall correction and of ground effects on V/STOL aircraft. In the loads and structures area, studies of tilt rotors, non-articulated rotors and matched stiffness rotors will be continued or initiated. The primary goals of the propulsion oriented research are to provide lightweight, high performance, quick response engines having satisfactory reliability, safety, low noise and economics of operation which can be properly matched to the airframe. Extensive studies will continue to define more adequately the criteria for handling qualities requirements for V/STOL aircraft in the very low speed flight regime where the inherent aerodynamic stability and control is greatly decreased. These studies will use simulators and flight test vehicles as available and appropriate.

Full scale wind tunnel tests have been completed of a model aircraft using a full span rotating cylinder flap as an efficient means of providing the powered lift required for improving propellor driven STOL aircraft. The rotating cylinder flap concept will be tested by modification of an OV-10A aircraft being provided by the Navy.

Subsonic Aircraft Supporting Research

	1967	1968	1969
Disciplinary research..............	$1,700,000	$580,000	$1,850,000
Proof of concept:			
Aircraft noise..................	4,400,000	4,200,000	5,750,000
Quiet research engine............	---	2,000,000	7,500,000
Total..........................	$6,100,000	$6,780,000	$15,100,000

Research on subsonic aircraft is oriented toward safety of flight and the reduction of noise. The class includes all of the commercial jet transports and many military types.

In the disciplinary areas aerodynamics research will be aimed at studying the lift, drag and stability characteristics of aircraft configurations most suitable for improved subsonic/transonic operation. Loads and structures research will examine the specific application of fatigue, buffeting and aeroelastic studies to advanced commercial aircraft. Propulsion research will include an increase in support of long neglected areas for fuel, combustor and engine component efficiency studies to suppress the tendency of jet engines to smoke. The safe climbout and landing techniques for noise minimization, the refinement of flight instrumentation for more accurate measurement of airspeed at transonic speeds and the meteorological environment of particular concern to operations at high transonic speeds will be studied. Flight dynamics research will be concentrated on continuing studies of aircraft control for flight through turbulence and will include both simulator and flight tests. The NASA has the responsibility under the Government's National Clear Air Turbulence program to coordinate studies of pilot aircraft response and to define means of alleviation of this critical flight safety problem area.

As its part of the Inter-Agency Aircraft Noise Abatement program, the NASA has the primary responsibility for the research and development leading to the reduction of aircraft noise at its source. This has involved NASA in proof of concept activities in aircraft noise and the quiet research engine.

The aircraft noise proof of concept supporting research covers the work necessary to provide means for minimizing the noise radiated from the inlet and the fan discharge ducts of turbofan engines such as are now installed in presently operating commercial jet aircraft and research directed toward developing a more positive means for accurate flight path control which would be required to modify current operational landing procedures in order to minimize noise on the ground below the approaching aircraft. The fan compressor noise minimization program was initiated in FY 1967 and in FY 1968 has involved wind tunnel testing design and testing of boilerplate nacelle modifications. In FY 1969 the final nacelle configurations will be constructed for flight proof tests on a 707 type aircraft and on a DC-8 type aircraft to provide a possible means for minimizing their noise output. The programs also include detailed analyses of the impact of such potential modifications on operating costs and efficiency. Flight path control studies will be continued utilizing the 707 prototype aircraft in flight tests to study the concept of direct lift control.

In FY 1968 preliminary work will be carried out to define the scope and some of the hardware components of a quiet research engine. The second phase of this proof-of-concept, to be implemented in FY 1969, will include detailed design work on the engine components and nacelle, small scale and large scale engine component fabrication and full scale tests of compressors and fans designed for minimum noise. The component research will explore the potential noise improvements offered by compressor blade vane spacing and number of blades, tailored suppression nozzles, internal mixing devices and various techniques of achieving low fan compressor tip speeds; such as, slotted fan/compressor blades, variable geometry stators, rotor speed control techniques and such secondary factors as bearing noise all directed toward application to a high bypass (up to 8 to 1) 20,000 pound thrust engine.

Supersonic Aircraft Technology Supporting Research

	1967	1968	1969
Disciplinary research..............	$12,040,000	$14,175,000	$19,220,000
Proof of concept:			
XB-70..........................	2,000,000	10,000,000	5,000,000
Total..........................	$14,040,000	$24,175,000	$24,220,000

In NASA's Aeronautical Vehicles program in supersonic aircraft technology, supporting research is conditioned largely to meet the needs of two national activities associated with civil (SST) and military (FX, VFAX) supersonic aircraft. In general, the NASA program is designed to study potential improvements not incorporated in original designs because of high technical risks, to study problem areas which might be expected to become critical in later stages of vehicle development or operation and to lay the groundwork for new state-of-the-art advances such as the SST or the F-111 have turned out to be.

The program to support the supersonic transport contains three major elements. The first, in direct support of the FAA and its contractors as the development proceeds, provides NASA facilities and/or technical support as detailed technical problems arise at frequent intervals. The second major activity is directed at problem areas which can be anticipated for the future. Among these are studies of the flight dynamics of the proposed design with a view toward aiding FAA in defining what these characteristics must be in detail. Management of an aircraft of this size and speed will represent a wholly new problem except for limited XB-70 experience. NASA considers it of utmost importance to supply this information both to guide development and to form a basis for certification and acceptance. This research involves a substantial number of technical personnel, several sophisticated simulators, in flight and ground based, and forms the principle objective of the XB-70 program. The third major activity is represented by the research directed at advanced or "second generation" supersonic transports. The NASA program is designed to explore the areas of technology which carry the potential of significant performance improvement but presently involve technical uncertainties. The principal area of research is therefore propulsion. Activities of a lesser magnitude are found in aerodynamics where, for example, a search continues for some means of alleviating sonic boom effects, in loads and structures where examination of high temperature composite materials is carried out and in operating environment where we are studying high altitude gust and temperature distributions.

The supersonic aircraft supporting research program contributes much to research in support of the military aircraft such as FX, VFAX, and AMSA. These vehicles also pose problems peculiar to their expected modes of operation. Rapid maneuvering at high speeds imposes problems of inlet-engine interaction. Demands for buffet free high acceleration maneuvers pose new problems in wing/configuration aerodynamics. The requirements for efficient subsonic loiter and efficient supersonic cruise at high and low altitudes create additional problems in aerodynamics.

In FY 1969 measurements of the stability and control characteristics of the XB-70A and the evaluation of its handling qualities throughout the complete flight test envelope will be completed. Special tests will be performed to obtain additional information leading to an explanation of the major differences found between flight measured characteristics and those obtained by theoretical prediction and wind tunnel techniques in FY 1968.

Another area to be explored in FY 1969 is the ground effect on the aerodynamic forces and moments in the landing configuration when close to the ground. This has not been accomplished on an aircraft of this size before. An important structural problem which has been noted during the flight tests of the XB-70 is the relatively large response to turbulence. A modal suppression system will be installed and flight tested to determine possible means of gust alleviation at supersonic speeds.

With the completion of the handling qualities program and the gust alleviation research program the XB-70 flight research program will be completed. The funding requirement for the XB-70, in FY 1969, will be for one-half year. The program is expected to be completed by January 1969.

Hypersonic Aircraft Technology Supporting Research

	1967	1968	1969
Disciplinary research..............	$3,400,000	$4,090,000	$4,780,000
Proof of concept:			
X-15.............................	880,000	3,448,000	---
Hypersonic research engine.......	2,000,000	7,000,000	6,600,000
Total............................	$6,280,000	$14,538,000	$11,380,000

The possibility of achieving sustained, efficient hypersonic flight has not been proven, yet systems analyses of such vehicles based upon best available theory shows it to be a potentially economically sound transport mode. Verification of the theories is required and the NASA research program is designed to provide information against which the adequacy of the theories can be judged. The program is directed first at examining the most fundamental first order assumptions in aerodynamics, propulsion and structures. Questions regarding the soundness of analyses in other disciplines are deferred until these primary answers have been obtained.

The program contains continued studies of the aerodynamics of hypersonic flow, research on the behavior of structures subjected to extreme heating rates and inlet, combustor, nozzle, supersonic mixing, combustion and heat transfer in the propulsion area. Funding is required for wind tunnel models, computer programs, structural specimens and the various components of hypersonic engine technology for tests in the Propulsion Research Laboratory and the Plum Brook Hypersonic Test Facility.

The various experiments currently being carried on the X-15 research aircraft will be completed by the end of FY 1968 or early in FY 1969 and it is not planned to operate the aircraft following the completion of these tests. Therefore no funding is required for the X-15 program in FY 1969.

The hypersonic research engine proof of concept program was initiated in FY 1965 as the result of an obvious need for information relating to propulsion systems operating at hypersonic speed in a real environment. The Garrett Corporation is proceeding with the design and development and construction of one flight weight regeneratively cooled research engine. A boilerplate engine will be under test in FY 1969 at the Ordnance Aerophysics Laboratory in clean air up to Mach 5. The regeneratively cooled engine will be delivered to the Lewis Plum Brook Research Facility for research testing in FY 1970.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1969 ESTIMATES

OFFICE OF TRACKING AND DATA ACQUISITION

TRACKING AND DATA ACQUISITION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

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

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

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

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

The Research and Development appropriation provides funds for: (a) the operation and maintenance of the worldwide facilities, (b) the procurement of equipment and modifications to adapt the facilities for new and changing flight project requirements, and (c) the investigation and development of

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advanced tracking and data acquisition equipment and techniques. The subsequent sections describe plans and related funding requirements to continue the Tracking and Data Acquisition program in each of these areas during FY 1969.

SUMMARY OF RESOURCES REQUIREMENTS:

	1967	1968	1969
Operations	$195,050,000	$213,600,000	$239,800,000
Equipment	62,000,000	49,450,000	52,200,000
Supporting Research and Technology	13,800,000	12,800,000	12,800,000
Total	$270,850,000	$275,850,000	$304,800,000

Distribution of Program Amount by Installation:

	1967	1968	1969
Marshall Space Flight Center	$800,000	$400,000	$300,000
Goddard Space Flight Center	195,800,000	197,350,000	227,300,000
Jet Propulsion Laboratory	51,350,000	57,200,000	55,300,000
Wallops Station	5,750,000	6,400,000	6,800,000
Flight Research Center	1,900,000	2,100,000	2,100,000
Langley Research Center	2,250,000	1,900,000	1,600,000
NASA Headquarters	13,000,000	10,500,000	11,400,000

BASIS OF FUND REQUIREMENTS:

Operations

Manned Space Flight Network	$65,650,000	$70,200,000	$91,500,000
Satellite Network	37,700,000	40,000,000	42,000,000
Deep Space Network	35,500,000	38,600,000	37,000,000
Other Instrumentation	6,500,000	6,500,000	6,700,000
Communications	39,500,000	45,800,000	48,600,000
Data Processing	10,200,000	12,500,000	14,000,000
Total	$195,050,000	$213,600,000	$239,800,000

Manned Space Flight Network Operations

The primary function of the Manned Space Flight Network is to provide tracking, data acquisition, communications, and command support for NASA's manned space flight programs. The Network: (a) provides spacecraft tracking data which are used for orbit and trajectory determination and to initiate and verify orbital maneuvers, (b) receives telemetered information concerning the condition of the astronauts and the performance of the spacecraft, (c) communicates information to control centers in real time for critical decisions, (d) transmits commands to the spacecraft, and (e) records the engineering data from the spacecraft.

In addition to support provided for manned missions, selected stations of the Network provide support to unmanned deep space and earth orbital projects of NASA and the Department of Defense. Based upon requirements for each mission, manned or unmanned, the manned space flight network (MSFN) and other resources of the Office of Tracking and Data Acquisition, such as the Space Tracking and Data Acquisition Network (STADAN), the NASA Communications Network (NASCOM), and the Deep Space Network (DSN), are called upon to provide support. Also providing tracking support, as required, are the Department of Defense (DOD), and the Australian Weapons Research Establishment (WRE).

The Manned Space Flight Network is a worldwide tracking and ground instrumentation system which originated with the Mercury program, was modified and expanded for the Gemini program and has been further modified and expanded for the Apollo program. Completed and fully checked out during FY 1968, the MSFN by December 1967, has already successfully supported three unmanned Apollo missions. Testing and training is continuing to assure readiness for manned orbital and lunar flights.

The Network consists of: (a) ten 30-foot diameter antenna stations located at Cape Kennedy, Florida; Bermuda; Antigua; Ascension; Canary Island; Carnarvon, Australia; Guam; Kauai, Hawaii; Guaymas, Mexico; and Corpus Christi, Texas; (b) three 85-foot diameter antenna stations located at Madrid, Spain; Canberra, Australia; and Goldstone, California; and (c) one transportable 30-foot diameter antenna station presently located at Grand Bahama Island. In addition, five instrumentation ships and eight aircraft, operated by the Department of Defense, and three 85-foot diameter antenna stations of the NASA Deep Space Network will provide support for Apollo. Secondary support will be provided by our NASA station at Tananarive, Madagascar; and by the Department of Defense stations at Point Arguello, California; Eastern Test Range Facilities; and White Sands, New Mexico, using existing equipment.

The station at Canton Island has been phased out and DOD support by two smaller ships used during Mercury, Gemini, and early Apollo flights will be terminated during FY 1968.

The currently planned mission workload will require a limited second shift of personnel at the stations for Apollo support in FY 1969. Leadtimes associated with programming, simulations, and checkout result in overlap between actual mission support and the preparation necessary for subsequent missions. This is beyond the capacity of a single shift of personnel and dictates the buildup for the second shift which is being implemented in FY 1968. The FY 1969 budget includes funds for these additional personnel and is reflected in the increased request over FY 1968 for Manned Space Flight Network Operations.

The second area of increase over FY 1968 is for DOD operational support. The DOD estimates for operating the Apollo ships and the Apollo/Range Instrumentation Aircraft in FY 1969 reflect the first full year of operations for these ships and aircraft. Also included are funds to reimburse the Air Force Eastern Test Range for down-range instrumentation services heretofore provided to NASA without charge. This change is one part of the results of a study which was made by the Bureau of the Budget of the entire Air Force Eastern Test Range operation to determine an appropriate basis for NASA reimbursement to the Eastern Test Range for costs attributable to support of NASA's requirements.

Satellite Network Operations

The primary function of the Satellite Network is to support NASA's unmanned scientific and applications satellite programs. The Network includes the electronic stations of the Space Tracking and Data Acquisition Network (STADAN) operated by the Goddard Space Flight Center, supplemented by the optical camera tracking stations operated by the Smithsonian Astrophysical Observatory. The STADAN stations provide a ground system which: (a) tracks each satellite, (b) determines the status of onboard systems, (c) commands the satellite functions, and (d) acquires stored or real-time data from the satellite. The optical camera tracking stations provide specialized services in precision orbital tracking as well as backup support to STADAN during launch and early orbit tracking of satellites.

STADAN stations are located at Fort Myers, Florida; Mojave, California; Quito, Ecuador; Lima, Peru; Santiago, Chile; Johannesburg, South Africa; Tananarive, Madagascar; Canberra, Australia; Fairbanks, Alaska; St. John's, Newfoundland; Winkfield, England; Rosman, North Carolina; and Toowoomba, Australia. In addition a range and range rate tracking system is located at Carnarvon, Australia, for specialized support.

Fiscal year 1968 marked the beginning of a full year of operating STADAN stations which had previously been modified or augmented to support increased program requirements. Modifications at Rosman, North Carolina, and Mojave, California, plus the new station at Toowoomba, Australia, provided excellent support for the Applications Technology Satellite (ATS) program. At Fairbanks, the station capability--which had been augmented by the addition of a 40-foot antenna and a Range and Range Rate system--provided the increased support required for the observatory satellites.

In FY 1967 and FY 1968, funding constraints required several reductions in the level of support provided to the projects. Operations at the Mojave station have been restricted to ATS support only, only one of three telemetry links at the Quito station is being operated, and the Winkfield station support has been reduced to one telemetry link and launch phase support of OGO. Operations have been reduced at all stations in the optical network and the station in Florida has been closed. Support of some older satellites has been terminated and other satellites are being reviewed for possible termination of support.

For FY 1969, it is planned to operate the network at essentially the same level of support as FY 1968. Since sixteen new satellites are scheduled for launch in FY 1969, there will be additional limitations imposed upon the data acquisition capability of the network even with the support reductions which have been effected. The increased funding required in FY 1969 is related to the operation of special OAO equipment at selected stations, and additional personnel to operate the control center complex at Goddard Space Flight Center.

Deep Space Network Operations

The primary function of the Deep Space Network is to support unmanned lunar and planetary space flight missions. The Network: (a) provides tracking data which are used to determine and make mid-course corrections and terminal maneuvers to spacecraft trajectories, (b) acquires engineering telemetry data concerning performance of the spacecraft, (c) transmits commands to the spacecraft to execute the above functions, and (d) receives and records the scientific data which are acquired from the spacecraft. The network consists of stations located at Goldstone, California; Woomera and Canberra, Australia; Madrid, Spain; Johannesburg, South Africa; Ascension Island; and Cape Kennedy, Flordia. The DSN Ascension Island station will be closed and the remaining elements phased into the MSFN station at Ascension Island starting July 1, 1968.

The control center for the Deep Space Network is the Space Flight Operations Facility (SFOF) located at the Jet Propulsion Laboratory in Pasadena, California. The SFOF: (a) receives information transmitted via ground communications from stations of the Deep Space Network; (b) processes the data; (c) displays the resulting information so that mission directors and associated project personnel can analyze mission performance and make critical decisions in near real time concerning functions to be executed by the spacecraft; and (d) transmits instructions to the stations for commands that must be sent to the spacecraft.

The Deep Space Network workload peaked in the first half of FY 1968 to meet the support requirements of the Lunar Orbiter, Surveyor, Mariner, and Pioneer programs. Completion of the Lunar Orbiter and Surveyor programs is allowing some reductions in the last half of FY 1968 which are reflected in the FY 1969 budget request. Staffing is being reduced at the stations, the SFOF, and in the network engineering area. The computer capability at the SFOF has also been reduced in FY 1968 and will continue at this reduced level in FY 1969.

The flight missions of the Pioneer program will continue through FY 1969. The Mariner Mars flyby missions are scheduled for launch in late FY 1969 and ground support is required well into FY 1970 for these missions. Support is also required for the Mariner V mission early in FY 1969 as it returns to view in its orbit around the sun. In addition, three stations in the Network, one each in Australia, Spain and California, will provide full joint support for the Apollo manned lunar missions. In summary, the Deep Space Network and the SFOF must be staffed and equipped to support five Pioneer, one Mariner V, the Mariner F and G missions, and Apollo during the FY 1969 time period.

Other Instrumentation Operations

Instrumentation systems are operated and maintained in support of sounding rockets and reentry vehicles launched from Wallops Station, Virginia, and the Churchill Research Range, Canada; and for flight research programs of the Flight Research Center, California. General purpose tracking, telemetry, data handling, recording, timing, plotting, and communication systems are provided as well as special purpose fixed and mobile optical and sound ranging (acoustical) equipment.

The instrumentation at Wallops Station is operated by NASA contractors and by other Government agencies such as the Environmental Science Services Administration (ESSA), the National Bureau of Standards, the U. S. Navy, the U. S. Air Force, and the Military Sea Transportation Service. Funds requested for FY 1969 will maintain a required level of effort which closely approximates that of prior years.

Mobile telemetry and optical equipment are maintained and operated along the eastern seaboard to support rocket flights from Wallops Station. This down-range support is funded by Langley Research Center.

Instrumentation at the Churchill Research Range consists of general purpose tracking, telemetry, command and control, and associated systems required to conduct sounding rocket experiments at this high latitude location. The Range is operated under the management of the National Research Council of Canada which shares the costs with NASA as a cooperative effort.

The Flight Research Center operates the Aerodynamics Test Range consisting of facilities at the Edwards Air Force Base and two up-Range sites at Ely and Beatty, Nevada. Programs supported by these facilities include various research aircraft and lifting body projects.

Communications Operations

The global communications system, which links together NASA's tracking stations and control centers, is operated by the Goddard Space Flight Center. Communication switching centers have been established at major locations such as Goddard, London, Honolulu, and Canberra, Australia, to maximize circuit sharing. Requirements in most cases are being met by providing alternate voice/data circuits instead of separate voice and data circuits, thereby reducing the total number of circuits needed.

In the Apollo program, the increased complexity of the missions and the number of vehicles to be supported require real-time centralized mission control. To achieve the required centralized control, it is essential that there be highly reliable and large capacity communications links between a central facility and the remote stations.

These communications links are being provided by satellite as well as conventional means. Communications satellites will provide alternate voice/data and teletype circuits to the Apollo ground stations at Canary Island; Ascension Island; and Carnarvon, Australia, and to the three Apollo insertion/injection ships located in the Atlantic, Pacific, and Indian Oceans.

The FY 1969 budget reflects the cost for providing real-time lunar television coverage from the Apollo spacecraft via the 85-foot antennas at Madrid and Goldstone to the Mission Control Center at Houston, Texas. In addition, new wideband service will be provided to the Madrid tracking complex via the new communications satellite earth station just outside Madrid to replace conventional services with a more reliable direct route. Most of the remainder of the increased budget request is for providing the increased capacity required for the heavier Apollo flight program in FY 1969.

Data Processing Operations

Information received in the form of tracking and telemetry data from satellites and space probes must be processed into a form that is useful to both those performing the real-time control of the space vehicle and those responsible for analyzing the scientific data acquired by the spacecraft.

Tracking data are processed to provide orbital elements which are used to supply stations with predictions on future passes of the spacecraft, and to provide position information that can be used by the scientific experimenters to determine where in the trajectory the scientific measurements were made.

Telemetry data must be processed to: (a) separate the information obtained from the various scientific experiments aboard the spacecraft, (b) consolidate information from each experiment, (c) apply the necessary scaling factors and calibrations of the measuring instruments, (d) determine spacecraft attitude, and (e) correlate these measurements with the position data mentioned above. Processed data are the primary product of the spacecraft missions, and it is through reduction and analyses of these data by the experimenters that a better understanding of space is achieved.

Several projects, particularly those in the Observatory and Geodetic classes, require extensive pre-mission orbit studies, including spacecraft position predictions and mutual visibility analyses. Studies are also required to work out operational methods and procedures to be used during the actual mission operation.

Support must be given to a wide variety of programs which vary from the small University Explorer satellites to the large Solar, Geophysical, and Astronomical Observatories, and the Applications satellites in the fields of communications and meteorology.

The FY 1969 budget request is based upon the workload which will result from previously launched satellites that will require continued support, plus additional satellites that are scheduled to be launched during the period. This will result in an increase in the orbital computations, telemetry data processing, and mission related computer support. The projected telemetry data processing workload, for instance, in FY 1969 is estimated to be about 20% above the FY 1968 workload in terms of numbers of tapes to be processed.

<u>Equipment</u>

	1967	1968	1969
Manned Space Flight Network.....	$27,700,000	$21,650,000	$17,500,000
Satellite Network...............	11,700,000	9,600,000	12,800,000
Deep Space Network..............	7,500,000	9,000,000	12,000,000
Other Instrumentation...........	4,000,000	4,200,000	4,300,000
Communications..................	6,000,000	3,200,000	3,000,000
Data Processing.................	5,100,000	1,800,000	2,600,000
Total........................	$62,000,000	$49,450,000	$52,200,000

Manned Space Flight Network Equipment

In calendar year 1967, implementation of the Apollo support capability was completed at the Manned Space Flight Network land stations at Goldstone, Canberra, Madrid, Canary Island, Antigua, and Grand Bahama Island. Concurrently, modifications of eight Apollo/Range Instrumentation Aircraft (A/RIA) were completed by the Air Force Electronic Systems Division, and three of the five Apollo instrumentation ships were completed by the Instrumentation Ships Project Office of the Navy. Completion of the remaining two, including the satellite communication capability, and final tests of the ships' systems will be accomplished before the end of FY 1968. With the conclusion of these activities, all facilities of the Manned Space Flight Network will have been augmented with the basic capability for Apollo support.

During FY 1968, activity has been increasingly devoted to assuring Manned Space Flight Network readiness to provide effective and reliable support for Apollo. This effort will be continued in FY 1969.

The capability of the Network to accomplish lunar distance tracking has been tested by using Lunar Orbiter spacecraft as tracking targets after completion of their primary scientific mission objectives. These tests with the Lunar Orbiter spacecraft have demonstrated that the operational accuracy of the Network's new Unified S-Band (USB) systems is sufficient for the stringent requirements of the lunar phases of the Apollo mission. The successful support of the recent Apollo 4 (AS-501) mission verified the compatibility of the new network systems with the equally new Saturn V launch vehicle and the Apollo spacecraft.

In addition to validation of the Network's basic capability, a primary goal of the tests with Lunar Orbiter and the early Apollo mission support is to determine any subsystem operational shortcomings and to identify any failure-prone subsystems. This type of effort will continue throughout calendar year 1968 as part of the continuing support of the Apollo earth-orbital missions and through tests with the Test and Training Satellite (TTS-1). The FY 1968 and FY 1969 budgets include funds for the necessary design and implementation of equipment modifications as a result of these tests to assure station and network readiness for effective and reliable support of the Apollo lunar missions.

Replacement of the remaining Gemini pulse code modulation (PCM) systems is the most significant system improvement identified as necessary by analysis of the results of calendar year 1967 test data. These systems, which were designed to support the simpler requirements of the Gemini program, can only be reprogrammed by manual reconfiguration of complex patchboards. Manual repatching is inherently mistake-prone; and, more particularly, the time required for changing the patchboards significantly increases the time required to reconfigure the stations' data systems in accordance with the differing requirements of each Apollo mission phase. The Apollo PCM systems, installed as part of the basic augmentation of the Network for Apollo, are reprogrammed quickly and reliably by using a library of magnetic tapes on which the necessary programs are stored. Funds are included in the FY 1969 budget to replace the remaining Gemini PCM systems with the new Apollo models, and to correct minor deficiencies in equipment capabilities as they are identified in the forthcoming mission support.

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Tracking and data acquisition requirements for missions in the Apollo program vary from mission to mission depending upon mission objectives, flight plans, and the requirement to investigate special problem areas in the spacecraft as they are encountered on the previous flights. In general, it is necessary to make changes in or augment network equipment to enable support of these varying requirements. Such changes are anticipated in all systems areas and funds are requested in FY 1969 for procurement of equipment at the system and module levels to provide for these mission to mission changes.

During FY 1969, the Network will be heavily engaged in mission support. In such an environment, a continuing effort will be necessary to maintain the support capability throughout the flight program. Accordingly, funds are requested in FY 1969 for equipment to be used in the training of station personnel, for minor facilities modifications, and for equipment and services necessary for off-line monitoring and analysis of station and system performance.

The broad spectrum of medical, science, and technology experiments now contemplated for Apollo Applications program (AAP) missions in calendar years 1970 and 1971 will require improvements in data handling capability at the network stations. Currently, most of the stations are equipped with three PCM systems to provide the decommutation capability necessary for Apollo mission control operations. The mission control operations for crucial phases of AAP missions will require the same level of support provided Apollo. Thus, additional PCM systems are required for the increased experiment support required for these AAP missions. Accordingly, funds are included in the FY 1969 budget to provide one additional PCM system at each of the network stations.

Funds also are requested for network support to cover the engineering effort required for system checkout, provision of standard test equipment, continuation of the test and training satellite capability, and reduction of network ADP leasing costs by purchase of computer input/output components used for evaluating network performance during mission operations. Also included are funds for procurement of module spares needed to preclude long periods of station downtime during missions.

Satellite Network Equipment

The equipment program for the Satellite Network in both FY 1968 and FY 1969 has been constrained to a sustaining type effort with emphasis on improved utilization of existing equipment and replacement of older equipment. Funding constraints in FY 1968 have resulted in the deferral of several items into FY 1969.

The major items deferred from FY 1968 have been the Station Technical Operations Control (STOC) consoles which are intended to centralize many of the individual routine operations at the stations. These consoles will provide both a related savings in manpower and a more rapid turnaround time between satellite passes. With a reduced turnaround time, more satellite passes can be supported with existing equipment.

As part of the replacement program, FY 1969 funds are needed to complete the procurement of solid state command transmitters and command encoders. The changeover to solid state devices from the vacuum tube equivalents will be completed with the FY 1969 procurement. Other replacement items include elements of the initial VHF Range and Range Rate tracking antennas to correct deficiencies, broadband feeds for the 85-foot antenna sites, and replacement of the existing command antennas that have been in use since 1960.

To meet specialized or unique mission to mission changes, equipment is needed at both the stations and the control centers. Typical items in this category are wideband receivers for Nimbus-D, sequential decoders for IMP-H, and display/control equipment for ATS-E and OGO-G. In addition, computer peripherals are needed to interface with the recently acquired third generation computer system at Goddard Space Flight Center for mission control of the complex OAO program, for orbit determination of the many and varied satellite programs, and to provide back-up to the Manned Space Flight Network computer complex.

Funds are also included in the FY 1969 request for the more routine types of effort associated with sustaining a global network. These include minor repairs and alterations, test and calibration equipment, and specialized non-expendable spare parts and components.

Deep Space Network Equipment

The FY 1969 budget request reflects an increase over FY 1968 to provide for new capability to meet the more demanding support requirements evolving for the planetary programs in the early 1970's. To meet these requirements, effort will be directed toward the development and testing of various prototype systems which will have general purpose application to the various planetary programs and minimize specialized project equipment requirements.

The long lead time implementation of a high power transmitter capability at the Goldstone 210-foot antenna site has been initiated in preparation for missions in the early 1970's. Procurement of portions of this system was started with FY 1967 funds and will be completed in FY 1969.

A standardized telemetry demodulation system for use by all planetary projects is being introduced into the Network commencing with the Mariner

'69 mission. This system is being procured with FY 1968 and FY 1969 funds.

A prototype system combining the tracking data handling and planetary ranging functions will be developed to fulfill new planetary flight trajectory data requirements. The FY 1969 budget includes funds for the initial procurement of operational units for the ranging portion of the system successfully demonstrated during the Mariner V mission using experimental hardware. The present tracking data handling equipment which was designed some ten years ago is required to be replaced and will be integrated with the ranging system.

In the past, equipment unique to a single project has been used in the DSN for the generation and verification of commands sent to the spacecraft. Prototype general purpose equipment for this function, applicable to future missions, will be used in support of the Mariner '69 mission. This equipment will also provide a direct, automatic command capability from the Space Flight Operations Facility (SFOF) and allows prompt and more reliable recovery action when unplanned flight conditions occur. This capability is not available with the present systems. Funds are included in the FY 1969 budget for the procurement of this equipment.

Other improvements planned for FY 1969 funds in support of the Pioneer and Mariner projects include the installation of advanced, more sensitive, receiving equipment on the 85-foot antennas. Temporary modifications of existing equipment were implemented at two 85-foot antenna sites during FY 1968. These improvements, along with special receiver innovations, increased the support period on Pioneer from 6 to 14 months by allowing the spacecraft to be tracked to considerably greater distances. It is planned to augment the 85-foot antennas sites with permanent similar improvements with FY 1969 funds to insure continued operational reliability.

Also planned for FY 1969 is the procurement of improved cooled cryogenic masers for all stations and operational precision time synchronization equipment at three prime locations. These improvements were originally planned for FY 1968; however, due to the more urgent need to support the new Mariner FY 1969 telemetry data processing requirements, they were deferred.

Estimates included in the FY 1969 request will provide for sustaining the network equipment at the necessary levels of reliability; primarily those systems that have been used extensively for the past several years. Examples include antenna and servo components, calibration and test equipment, recorders, microwave components, cabling, and power generation and distribution equipment which requires repair and replacement due to performance and reliability considerations. In addition, funds are included to accommodate the mission to mission changes, engineering improvements, and the necessary module spares provisioning for ensuring rapid correction of malfunctioning equipment.

Other Instrumentation Equipment

A wide variety of fixed and mobile equipment is used to provide instrumentation support for sounding rockets and reentry vehicles launched from Wallops Station and other locations, and for flight research projects conducted at the Flight Research Center.

At Wallops Station, these funds in FY 1969 will sustain existing capability by the provision of maintenance and spare parts, the procurement of nonrecoverable flight hardware (antennas, transponders, command/destruct receivers, and small test rockets for calibrating ground support equipment) and the replacement of the surplus World War II SPS-12 range surveillance radar by a new Federal Aviation Administration (FAA) developed surveillance radar. To improve utilization of existing capabilities, the mobile range facility will be augmented with equipment to permit reliability checks in the field when the facility is operating in remote areas.

During FY 1969, the Flight Research Center will complete conversion of the Aerodynamics Test Range radar systems from S-band to C-band frequencies. Fiscal year 1969 funds are required for integration of the system into existing instrumentation, and for associated ground support and test equipment. At Langley Research Center, FY 1969 funds are required for completing the updating of telemetry systems initiated in FY 1968.

Communications Equipment

During FY 1968, a major modification was undertaken to equip the switching centers to handle high speed data transmission required for Apollo. The major effort in FY 1969 will be to add this equipment to the Madrid switching center. The addition of Madrid to the high speed data network will permit improved circuit utilization and a relative savings in circuit costs.

Also included in the FY 1969 budget is equipment which will allow automatic measurement and reporting of data circuit characteristics. With increased data speeds of up to 7,200 bits per second, and the need for better quality data, the automatic equipment will be capable of encoding the circuit measurements into standard data impulses suitable for input into computers. Analysis of the measurement and display of the data by computer will allow automatic reporting of circuits whose measured characteristics fall below the standard for data transmission.

The FY 1969 request also includes funds for replacement of equipments for telephone and teletype systems at the overseas stations, for small parts used in the fabrication of prototype assemblies such as monitor and display consoles, and for the spare parts to sustain the network.

Data Processing Equipment

The operational data processing equipment requires a continuing program of minor redesign, modification, and improvement, as well as normal maintenance and repair. While the data processing lines are designed to be as flexible as possible, changes and updating are necessary to meet the requirements of new programs and to accommodate **mission-to-mission** changes within existing programs. Changes are directed toward accelerating the reduction of data and thus preventing the acquisition of new processing lines. The FY 1969 budget includes funds to provide the components necessary for these modifications and improvements.

The FY 1969 increase is required because of the growing data processing workload. The computers used for processing of the telemetry tapes require additional memory units and associated equipment to increase the speed with which data can be processed. The memory capacity of these computers is at the present time the limiting factor in the data processing capability at Goddard Space Flight Center.

Supporting Research and Technology

	1967	1968	1969
New Systems	$644,000	$685,000	$1,350,000
Integrated Systems Analysis, Development, and Test	3,622,000	2,916,000	3,320,000
Antenna Subsystems	1,598,000	1,505,000	1,080,000
Receiving and Transmitting Subsystems	2,426,000	2,481,000	2,250,000
Data Handling and Control	1,822,000	1,920,000	1,580,000
Data Processing and Reduction	1,784,000	1,660,000	2,090,000
Spacecraft Subsystems	1,904,000	1,633,000	1,130,000
Total	$13,800,000	$12,800,000	$12,800,000

The Supporting Research and Technology (SRT) program is aimed at assuring the efficient and effective support of future manned and unmanned space flight missions. The program provides the developments necessary for the orderly augmentation of tracking and data acquisition support systems. In FY 1969, emphasis will be placed on network performance and operations technology. Techniques such as station automation, spacecraft on-board data handling and control, and associated software will be examined with the objective of identifying methods to lower network operations costs and improve network effectiveness for support of future space flight missions. The program for SRT comprises effort in seven task areas as follows.

New Systems

The primary effort in this category will continue to be focused on the Data Relay Satellite System (DRSS). Systems definition studies will continue in FY 1969, and an engineering test model of a phased-array antenna will be built and evaluated for applicability to the DRSS system. In the DRSS concept, a synchronous orbit spacecraft with steerable antenna beams is used to transfer data directly to and from low orbit spacecraft and control centers--an operating technique which could eliminate the need for instrumented aircraft and appreciably reduce ground support costs.

Integrated Systems Analysis, Development, and Test

In this task area, software concepts and hardware models are proven in real or simulated operating environments before being implemented in the network stations and control centers. Studies and tests will continue on the use of digital techniques to determine the optimum level of automation for the station monitoring and control functions. Studies also will continue on techniques for integrating into the networks advanced hardware for data handling and control purposes. Work will continue on metric evaluation and calibration of the Manned Space Flight Network while Apollo operations are underway. Also, a similar "test-while-using" program is underway for the 210-foot diameter antenna at Goldstone to determine operating techniques and the limits of performance capabilities.

Antenna Subsystems

Effort in this category is aimed at three primary objectives: decreasing the time required to change the antenna mode from one mission to another, improving the reliability and reducing the maintenance of large antennas, and more effective utilization of existing support capability through automation and component improvements.

To provide rapid changeover of the antenna mode, concepts involving the use of multiple frequencies and a wideband feed system are being evaluated. To improve the support effectiveness of large steerable antennas, studies will continue on digital techniques to automatically program operations, and to monitor, test, and analyze overall performance.

Receiving and Transmitting Subsystems

Effort in FY 1969 under this task area has several aims: assessment of techniques which aid in automating station operations, support of new modulation requirements, improvement of frequency control and stability at the stations, and evaluation of new transmitting and receiving technology.

The advanced receiver effort will evaluate control techniques for automatic reception of spacecraft tracking and telemetry signals.

Work will also continue on modulation and demodulation techniques and a low cost, highly stable atomic frequency standard for support of interplanetary missions.

Data Handling and Control Subsystems

In FY 1969, work in this category will consist of two primary SRT efforts: The Satellite Network station automation effort aimed at providing this network with a moderate reduction in the level of manual operations and the Deep Space Network effort on data handling and control of future planetary missions.

Because the earth satellite data handling workload is still increasing, more effective handling techniques will continue to be developed and evaluated. Work on subsystems and software includes language, control and display techniques, equipment switching techniques, data analyses and displays programming, and data error detection and correction.

Data Processing and Reduction

An increase in the activity in this area is planned for FY 1969 due to the advanced developments needed in the Deep Space Network to support future planetary mission. New techniques are needed in the control center to accept, process, reduce, and display the increased data flow. Studies, modeling, and development of the advanced data processing system and the associated software will continue in FY 1969.

New innovations for the Satellite Telemetry Automatic Reduction Systems (STARS) data processing lines will be assessed. Techniques will be developed for fulfilling data processing and reduction requirements of missions using advanced coding schemes.

Spacecraft Subsystems

The main objective of this task area is to continue effective support of the flight programs through development of common-usage spacecraft electronic subsystems which correspond with tracking and data acquisition ground systems. Effort will continue in FY 1969 with the objective of decreasing weight and cost, and increasing the performance and reliability of on-board telecommunications subsystems.

For planetary spacecraft where extreme limitations are placed on weight and distance, special techniques will be developed to provide on-board data compression, and a low data rate telemetry link. Also, studies will continue on techniques for acquiring a signal for direct reception from a planetary capsule during its entry phase.

To improve spacecraft subsystems effectiveness and to provide flexibility in the design of earth satellite missions, several on-board components will be developed, such as a unified radio frequency subsystem for S-band, and a spacecraft data system, including processor, logic system, and data storage modules.

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RESEARCH AND DEVELOPMENT

FISCAL YEAR 1969 ESTIMATES

OFFICE OF TECHNOLOGY UTILIZATION — TECHNOLOGY UTILIZATION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

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

SUMMARY OF RESOURCES REQUIREMENTS:

	1967	1968	1969
Identification and Publication	$1,265,000	$1,500,000	$1,600,000
Evaluation	650,000	700,000	800,000
Dissemination	2,085,000	1,600,000	1,400,000
Analysis	1,000,000	200,000	200,000
Total	$5,000,000	$4,000,000	$4,000,000

Distribution of Program Amount by Installation:

	1967	1968	1969
NASA Headquarters	$5,000,000	$4,000,000	$4,000,000

BASIS OF FUND REQUIREMENTS:

Identification and Publication

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

Evaluation

Personnel at NASA installations and research institutes evaluate the new technology so identified, determine its potential industrial utility and prepare reports which are published and made available to the scientific, industrial and academic communities.

Dissemination

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

Analysis

This program element is concerned with the goal of understanding new and improved techniques for managing complex research and development activities. Methods used in achieving this goal include support of research covering the organization and management of large research and development projects, and defining the various roles of the research director in both government and industry.

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