Mr Lilly

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ESTIMATES OF APPROPRIATIONS

FISCAL YEAR 1961

VOLUME II

RESEARCH AND DEVELOPMENT

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT

ESTIMATES OF APPROPRIATIONS

FISCAL YEAR 1961

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Research and Development

[For an additional amount for "Research and Development", as authorized by Public Law 86-12, $16,675,000, to remain available until expended.]

For contractual research, development, operations, technical services, repairs, alterations, and minor construction, and for supplies, materials, and equipment necessary for the conduct and support of aeronautical and space research and development activities of the National Aeronautics and Space Administration; not to exceed [$500] for newspapers and periodicals; and purchase of [thirty-two] passenger motor vehicles, of which [nineteen] shall be for replacement only; [$318,675,000], to remain available until expended[: *Provided*, That no part of the foregoing appropriation shall be available for other items of a capital nature which exceed $250,000 until fourteen days have elapsed after notification as required by law to the Committee on Science and Astronautics of the House of Representatives and the Committee on Aeronautical and Space Sciences of the Senate: *Provided further*, That no part of this appropriation shall be available for payment of salaries of National Aeronautics and Space Administration personnel]

newspapers and periodicals, but

$1,000

other than scientific and technical, trade, or traffic periodicals for official use

sixty

twenty-nine

$621,453,000

:Provided, That $20,000,000 of this appropriation shall be immediately available

(42 U.S.C. 2451 et seq.;

50 U.S.C. 151-160, 511-515;

Supplemental Appropriation Act, 1960; authorizing

legislation to be proposed for 1961.)

Appropriated 1960, $335,350,000 Estimate 1961, [a]$621,453,000

Appropriated (adjusted) 1960, $320,350,000

[a]Includes $92,684,000 transferred in the estimates from "Salaries and expenses, Advanced Research Projects Agency, Department of Defense." The amounts obligated in 1959 and 1960 are shown in the schedule as comparative transfers.

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Standard Form 3a
(Approved by President June 15, 1923 Revised October 28, 1947)

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Use in preparing schedules of obligations accompanying estimates for lump-sum appropriations

Appropriation title:
(C. 130 C. & I. c. flush)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
RESEARCH AND DEVELOPMENT

Program and Financing

	1959 actual	1960 estimate	1961 estimate
Program by activities:			
1. Aeronautical and space research:			
(a) Support of NASA plant	$2,271,100	$11,500,000	$22,000,000
(b) Research grants and contracts	256,950	2,000,000	6,000,000
2. Space flight development and operations:			
(a) Support of NASA plant	613,000	4,000,000	23,000,000
(b) Scientific investigations in space	16,808,332	45,000,000	85,000,000
(c) Satellite applications	233,282	5,000,000	15,000,000
(d) Manned space flight	4,339,192	50,000,000	80,000,000
(e) Vehicle development	21,404,778	90,182,980	98,000,000
(f) Space propulsion technology	5,261,086	25,000,000	52,000,000
(g) Vehicle systems technology	2,972,610	5,000,000	12,000,000
(h) Tracking and data acquisition	911,334	11,000,000	15,000,000
3. Program direction: Support of NASA plant	44,716	1,500,000	2,000,000
Total program costs	55,116,380	250,182,980	410,000,000
4. Supplies or services transferred in (-) without charge, net	-2,408,121	-1,560,931	-1,637,000
Total program costs, funded	52,708,259	248,622,049	408,363,000
	(Memo cost: 21.4)	(Memo cost: 7.9)	(Memo cost: 7.9)	(Memo cost: 7)

U. S. GOVERNMENT PRINTING OFFICE 16—65104-1

Standard Form 3a
(Approved by President June 15, 1923 Revised October 28, 1947)

Appropriation title:
(O. 120 O. & L. a. Smith)

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Use in preparing schedules of obligations accompanying estimates for lump-sum appropriations

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
RESEARCH AND DEVELOPMENT

Program and Financing

	1959 actual	1960 estimate	1961 estimate
5. Relation of costs to obligations: Obligations incurred for costs of other years, net.....	$142,300,252	$132,946,972	$213,000,000
Total program (obligations).....	195,008,511	381,569,021	621,453,000
Financing:			
Comparative transfers from (-) Department of Defense	-19,325,020	-55,182,980	.....
Unobligated balance transferred from "United States scientific satellite," Department of Defense (72 Stat. 433).....	-25,541,282	.....	.....
Unobligated balance brought forward.....	.....	-20,936,041	-20,000,000
Advances and reimbursements from other accounts (-)	.....	-5,100,000	-5,000,000
Unobligated balance carried forward.....	20,936,041	20,000,000	25,000,000
New obligational authority.....	171,078,250	320,350,000	621,453,000
New obligational authority:			
Appropriation.....	$50,000,000	$335,350,000	$621,453,000
Transferred (72 Stat. 433) from--			
"Salaries and expenses, Advanced Research Projects Agency, Department of Defense".....	59,200,000	.....	.....
"Aircraft, missiles, and related procurement, Air Force".....	45,100,000	.....	.....
"Research, development, test, and evaluation, Air Force".....	12,700,000	.....	.....
"Research, development, test, and evaluation, Army".....	4,078,250	.....	.....
Transferred to "Construction and equipment, National Aeronautics and Space Administration" (Public Law 86-213).....	.....	-15,000,000	.....
Appropriation (adjusted).....	171,078,250	320,350,000	621,453,000
(Mono cast: 21.4)	(Mono cast: 7.9)	(Mono cast: 7.9)	(Mono cast: 7)

U. S. GOVERNMENT PRINTING OFFICE 16—35814-4

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
RESEARCH AND DEVELOPMENT

PROGRAM AND PERFORMANCE

This appropriation provides for the contractual costs of research, development, procurement, and operations.

1. Aeronautical and space research--(a) Support of NASA plant.--The increase in 1961 in the requirements for contractual services, supplies, and equipment required in the operation of the NASA research centers results chiefly from the need for providing the laboratories with new specialized types of equipment required for research on problems of space which were not required in prior years when the principal emphasis was on aeronautics.

(b) Research grants and contracts.--The 1961 program contemplates additional support of research on materials and in certain fields, such as the space aspects of medical and biological research, for which the NASA does not have a capability at its own research centers.

2. Space flight development and operations--(a) Support of NASA plant.--Funds are provided in this subactivity for contractual services, supplies, and equipment required in the operation of the NASA space flight development centers, stations, and offices. The increase in 1961 is required to support the increased personnel and workload of these organizations.

(b) Scientific investigations in space.--This provides for an increased scientific program in space in 1961, utilizing sounding rockets, earth satellites, and lunar and planetary probes.

(c) Satellite applications.--Development of meteorological and passive communications satellites will be continued in 1961.

(d) Manned space flight.--The funding included for 1961 is expected to carry the Mercury program into the operational phase. In addition, a supplemental appropriation is anticipated for 1960 and is shown below under Proposed for later transmission.

(e) Vehicle development.--This subactivity provides for the development, fabrication, and launching of advanced space vehicles. Principal emphasis in 1961 will be on the Saturn very high thrust booster vehicle and on the Centaur vehicle with a high-energy upper stage.

(f) Space propulsion technology.--This subactivity funds the development of advanced propulsion techniques and systems for application to future space vehicles. Work will be continued in 1961 on the single chambered 1.5 million pound thrust engine; advanced liquid and solid fuel rocket engines; nuclear rocket and electrical propulsion systems; and nuclear, solar, and electrical auxiliary power supplies for payload applications.

(g) Vehicle systems technology.--Increased funding is provided in 1961 for developing systems and components for midcourse and terminal guidance, and attitude control systems for payload packages.

(h) Tracking and data acquisition.--This subactivity provides for the operation by contract of the Minitrack satellite tracking network, the deep space network, and the special tracking facilities for the Mercury manned space flight program. It also covers costs of data transmission and reduction, and research and development in the fields of tracking, data acquisition, and data handling.

3. Program direction.--This activity provides for the contractual services, supplies, and equipment for the Administration's headquarters and western operations offices.

4. Relation of costs to obligations.--The relationship is derived from year-end balances of selected and applicable adjustment resources as reflected in the following table:

	1958 actual	1959 actual	1960 estimate	1961 estimate
Selected resources at end of year:				
Inventories and items on order:				
Stores (goods unconsumed by projects).....	$2,514,811	$2,375,654	$2,360,642	$3,080,642
Unpaid undelivered orders (appropriation balances obligated for goods and services on order not yet received).....	.....	140,821,634	273,299,471	484,669,471
Advances (payments for goods and services on order not yet received).....	.....	1,515,853	2,000,000	3,000,000

	1958 actual	1959 actual	1960 estimate	1961 estimate
Total selected resources at end of year	2,514,811	144,713,141	277,660,113	490,750,113
Selected resources at start of year (-)		-2,514,811	-144,713,141	-277,660,113
Adjustment of selected resources reported at start of year		101,922	.....	.....
Obligations incurred for costs of other years, net		142,300,252	132,946,972	213,090,000

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Use in preparing schedules of obligations accompanying estimates for lump-sum appropriations

U. S. GOVERNMENT PRINTING OFFICE 16—85604-1

Appropriation title:
(O. 130 O. & L. e. flush)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
RESEARCH AND DEVELOPMENT

Object Classification

	1959 actual	1960 estimate	1961 estimate
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION			
Total number of permanent positions	356	.....	.....
Average number of all employees	150	.....	.....
Number of employees at end of year	356	.....	.....
Average GS grade and salary	11.3 $7,295	.....	.....
Average salary for grades established by the Administrator of the NASA	$4,312	.....	.....
01 Personal services:			
Permanent positions	$1,016,436	.....	.....
Positions other than permanent	1,687	.....	.....
Other personal services	153,870	.....	.....
Total personal services	1,171,993	.....	.....
02 Travel	188,693	.....	.....
03 Transportation of things	9,182	1,485,000	3,993,000
04 Communication services	.....	2,346,500	7,786,000
07 Other contractual services:			
Repairs and alterations	129,878	2,022,022	5,060,000
Miscellaneous services	54,995,270	154,487,332	338,614,000
Services performed by other agencies (Mono cast: 21.4)	91,138,549 (Mono cast: 7.9)	145,182,980 (Mono cast: 7.9)	140,000,000 (Mono cast: 7)

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(Approved by President June 15, 1923 Revised October 28, 1947)

Type size: 6 point, 22 picas

Use in preparing schedules of obligations accompanying estimates for lump-sum appropriations

Appropriation title:
(C. 130 C. & I. c. flush)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
RESEARCH AND DEVELOPMENT

Object Classification

	1959 actual	1960 estimate	1961 estimate
08 Supplies and materials	42,440,520	60,000,000	100,000,000
09 Equipment	2,863,401	16,000,000	26,000,000
11 Grants, subsidies, and contributions	65,914	.....	.....
15 Taxes and assessments	298	.....	.....
Total, National Aeronautics and Space Administration	193,003,698	381,523,834	621,453,000
ALLOCATION ACCOUNTS			
Total number of permanent positions	3	.....	.....
Average number of all employees	2	.....	.....
Average GS grade and salary	6.0 $5,242	.....	.....
01 Personal services:			
Permanent positions	$10,389	.....	.....
Other personal services	149	.....	.....
Total personal services	10,538	.....	.....
04 Communication services	59	.....	.....
07 Other contractual services	1,880,479	30,483	.....
09 Equipment	1,789	239	.....
10 Lands and structures	111,270	14,465	.....
(Mono cast: 21.4)	(Mono cast: 7.9)	(Mono cast: 7.9)	(Mono cast: 7)

U. S. GOVERNMENT PRINTING OFFICE 16—85104-4

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Appropriation title:
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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
RESEARCH AND DEVELOPMENT

Object Classification

	1959 actual	1960 estimate	1961 estimate
11 Grants, subsidies, and contributions	670	.....	.....
Total, allocation accounts	2,004,813	45,187	.....
Total obligations	195,008,511	381,569,021	621,453,000
Obligations are distributed as follows:			
National Aeronautics and Space Administration	$193,003,698	$381,523,834	$621,453,000
Department of the Army	132,836	17,164	.....
Atomic Energy Commission	1,871,977	28,023	.....
(Mono cast: 11.4)	(Mono cast: 7.9)	(Mono cast: 7.9)	(Mono cast: 7)

U. S. GOVERNMENT PRINTING OFFICE 16—83804-1

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

RESEARCH AND DEVELOPMENT PROGRAMS

Page No.	Program	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1960 Supplemental	Fiscal Year 1961
	AERONAUTICAL AND SPACE RESEARCH:				
110	Support of NASA plant.....	$1,097,651	$22,684,000	---	$51,345,000
144	Research grants and contracts.....	3,028,000	4,950,000	---	10,000,000
-	Support of JPL plant.....	8,156,500 1/	---	---	---
	SCIENTIFIC INVESTIGATIONS IN SPACE:				
147	Sounding rockets.....	3,556,170	8,811,000	---	8,000,000
150	Scientific satellites.....	21,305,114	23,813,000	---	41,700,000
154	Lunar and planetary exploration....	31,882,607	49,000,000	---	45,000,000
-	Vanguard.....	21,943,582 1/	---	---	---
	SATELLITE APPLICATIONS:				
158	Meteorology.....	987,550	7,930,000	---	20,700,000
161	Communications.....	3,574,806	3,170,000	---	5,600,000
164	MANNED SPACE FLIGHT.....	46,416,333	74,962,000	$12,200,000	107,750,000
168	VEHICLE SYSTEMS TECHNOLOGY.....	1,903,651	6,737,000	---	21,200,000
	SPACE PROPULSION TECHNOLOGY:				
171	Solid rockets.....	615,898	3,785,000	---	2,800,000
174	Liquid rockets.....	15,978,589	30,328,000	---	63,000,000
177	Nuclear systems technology.....	3,810,496	6,000,000	---	10,000,000
181	Space power technology.....	---	4,814,000	---	8,000,000
	VEHICLE DEVELOPMENT:				
183	Scout.....	6,048,000	2,800,000	---	---
186	Delta.....	12,927,417	13,300,000	---	12,500,000
189	Vega.....	14,291,494	4,000,000	---	---
191	Centaur.....	4,000,000	37,000,000	---	47,000,000
193	Saturn.....	---	---	---	134,308,000
195	TRACKING AND DATA ACQUISITION.....	3,095,674	16,266,000	---	32,550,000
	TOTAL...	$204,619,532	$320,350,000	$12,200,000	$621,453,000

1/ Funded under program activities in 1960 and 1961.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

SUPPORT OF NASA PLANT

Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
$1,097,651	$22,684,000	$51,345,000

1. OBJECTIVES:

To provide funds for certain transportation expenses, leased communication lines, contractual services, repairs, alterations, minor construction, supplies, materials, and equipment required in the operation of all NASA installations.

2. JUSTIFICATION:

A summary table of the funds required under this program is presented on the following page, breakdowns are provided by location and by object of expediture. The major funding increases reflected in the estimates for 1961 are due primarily to the following factors:

(a) Transfer of the development operations division of the Army Ballistic Missiles Agency, Huntsville, Alabama to the NASA.

(b) The expensive and increasingly complex nature of experimental research in general and on space programs in particular.

(c) High initial tool-up costs for accelerated attack on advanced research areas (materials, electrical power generation, hypersonic aerodynamics and control, guidance and navigation).

(d) The addition of a number of major new facilities involving high operating costs (the Lewis Plum Brook research facilities, the Ames 3.5-foot hypersonic tunnel, and the Langley 7-foot thermal structures tunnel).

(e) The large backlog of necessary repair, alteration, and facility modernization projects.

(f) The increasing rate of obsolescence on research equipment and instrumentation.

(g) The substantial increase in the anticipated number of research vehicle firings.

Detailed breakdowns by object of expenditure are presented on pages 110b through 143.

(e) The large backlog of necessary repair, alteration, and facility modernization projects.

(f) The increasing rate of obsolescence on research equipment and instrumentation.

(g) The substantial increase in the anticipated number of research vehicle firings.

Detailed breakdowns by object of expenditure are presented on pages 110b through 143.

SUPPORT OF PLANT - NASA HUNTSVILLE

R&D Appropriation

	Estimates by Object	FY 1961
03	Transportation of Things	$ 2,124,000
04	Communications Services (leased lines)	100,000
	Huntsville to Cape Canaveral	(21,800)
	Huntsville to Goddard Center	(40,500)
	Huntsville to Washington	(37,700)
07	Other Contractual Services	9,773,000
	Major Repairs & Alterations: (480,000)	
	Modif. of aeroballistic building	(120,000)
	Modif. of bldg. to provide additional office space	(120,000)
	Alterations of the mock-up building	(90,000)
	Modif. of the photographic lab.	(60,000)
	Modif. of the vehicle maintenance bldg.	(50,000)
	Modif. of the equip. maintenance bldg.	(40,000)
	Minor Repairs & Alterations: (1,320,000)	
	Automotive equipment & aircraft	(80,000)
	Bldgs, facilities & ground	(700,000)
	Instruments and research equip.	(400,000)
	Shop & office equipment	(40,000)
	Utility installations & process systems	(100,000)
	Miscellaneous Services: (5,370,000)	
	Contractual operation of computing center	(2,600,000)
	Plant & vehicle maintenance	(1,400,000)
	Consulting & engineering services	(300,000)
	Photographic services	(260,000)
	Modif. to bldgs.	(250,000)
	Machine shop & metal fab. svcs.	(240,000)
	Hire of motor vehicles	(170,000)
	Janitorial services	(100,000)
	Graduate study leave tuition	(50,000)
	Services performed by other Government Agencies:	
	Tenant occupancy overhead charge	(2,603,000)
08	Supplies and Materials	4,000,000
	Fabrication	(1,500,000)
	Plant Operations	(300,000)
	Maintenance & Improvements	(1,000,000)
	Office operations	(500,000)
	Report Reproduction	(200,000)

	Estimates by Object	FY 1961
03	Supplies and Materials (cont'd)	$
	Medical Security & Safety	(20,000)
	Rocket Propellants	(330,000)
	Other fuels & lubricants	(150,000)
09	Equipment	2,755,000
	Replacement Equipment: (2,066,000)	
	Scientific & research equipment	(1,737,000)
	Machine tools & shop equip.	(329,000)
	Recurring Equipment: (413,000)	
	Indicating & recording equipment	(298,000)
	Operating & testing equipment	(115,000)
	New Equipment: (276,000)	
	Machine tools & shop equipment	(276,000)
	TOTALS	$18,752,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

SUPPORT OF NASA PLANT

	F.Y. 1959			F.Y. 1960	F.Y. 1961
Analysis by location:	Salaries and Expenses	Research and Development	Total	Research and Development	Research and Development
NASA Headquarters	$1,096,530	$90,047	$1,186,577	$1,683,000	$2,025,000
Langley Center	3,804,425	518,403	4,322,828	5,262,600	9,100,000
Ames Center	2,521,478	---	2,521,478	3,637,000	4,070,000
Lewis Center	3,633,192	187,656	3,820,848	6,256,000	9,180,000
Flight Center	670,328	21,562	691,890	833,600	1,050,000
Goddard Center	107,737	144,700	252,437	4,190,800	6,068,000
Wallops Station	592,693	---	592,693	769,000	1,052,000
NASA Huntsville	---	---	---	---	18,752,000
Western Office	21,772	---	21,772	46,000	35,000
AMRO Office	125	---	125	6,000	8,000
PMRO Office	---	---	---	---	5,000
Wright Office	18	---	18	---	---
Total obligations, 1959	12,448,298	962,368	13,410,666	---	---
New obligational authority, 1960 and 1961	---	---	---	22,684,000	51,345,000
1959 balance available for obligation in 1960	---	135,283	135,283	---	---
Total	$12,448,298	$1,097,651	$13,545,949	$22,684,000	$51,345,000
Analysis by object of expenditure:					
03 Transportation of things	$271,055	---	$271,055	$1,485,000	$3,993,000
04 Communication services	60,313	---	60,313	156,500	336,000
07 Other contractual services	2,200,531	$318,869	2,519,400	6,090,500	17,542,000
08 Supplies and materials	6,513,992	413,061	6,927,053	8,636,000	17,607,000
09 Equipment	3,402,407	230,438	3,632,845	6,316,000	11,867,000
Total	$12,448,298	$962,368	$13,410,666	$22,684,000	$51,345,000

$18,752,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

03 TRANSPORTATION OF THINGS

	F.Y. 1959			F.Y. 1960	F.Y. 1961
	Salaries and Expenses	Research and Development	Total	Research and Development	Research and Development
Analysis by location:					
NASA Headquarters	$35,790	---	$35,790	$200,000	$300,000
Langley Center	81,922	---	81,922	117,400	120,000
Ames Center	26,929	---	26,929	40,000	45,000
Lewis Center	94,796	---	94,796	173,000	300,000
Flight Center	8,806	---	8,806	16,600	9,000
Goddard Center	7,813	---	7,813	916,000	1,012,000
Wallops Station	14,999	---	14,999	20,000	80,000
NASA Huntsville	---	---	---	---	2,124,000
Western Office	---	---	---	1,000	1,000
AMRO Office	---	---	---	1,000	1,000
PMRO Office	---	---	---	---	1,000
Total	$271,055	---	$271,055	$1,485,000	$3,993,000

Analysis by types of transportation:			
Transportation of supplies and equipment	$252,316	$1,455,000	$3,893,000
Drayage and other local transportation	18,739	30,000	100,000
Total	$271,055	$1,485,000	$3,993,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

04 COMMUNICATION SERVICES

Analysis by location:	F.Y. 1959 Salaries and Expenses	F.Y. 1959 Research and Development	F.Y. 1959 Total	F.Y. 1960 Research and Development	F.Y. 1961 Research and Development
NASA Headquarters	$4,524	---	$4,524	$34,000	$40,000
Langley Center	---	---	---	8,500	10,000
Lewis Center	574	---	574	3,000	6,000
Flight Center	52,036	---	52,036	108,000	108,000
Goddard Center	3,179	---	3,179	---	---
Wallops Station	---	---	---	3,000	72,000
NASA Huntsville	---	---	---	---	100,000
Total	$60,313	---	$60,313	$156,500	$336,000

Analysis of leased lines:	F.Y. 1959 Total	F.Y. 1960 Research and Development	F.Y. 1961 Research and Development
NASA Headquarters:			
Washington to Langley Center	$2,012	$3,000	$3,000
Washington to AMRO Office	2,512	3,000	3,000
Washington to Los Angeles, California	---	28,000	32,000
Washington to PMRO Office	---	---	2,000
Langley Center:			
Langley Center to Wallops Station	---	5,000	5,000
Langley Center to Washington	---	3,500	5,000
Lewis Center:			
Cleveland to Plumbrook	574	3,000	6,000

Flight Center:			
X-15 tracking range	$52,036	$108,000	$108,000
Goddard Center:			
Langley Center to Wallops Station	3,179	---	---
Wallops Station:			
Chincoteague to NASA Headquarters	---	---	22,000
Chincoteague to various FAA and Air Force stations, and U. S. Weather Bureau	---	3,000	50,000
NASA Hunstsville:			
Huntsville to Cape Canaveral	---	---	21,800
Huntsville to Goddard Center	---	---	40,500
Huntsville to Washington	---	---	37,700
Total	$60,313	$156,500	$336,000

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

07 OTHER CONTRACTUAL SERVICES

	F.Y. 1959			F.Y. 1960	F.Y. 1961
Analysis by location:	Salaries and Expenses	Research and Development	Total	Research and Development	Research and Development
NASA Headquarters	$553,246	$32,000	$585,246	$1,059,000	$1,200,000
Langley Center	629,588	281,204	910,792	875,200	1,342,000
Ames Center	293,303	---	293,303	767,000	1,125,000
Lewis Center	523,830	---	523,830	1,000,000	1,374,000
Flight Center	126,505	1,885	128,390	135,000	149,000
Goddard Center	2,332	3,780	6,112	1,964,800	2,331,000
Wallops Station	68,825	---	68,825	271,000	235,000
NASA Huntsville	---	---	---	---	9,773,000
Western Office	2,894	---	2,894	18,500	13,000
Wright Office	8	---	8	---	---
Total	$2,200,531	$318,869	$2,519,400	$6,090,500	$17,542,000
Analysis by types of service:					
Repairs and alterations	$1,091,832	$129,878	$1,221,710	$2,012,100	$5,060,000
Miscellaneous services	753,614	176,991	930,605	1,522,400	7,403,000
Services by other Government agencies	355,085	12,000	367,085	2,556,000	5,079,000
Total	$2,200,531	$318,869	$2,519,400	$6,090,500	$17,542,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

REPAIRS AND ALTERATIONS

Analysis by location:	F.Y. 1959 Salaries and Expenses	F.Y. 1959 Research and Development	F.Y. 1959 Total	F.Y. 1960 Research and Development	F.Y. 1961 Research and Development
NASA Headquarters	$6,282	---	$6,282	$10,000	$10,000
Langley Center	469,432	$128,227	597,659	565,200	958,000
Ames Center	160,832	---	160,832	508,500	766,000
Lewis Center	300,759	---	300,759	528,000	669,000
Flight Center	94,493	---	94,493	92,500	60,000
Goddard Center	---	1,651	1,651	107,800	600,000
Wallops Station	58,878	---	58,878	189,500	191,000
NASA Huntsville	---	---	---	---	1,800,000
Western Office	1,148	---	1,148	10,600	6,000
Wright Office	8	---	8	---	---
Total	$1,091,832	$129,878	$1,221,710	$2,012,100	$5,060,000

Analysis by item or category:

NASA Headquarters:

Minor repairs and alterations:

Automotive equipment	$90	$100	$100
Office equipment	6,192	9,900	9,900
Total, NASA Headquarters	$6,282	$10,000	$10,000

	F.Y. 1959	F.Y. 1960	F.Y. 1961
Langley Center:			
Major repairs and alterations:			
Alterations to building to provide office space for Goddard Space Task Group	$103,454	$102,200	---
Modification of transport aircraft	198,740	---	---
Maintenance of grounds	56,706	60,000	$60,000
Maintenance of buildings, structures, and parking lots	---	75,500	75,500
Replacement of hot-water pipe line in West area	---	28,300	---
Construction of Mach 15 helium jet	---	54,400	---
Construction of Mach 13 ceramic-heated jet and velocity computer	---	25,800	---
Construction of 20-mm light-gas gun	---	43,500	---
Replacement of main drive shaft couplings of the Unitary Plan tunnel	---	---	80,500
Modifications to equipment to develop instrumentation for interplanetary orbiting vehicles	---	---	75,000
Improvements to radar equipment for detecting objects during atmospheric reentry	---	---	100,000
Installation of equipment for developing airborne detectors for guidance of intercepter missiles	---	---	100,000
Modifications to equipment to provide measuring devices for reentry heating and thermal radiation	---	---	152,000
Installation of equipment for heat-transfer oblation studies	---	---	120,000
Minor repairs and alterations:			
Automotive equipment and aircraft	2,366	2,500	2,500
Buildings, facilities, and grounds	145,890	80,500	100,000
Instruments and research equipment	49,993	50,000	50,000
Shop and office equipment	21,067	22,500	22,500
Utility installations and process systems	19,443	20,000	20,000
Total, Langley Center	$597,659	$565,200	$958,000

	F.Y. 1959	F.Y. 1960	F.Y. 1961
Ames Center:			
Major repairs and alterations:			
Modification to the 1- by 3-foot supersonic tunnel to increase speed range	$52,144	---	---
Alterations to the 7- by 9-foot supersonic tunnel to increase window area in side walls of tunnel	---	$80,000	---
Modernization of lighting equipment in shop areas	---	60,000	---
Improvements to the power supply in various facilities to permit use of advanced-type instrumentation	---	60,000	---
Painting exterior of the Unitary Plan tunnel	---	50,000	---
Alterations to the 6-foot supersonic tunnel auxiliary air system to provide additional vacuum capacity	---	48,000	---
Modifications to the supersonic free-flight tunnel diffuser to permit use of larger air guns	---	30,000	---
Installation of air conditioning equipment in the Unitary Plan tunnel control rooms	---	29,500	---
Alterations to the supersonic free-flight tunnel to provide additional shop space	---	25,000	---
Installation of a high-pressure air and helium distribution system	---	---	$128,000
Erection of a prefabricated building for storing of military supplies and equipment	---	---	80,000
Modification of the hypervelocity ballistic range to increase test capabilities	---	---	175,000
Alterations to the airplane hangar No. 2 to provide heating facilities	---	---	157,000
Repairs to the fan blades of the 40- by 80-foot tunnel	---	---	85,000
Minor repairs and alterations:			
Automotive equipment and aircraft	1,368	1,000	1,000
Building, facilities, and grounds	34,301	50,000	60,000

	F.Y. 1959	F.Y. 1960	F.Y. 1961
Ames Center (continued):			
Minor repairs and alterations (continued):			
Instruments and research equipment	$20,848	$25,000	$30,000
Shop and office equipment	6,249	10,000	10,000
Utility installations and process systems	45,922	40,000	40,000
Total, Ames Center	$160,832	$508,500	$766,000
Lewis Center:			
Major repairs and alterations:			
Installation of containment vessel for liquid flourine rocket propellant test rig	$29,542	---	---
Installation of computing equipment	50,800	---	---
Maintenance of roads, walks, and parking lots	9,825	$43,000	$40,000
Painting of buildings and structures	7,564	25,000	25,000
Maintenance of grounds	24,971	33,000	33,000
Modification to research apparatus for fuel element experiments	---	25,000	---
Repairs to the 8- by 6-foot supersonic tunnel exhauster	---	28,000	---
Alterations to the 24-foot valve at the Unitary Plan tunnel	---	25,000	---
Modifications to rocket vehicles for research on space landing maneuvers	---	28,000	---
Modifications to B-57 aircraft for propulsion research in zero maneuvers	---	50,000	---
Renovation to building at Plum Brook	---	30,000	---
Installation of transient data playback equipment	---	---	---
Installation of transient data cable	---	45,000	---
Installation of combustion tunnel for studies on solid propellants	---	---	70,000
Alterations to the 10-foot supersonic tunnel for research on problems of take-off and landing of rocket powered vehicles	---	---	35,000

	F.Y. 1959	F.Y. 1960	F.Y. 1961
Lewis Center (continued):			
Major repairs and alterations (continued):			
Installation of equipment for liquid propellant pressurization research	---	---	$40,000
Modifications to test rig for research on gas generator and heat exchanger systems for space vehicles	---	---	80,000
Modification of equipment for research on liquid hydrogen liquid oxygen flow systems	---	---	60,000
Installation of test facility for studies on scale effects of liquid hydrogen fuel tanks	---	---	70,000
Minor repairs and alterations:			
Automotive equipment and aircraft	$269	$500	1,000
Buildings, facilities, and grounds	43,500	40,000	40,000
Instruments and research equipment	76,412	90,500	100,000
Shop and office equipment	17,938	25,000	25,000
Utility installations and process systems	39,938	40,000	50,000
Total, Lewis Center	$300,759	$528,000	$669,000
Flight Center:			
Major repairs and alterations:			
Extension of flight line ramp	---	$40,000	---
Minor repairs and alterations:			
Automotive equipment and aircraft	$3,312	1,000	$3,000
Buildings, facilities, and grounds	29,875	32,000	15,000
Instruments and research equipment	38,860	11,000	25,000
Shop and office equipment	3,927	1,500	4,000

	F.Y. 1959	F.Y. 1960	F.Y. 1961
Flight Center (continued):			
Minor repairs and alterations (continued):			
Utility installations and process systems	$18,519	$7,000	$13,000
Total, Flight Center	$94,493	$92,500	$60,000
Goddard Center:			
Major repairs and alterations:			
Alterations to powerplant building at Langley Center to provide additional space for Goddard Space Task Group	---	$57,800	---
Alterations to Vanguard hangar at Atlantic Missile Range to provide space for Project Mercury space group	---	40,000	$150,000
Construction of electrical substation	---	---	240,000
Erection of security fence	---	---	25,000
Minor repairs and alterations:			
Buildings, facilities, and grounds	$1,651	10,000	180,000
Instruments and research equipment	---	---	2,000
Shop and office equipment	---	---	3,000
Total, Goddard Center	$1,651	$107,800	$600,000
Wallops Station:			
Major repairs and alterations:			
Maintenance of radar tracking equipment	$27,195	$36,000	$36,000
Maintenance of buildings and grounds	---	70,500	70,000
Minor repairs and alterations:			
Automotive equipment and aircraft	4,580	5,000	5,000

	F.Y. 1959	F.Y. 1960	F.Y. 1961
Wallops Station (continued):			
Minor repairs and alterations (continued):			
Buildings, facilities, and grounds	$18,043	$66,000	$68,000
Instruments and research equipment	808	1,000	1,000
Shop and office equipment	212	1,000	1,000
Utility installations and process systems	8,040	10,000	10,000
Total, Wallops Station	$58,878	$189,500	$191,000
NASA Huntsville:			
Major repairs and alterations:			
Modification of the aeroballistics building	---	---	$120,000
Modification of buildings to provide additional office space	---	---	120,000
Alterations of the mock-up building	---	---	90,000
Modification of the photographic laboratory	---	---	60,000
Modification of the vehicle maintenance building	---	---	50,000
Modification of the equipment maintenance building	---	---	40,000
Minor repairs and alterations:			
Automotive equipment and aircraft	---	---	80,000
Buildings, facilities, and grounds	---	---	700,000
Instruments and research equipment	---	---	400,000
Shop and office equipment	---	---	40,000
Utility installations and process systems	---	---	100,000
Total, NASA Hunstsville	---	---	$1,800,000
Western Office:			
Minor repairs and alterations:			
Building maintenance	$1,006	$10,100	$5,500

	F.Y. 1959	F.Y. 1960	F.Y. 1961
Western Office (continued):			
Minor repairs and alterations (continued):			
Office equipment	$142	$500	$500
Total, Western Office	$1,148	$10,600	$6,000
Wright Office:			
Minor repairs and alterations:			
Automotive equipment	$8	---	---
Total, repairs and alterations	$1,221,710	$2,012,100	$5,060,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

MISCELLANEOUS SERVICES

Analysis by location:	F.Y. 1959 Salaries and Expenses	F.Y. 1959 Research and Development	F.Y. 1959 Total	F.Y. 1960 Research and Development	F.Y. 1961 Research and Development
NASA Headquarters	$287,650	$20,000	$307,650	$469,000	$570,000
Langley Center	77,159	152,977	230,136	228,000	246,000
Ames Center	124,306	---	124,306	240,500	252,000
Lewis Center	219,735	---	219,735	467,000	700,000
Flight Center	31,151	1,885	33,036	40,000	85,000
Goddard Center	2,332	2,129	4,461	50,000	131,000
Wallops Station	9,535	---	9,535	20,000	42,000
NASA Huntsville	---	---	---	---	5,370,000
Western Office	1,746	---	1,746	7,900	7,000
Total	$753,614	$176,991	$930,605	$1,522,400	$7,403,000

Analysis by item or category:

NASA Headquarters:

Abstracting services	---	$75,000	$75,000
Building maintenance	$3,554	5,000	5,000
Consultants and management surveys	88,358	20,000	20,000
Exhibits for public information	4,340	50,000	50,000
Graphic and related art services	61,557	100,000	100,000
Microfilming services	---	---	30,000
Miscellaneous items	14,567	20,000	10,000
Photographic and film processing services	58,426	100,000	120,000
Recruiting advertising	40,481	39,000	100,000
Translations of foreign periodicals	36,367	60,000	60,000
Total, NASA Headquarters	$307,650	$469,000	$570,000

	F.Y. 1959	F.Y. 1960	F.Y. 1961
Langley Center:			
Cleaning and laundering services	$10,650	$11,000	$11,000
Consulting services	67,856	40,000	42,000
Graduate study tuition	13,275	40,000	43,000
Hire of motor vehicles	25,349	26,000	26,000
Machine shop and metal fabrication serices	83,932	80,000	90,000
Photographic and film processing services	17,909	20,000	23,000
Recruiting advertising	3,048	3,000	3,000
Rigging and carting services	8,117	8,000	8,000
Total, Langley Center	$230,136	$228,000	$246,000
Ames Center:			
Cleaning and laundering services	$3,289	$5,000	$9,000
Consulting and engineering services	10,906	50,500	55,000
Graduate study tuition	12,545	26,000	30,000
Hire of motor vehicles	786	1,500	2,000
Machine shop and metal fabrication services	17,893	25,000	30,000
Medical services	414	25,000	35,000
Photographic and film processing services	9,537	22,000	30,000
Recruiting advertising	448	500	1,000
Rigging and carting services	14,899	30,000	---
Technical services for maintenance of computing machines	53,589	55,000	60,000
Total, Ames Center	$124,306	$240,500	$252,000
Lewis Center:			
Cleaning and laundering services	$2,787	$24,000	$30,000
Consulting and engineering services	21,965	20,000	30,000
Gas cylinder refilling charges	3,202	3,000	3,000
Graduate study tuition	14,460	15,000	15,000
Machine shop and metal fabrication services	135,127	347,000	460,000
Medical services	17,880	20,000	20,000
Miscellaneous items	7,170	6,000	6,000

	F.Y. 1959	F.Y. 1960	F.Y. 1961
Lewis Center (continued):			
Photographic and film processing services	$3,780	$4,000	$4,000
Recruiting advertising	1,177	2,000	2,000
Removal and disposal of radioactive waste materials	2,000	16,000	120,000
Testing and analysis services	10,187	10,000	10,000
Total, Lewis Center	$219,735	$467,000	$700,000
Flight Center:			
Janitorial services	$26,000	$26,000	$26,000
Machine shop and metal fabrication services	3,291	10,000	55,000
Miscellaneous items	1,970	100	100
Photographic and film processing services	1,775	3,900	3,900
Total, Flight Center	$33,036	$40,000	$85,000
Goddard Center:			
Cleaning and laundering services	---	---	$10,000
Consulting and engineering services	---	---	10,000
Exterminating services	---	---	1,000
Graduate study tuition	---	$5,000	10,000
Hire of motor vehicles	---	---	15,000
Machine shop and metal fabrication services	$4,461	30,000	35,000
Medical services	---	---	2,000
Photographic and film processing services	---	---	3,000
Rigging and carting services	---	15,000	45,000
Total, Goddard Center	$4,461	$50,000	$131,000
Wallops Station:			
Consulting and engineering services	$339	$500	$500
Exterminating services	240	300	300
Graduate study tuition	1,450	1,500	1,500

	F.Y. 1959	F.Y. 1960	F.Y. 1961
Wallops Station (continued):			
Hire of motor vehicles	---	$9,000	$30,000
Machine shop and metal fabrication services	$1,511	2,000	2,000
Photographic and film processing services	3,498	4,000	5,000
Rigging and carting services	2,497	2,700	2,700
Total, Wallops Station	$9,535	$20,000	$42,000
NASA Hunstsville:			
Contractual operation of computing center	---	---	$2,600,000
Plant and vehicle maintenance	---	---	1,400,000
Consulting and engineering services	---	---	300,000
Photographic services	---	---	260,000
Modification to buildings	---	---	250,000
Machine shop and metal fabrication services	---	---	240,000
Hire of motor vehicles	---	---	170,000
Janitorial services	---	---	100,000
Graduate study leave tuition	---	---	50,000
Total, NASA Huntsville	---	---	$5,370,000
Western Office:			
Rental of motor vehicle	$1,192	$1,000	---
Engineering services	100	---	---
Janitorial services	---	2,100	$2,100
Recruiting advertising	---	1,600	1,000
Photographic services	178	2,700	3,400
Miscellaneous services	276	500	500
Total, Western Office	$1,746	$7,900	$7,000
TOTAL, MISCELLANEOUS SERVICES	$930,605	$1,522,400	$7,403,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

SERVICES PERFORMED BY OTHER GOVERNMENT AGENCIES

	F.Y. 1959			F.Y. 1960	F.Y. 1961
Analysis by locations:	Salaries and Expenses	Research and Development	Total	Research and Development	Research and Development
NASA Headquarters	$259,314	$12,000	$271,314	$580,000	$620,000
Langley Center	82,997	---	82,997	82,000	138,000
Ames Center	8,165	---	8,165	18,000	107,000
Lewis Center	3,336	---	3,336	5,000	5,000
Flight Center	861	---	861	2,500	4,000
Goddard Center	---	---	---	1,807,000	1,600,000
Wallops Station	412	---	412	61,500	2,000
NASA Huntsville	---	---	---	---	2,603,000
Total	$355,085	$12,000	$367,085	$2,556,000	$5,079,000

Analysis by agency and type of service:			
Atomic Energy Commission:			
Consulting services	$900	$2,000	$2,000
Department of Agriculture:			
Maintenance of roads and grounds	---	---	$20,000
Department of Commerce:			
Bureau of Standards:			
Research services	111,317	---	---
Calibration of instruments	1,718	2,500	2,500
Patent Board	2,700	3,000	3,000
Weather Bureau:			
Measurements and forecasts	---	60,000	---

Analysis by agency and type of service:	F.Y. 1959	F.Y. 1960	F.Y. 1961
Department of Defense:			
Air Force:			
Contract administration services	---	$210,000	$240,000
Machine shop and metal fabrication services	$426	1,800	3,300
Technical services	2,767	3,200	3,200
Army:			
Contract administration and auditing services	1,975	84,500	107,000
Technical services	3,306	1,500	1,500
Tenant occupancy overhead charges (Huntsville)	---	---	2,603,000
Navy:			
Contract administration and auditing services	---	107,500	155,000
Machine shop and metal fabrication services	69,578	70,000	150,000
Research services	15,000	30,000	---
Technical services	1,438	2,500	3,000
Tenant occupancy overhead charges (Goddard)	6,802	1,813,500	1,336,500
Tenant occupancy overhead charges (Ames)	7,402	16,000	101,000
Department of Health, Education, and Welfare:			
Medical services	1,642	5,000	15,000
Department of the Treasury:			
Bureau of Engraving:			
Technical services	1,831	---	---
General Services Administration:			
Building maintenance	101,063	60,000	60,000
Guard and janitorial services	---	30,000	250,000
Technical services	3,170	3,000	3,000
National Science Foundation:			
Research services	22,050	50,000	20,000
U. S. Information Center:			
Preparation of foreign brochure	12,000	---	---
TOTAL	$367,085	$2,556,000	$5,079,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

08 SUPPLIES AND MATERIALS

	F.Y. 1959			F.Y. 1960	F.Y. 1961
	Salaries and Expenses	Research and Development	Total	Research and Development	Research and Development
Analysis by location:					
NASA Headquarters.....	$191,115	$20,661	$211,776	$240,000	$320,000
Langley Center.....	2,385,304	176,782	2,562,086	3,224,500	5,610,000
Ames Center.....	1,177,031	---	1,177,031	1,500,000	1,500,000
Lewis Center.....	1,994,105	187,656	2,181,761	2,800,000	4,000,000
Flight Center.....	297,161	2,705	299,866	250,000	400,000
Goddard Center.....	---	25,257	25,257	210,000	1,227,000
Wallops Station.....	467,789	---	467,789	405,000	540,000
NASA Huntsville.....	---	---	---	---	4,000,000
Western Office.....	1,352	---	1,352	4,500	6,000
AMRO Office.....	125	---	125	2,000	3,000
PMRO Office.....	---	---	---	---	1,000
Wright Office.....	10	---	10	---	---
Total.....	$6,513,992	$413,061	$6,927,053	$8,636,000	$17,607,000

	F.Y. 1959	F.Y. 1960	F.Y. 1961
Analysis of transactions:			
Procured from appropriated funds:			
Inventory, close of fiscal year	$2,409,710		
Inventory adjustments	101,132		
Inventory, start of fiscal year[1/]	2,308,578	$2,317,413	$2,310,642
On order, not received, start of fiscal year	1,752,905	1,142,166	1,147,000
Net adjustments	188,245	204,000	204,000
Total obligations	6,927,053	8,685,905	17,607,000
Total available for usage	11,176,781	12,349,484	21,268,642
Less inventory, end of fiscal year[1/]	2,317,413	2,310,642	3,030,642
Less on order not received, end of fiscal year	1,142,166	1,147,000	1,307,000
Total usage	$7,717,202	$8,891,842	$16,931,000
Acquired without reimbursement:			
Inventory, start of fiscal year	$105,101	$58,241	$50,000
On order, not received, start of fiscal year	43,940	8,230	12,540
Inventory adjustments	-3,232	---	---
Total acquired	2,328,783	1,557,000	1,637,000
Total available for usage	2,474,592	1,623,471	1,699,540
Less inventory, end of fiscal year	58,241	50,000	50,000
Less on order not received, end of fiscal year	8,230	12,540	12,540
Total usage	$2,408,121	$1,560,931	$1,637,000

1/ Does not include figures for NASA Huntsville Facility.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

USAGE OF SUPPLIES AND MATERIALS

	Fabrication	Plant operations	Maintenance and improvements	Office operations	Report reproduction	Medical, security and safety	Fuels and lubricants: Rocket propellants	Fuels and lubricants: All other	Total
Fiscal Year 1959 (actual):									
Headquarters..	---	---	-	$223,834	---	---	---	---	$223,834
Langley.....	$1,013,851	$697,852	$748,843	102,932	$125,000	$15,052	$51,165	$257,044	3,011,739
Ames.....	413,454	249,587	155,500	117,176	39,100	12,244	---	123,215	1,110,276
Lewis.....	737,114	829,252	122,674	70,549	30,152	17,563	105,886	104,376	2,017,566
Flight.....	83,661	106,242	40,308	11,447	2,243	937	2,850	44,752	292,440
Goddard.....	---	---	---	25,257	---	---	---	---	25,257
Wallops.....	38,799	64,388	46,996	4,253	---	1,293	818,395	60,479	1,034,603
Western.....	---	---	---	1,352	---	---	---	---	1,352
AMROO.....	---	---	---	125	---	---	---	---	125
Wright.....	---	---	---	10	---	---	---	---	10
TOTAL.....	$2,286,879	$1,947,321	$1,114,321	$556,935	$196,495	$47,089	$978,296	$589,866	$7,717,202
Fiscal Year 1960 (estimated):									
Headquarters..	---	---	---	$247,077	---	---	---	---	$247,077
Langley.....	$1,003,675	$679,909	$729,945	100,073	$120,676	$14,717	$458,037	$244,296	3,351,328
Ames.....	468,000	344,000	217,000	120,821	40,000	16,000	150,000	125,000	1,480,821
Lewis.....	650,000	750,000	113,176	80,000	30,000	20,000	1,000,000	200,000	2,843,176
Flight.....	71,000	70,000	30,000	12,000	2,500	1,000	50,000	23,196	259,696
Goddard.....	110,000	---	---	101,093	---	---	---	---	211,093
Wallops.....	120,000	100,000	105,651	15,000	---	3,000	30,000	120,000	493,651
Western.....	---	---	---	3,000	---	---	---	---	3,000
AMROO.....	---	---	---	2,000	---	---	---	---	2,000
TOTAL.....	$2,422,675	$1,943,909	$1,195,772	$681,064	$193,176	$54,717	$1,688,037	$712,492	$8,891,842

USAGE OF SUPPLIES AND MATERIALS - CONTINUED

	Fabrication	Plant operations	Maintenance and improvements	Office operations	Report reproduction	Medical, security and safety	Fuels and lubricants: Rocket propellants	Fuels and lubricants: All other	Total
Fiscal Year 1961 (estimated):									
Headquarters...	---	---	---	$320,000	---	---	---	---	$320,000
Langley.....	$2,141,533	$719,103	$772,024	105,842	$127,633	$15,565	$1,382,921	$258,379	5,523,000
Ames.....	460,000	344,000	210,000	120,000	40,000	16,000	160,000	130,000	1,480,000
Lewis.....	900,000	1,000,000	160,000	80,000	35,000	25,000	1,700,000	200,000	4,100,000
Flight.....	80,000	80,000	60,000	12,000	3,000	1,000	110,000	55,000	401,000
Goddard.....	---	150,000	132,000	100,000	30,000	15,000	---	40,000	467,000
Wallops.....	50,000	150,000	166,000	20,000	---	4,000	30,000	210,000	630,000
NASA Huntsville	1,500,000	300,000	1,000,000	500,000	200,000	20,000	330,000	150,000	4,000,000
Western.....	---	---	---	6,000	---	---	---	---	6,000
AMROO.....	---	---	---	3,000	---	---	---	---	3,000
PMROO.....	---	---	---	1,000	---	---	---	---	1,000
TOTAL.....	$5,131,533	$2,743,103	$2,500,024	$1,267,842	$435,633	$96,565	$3,712,921	$1,043,379	$16,931,000

Definitions of Functional Headings

Fabrication - In-house construction of research models, research set-ups, test vehicles, temporary installations, instruments, and items of equipment.

Plant operations - Operation of all facilities, supporting shops, utility systems, motor vehicles, and aircraft.

Maintenance and improvements - Maintenance, repair, alteration, or improvements to land, buildings, structures, facilities, equipment, roads, utility systems, motor vehicles, and aircraft.

Office operations - Office activities, including drafting, library, and computing functions, and reproduction work not included under "Report reproduction".

Report reproduction - Processing, duplicating, and distributing research reports.

Medical, security, and safety - Execution of health, security, and safety programs.

Fuels and lubricants:

Rocket propellants - Solid and liquid rocket propellants.

All other - Nuclear fuel elements and all fuels and lubricants other than rocket propellants.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

09 EQUIPMENT

	F.Y. 1959			F.Y. 1960	F.Y. 1961
Analysis by location:	Salaries and Expenses	Research and Development	Total	Research and Development	Research and Development
NASA Headquarters	$311,855	$37,386	$349,241	$150,000	$165,000
Langley Center	707,611	60,417	768,028	1,037,000	2,018,000
Ames Center	1,024,215	---	1,024,215	1,330,000	1,400,000
Lewis Center	1,019,887	---	1,019,887	2,280,000	3,500,000
Flight Center	185,820	16,972	202,792	324,000	384,000
Goddard Center	94,413	115,663	210,076	1,100,000	1,498,000
Wallops Station	41,080	---	41,080	70,000	125,000
NASA Huntsville	---	---	---	---	2,755,000
Western Office	17,526	---	17,526	22,000	15,000
AMRO Office	---	---	---	3,000	4,000
PMRO Office	---	---	---	---	3,000
Total	$3,402,407	$230,438	$3,632,845	$6,316,000	$11,867,000
Analysis by class of equipment:					
Replacement equipment	$396,559	---	$396,559	$433,550	$2,684,300
Recurring equipment	1,121,790	$665	1,122,455	1,820,350	2,847,850
New equipment	1,884,058	229,773	2,113,831	4,062,100	6,334,850
Total	$3,402,407	$230,438	$3,632,845	$6,316,000	$11,867,000

Equipment acquired without reimbursement:	F.Y. 1959	F.Y. 1960	F.Y. 1961
Atomic Energy Commission	$37,812	$32,000	$32,000
Department of Defense:			
Air Force	5,334,338	2,571,000	2,571,000
Army	660,570	160,000	160,000
Navy	709,070	442,000	442,000
Other	12,239	11,000	11,000
Total	$6,754,029	$3,216,000	$3,216,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

REPLACEMENT EQUIPMENT

Analysis by location:	F.Y. 1959 Salaries and Expenses	F.Y. 1959 Research and Development	F.Y. 1959 Total	F.Y. 1960 Research and Development	F.Y. 1961 Research and Development
NASA Headquarters	$61,110	---	$61,110	$10,000	$10,000
Langley Center	84,095	---	84,095	183,300	185,000
Ames Center	179,473	---	179,473	136,850	207,400
Lewis Center	33,772	---	33,772	40,000	107,000
Flight Center	33,363	---	33,363	30,000	40,000
Goddard Center	---	---	---	11,400	21,900
Wallops Station	3,247	---	3,247	22,000	47,000
NASA Huntsville	---	---	---	---	2,066,000
Western Office	1,499	---	1,499	---	---
Total	$396,559	---	$396,559	$433,550	$2,684,300

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

REPLACEMENT EQUIPMENT

	Scientific and research equipment	Utility systems, service, and safety equipment	Machine tools and shop equipment	Automotive and other mobile equipment	Drafting offices, and reproduction equipment	Total
Fiscal Year 1959:						
NASA Headquarters..	---	---	---	$1,500	$59,610	$61,110
Langley Center.....	---	$2,408	$9,845	16,896	54,946	84,095
Ames Center.....	$45,401	2,567	98,944	9,806	22,755	179,473
Lewis Center.....	1,449	1,462	2,043	17,649	11,169	33,772
Flight Center.....	9,854	6,310	7,200	7,326	2,673	33,363
Goddard Center.....	---	---	---	---	---	---
Wallops Station....	---	---	735	2,000	512	3,247
Western Office.....	---	---	---	1,499	---	1,499
Total.....	$56,704	$12,747	$118,767	$56,676	$151,665	$396,559
Fiscal Year 1960:						
NASA Headquarters..	---	---	---	---	$10,000	$10,000
Langley Center.....	---	$2,000	$2,000	$64,300	115,000	183,300
Ames Center.....	$80,000	2,500	30,000	2,800	21,550	136,850
Lewis Center.....	1,000	1,000	2,000	21,000	15,000	40,000
Flight Center.....	10,000	7,000	8,000	4,000	1,000	30,000
Goddard Center.....	---	---	---	11,400	---	11,400
Wallops Station....	---	3,000	4,500	12,500	2,000	22,000
Total.....	$91,000	$15,500	$46,500	$116,000	$164,550	$433,550

Fiscal Year 1961:	Scientific and research equipment	Utility systems, service, and safety equipment	Machine tools and shop equipment	Automotive and other mobile equipment	Drafting office, and reproduction equipment	Total
NASA Headquarters..	---	---	---	---	$10,000	$10,000
Langley Center.....	---	$10,000	$20,000	$105,000	50,000	185,000
Ames Center.....	$112,000	3,000	65,000	3,900	23,500	207,400
Lewis Center.....	76,000	1,400	2,000	12,600	15,000	107,000
Flight Center.....	15,000	10,000	10,000	4,000	1,000	40,000
Goddard Center.....	---	---	---	21,900	---	21,900
Wallops Station....	---	4,000	5,000	34,900	3,100	47,000
NASA Huntsville....	1,737,000	---	329,000	---	---	2,066,000
Total.....	$1,940,000	$28,400	$431,000	$182,300	$102,600	$2,684,300

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

RECURRING EQUIPMENT

Analysis by location:	F.Y. 1959 Salaries and Expenses	F.Y. 1959 Research and Development	F.Y. 1959 Total	F.Y. 1960 Research and Development	F.Y. 1961 Research and Development
Langley Center	$437,380	---	$437,380	$482,700	$1,180,000
Ames Center	239,570	---	239,570	280,000	300,000
Lewis Center	372,891	---	372,891	470,000	525,000
Flight Center	57,880	---	57,880	65,000	78,000
Goddard Center	---	$665	665	500,650	305,850
Wallops Station	14,069	---	14,069	22,000	46,000
NASA Hunstsville	---	---	---	---	413,000
Total	$1,121,790	$665	$1,122,455	$1,820,350	$2,847,850

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

RECURRING EQUIPMENT

	Indicating and recording equipment			Operating and testing equipment			
	Electrical and electronic	Mechanical and hydraulic	Photographic and optical	Electrical and electronic	Mechanical and hydraulic	Optical	Total
Fiscal Year 1959:							
Langley Center.....	$327,582	$5,970	$42,675	$58,454	$495	$2,204	$437,380
Ames Center.....	131,882	22,463	18,532	36,920	18,904	10,869	239,570
Lewis Center.....	152,139	48,811	5,127	23,652	131,523	11,639	372,891
Flight Center.....	36,895	---	7,425	13,560	---	---	57,880
Goddard Center.....	665	---	---	---	---	---	665
Wallops Station....	---	240	8,565	5,264	---	---	14,069
Total.....	$649,163	$77,484	$82,324	$137,850	$150,922	$24,712	$1,122,455
Fiscal Year 1960:							
Langley Center.....	$369,700	$9,000	$20,000	$80,000	$1,000	$3,000	$482,700
Ames Center.....	150,000	25,000	25,000	40,000	25,000	15,000	280,000
Lewis Center.....	200,000	60,000	5,000	30,000	160,000	15,000	470,000
Flight Center.....	40,000	3,000	8,000	14,000	---	---	65,000
Goddard Center.....	465,650	---	35,000	---	---	---	500,650
Wallops Station....	4,000	500	10,000	6,500	500	500	22,000
Total.....	$1,229,350	$97,500	$103,000	$170,500	$186,500	$33,500	$1,820,350

Fiscal Year 1961:	Indicating and recording equipment			Operating and testing equipment			
	Electrical and electronic	Mechanical and hydraulic	Photographic and optical	Electrical and electronic	Mechanical and hydraulic	Optical	Total
Langley Center....	$836,000	$10,000	$110,000	$220,000	$1,000	$3,000	$1,180,000
Ames Center.....	150,000	25,000	25,000	50,000	25,000	25,000	300,000
Lewis Center.....	250,000	60,000	5,000	30,000	160,000	20,000	525,000
Flight Center.....	47,000	5,000	8,000	18,000	---	---	78,000
Goddard Center....	285,850	---	20,000	---	---	---	305,850
Wallops Station...	6,000	1,000	28,000	9,000	1,000	1,000	46,000
NASA Huntsville...	223,000	35,000	40,000	80,000	15,000	20,000	413,000
Total.....	$1,797,850	$136,000	$236,000	$407,000	$202,000	$69,000	$2,847,850

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

NEW EQUIPMENT

Analysis by location:	F.Y. 1959 Salaries and Expenses	F.Y. 1959 Research and Development	F.Y. 1959 Total	F.Y. 1960 Research and Development	F.Y. 1961 Research and Development
NASA Headquarters	$250,745	$37,386	$288,131	$140,000	$155,000
Langley Center	186,136	60,417	246,553	371,000	653,000
Ames Center	605,172	---	605,172	913,150	892,600
Lewis Center	613,224	---	613,224	1,770,000	2,868,000
Flight Center	94,577	16,972	111,549	229,000	266,000
Goddard Center	94,413	114,998	209,411	587,950	1,170,250
Wallops Station	23,764	---	23,764	26,000	32,000
NASA Huntsville	---	---	---	---	276,000
Western Office	16,027	---	16,027	22,000	15,000
AMRO Office	---	---	---	3,000	4,000
PMRO Office	---	---	---	---	3,000
Total	$1,884,058	$229,773	$2,113,831	$4,062,100	$6,334,850

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

NEW EQUIPMENT

	Scientific and research equipment	Utility systems, service, and safety equipment	Machine tools and shop equipment	Automotive and other mobile equipment	Drafting office, and reproduction equipment	Total
Fiscal Year 1959:						
NASA Headquarters..	---	---	---	$3,450	$284,681	$288,131
Langley Center.....	$38,066	$91,006	$46,632	3,713	67,136	246,553
Ames Center.....	512,260	25,643	48,636	---	18,633	605,172
Lewis Center.....	481,459	57,430	50,012	---	24,323	613,224
Flight Center.....	88,349	6,012	5,509	5,499	6,180	111,549
Goddard Center.....	---	2,324	2,210	1,800	203,077	209,411
Wallops Station....	---	6,514	3,180	---	14,070	23,764
Western Office.....	---	---	---	---	16,027	16,027
Total.....	$1,120,134	$188,929	$156,179	$14,462	$634,127	$2,113,831
Fiscal Year 1960:						
NASA Headquarters..	---	---	---	$1,500	$138,500	$140,000
Langley Center.....	$211,000	$70,000	$40,000	---	50,000	371,000
Ames Center.....	778,150	35,000	75,000	---	25,000	913,150
Lewis Center.....	1,629,600	30,000	60,400	25,000	25,000	1,770,000
Flight Center.....	207,500	8,500	13,000	---	---	229,000
Goddard Center.....	369,000	15,000	30,000	56,950	117,000	587,950
Wallops Station....	---	8,000	3,000	---	15,000	26,000
Western Office.....	---	---	---	1,500	20,500	22,000
AMRO.....	---	---	---	---	3,000	3,000
Total.....	$3,195,250	$166,500	$221,400	$84,950	$394,000	$4,062,100

Fiscal Year 1961:	Scientific and research equipment	Utility systems, service, and safety equipment	Machine tools and shop equipment	Automotive and other mobile equipment	Drafting office and reproduction equipment	Total
NASA Headquarters..	---	---	---	---	$155,000	$155,000
Langley Center.....	$417,500	$80,500	$120,000	---	35,000	653,000
Ames Center.....	735,000	50,000	90,000	$7,600	10,000	892,600
Lewis Center.....	2,710,000	30,000	80,000	33,000	15,000	2,868,000
Flight Center.....	224,700	8,500	25,000	3,800	4,000	266,000
Goddard Center.....	655,000	47,000	143,000	90,250	235,000	1,170,250
Wallops Station....	---	10,000	7,000	5,900	9,100	32,000
NASA Huntsville....	---	---	276,000	---	---	276,000
Western Office.....	---	---	---	---	15,000	15,000
AMRO Office.....	---	---	---	---	4,000	4,000
PMRO Office.....	---	---	---	1,500	1,500	3,000
Total.....	$4,742,200	$226,000	$741,000	$142,050	$483,600	$6,334,850

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

RESEARCH GRANTS AND CONTRACTS

Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
$3,994,510 1/	$4,950,000	$10,000,000

1. OBJECTIVES:

To utilize most effectively the non-governmental research talent and facilities of the nation for the conduct of fundamental and applied research necessary for advancing aeronautical and space technology.

2. JUSTIFICATION:

In order to keep pace with the nation's growing space program it is necessary that an increase in funds be made available to permit the NASA to utilize, through the medium of research grants or contracts, the services of the scientific personnel of the nation's universities and other non-governmental research establishments. It is only through this mechanism that the services of some of the nation's most eminent scientists may be utilized to assist in the solution of existing urgent problems in aeronautical and space technology, and to conduct the long-range fundamental research investigations that provide the knowledge upon which future programs may be based. This procedure also permits the Government to utilize unique facilities that exist outside its own laboratories for the solution of urgent problems.

Particular attention must be given not only to encouraging work by existing groups but also to aiding in the establishment of new centers in the nation's universities for research in the space sciences.

1/ Includes $966,510 provided under "Salaries and Expenses".

Shortly after the establishment of the NASA, a program of long term support was initiated in the universities by means of research grants. Where appropriate, research type contracts were developed for utilization in the support of research that was applied in nature. The continuation and expansion of these programs during the fiscal year 1960 has shown that the NASA has developed the facility for handling this type of program with a high degree of satisfaction to the universities and research centers involved and in a manner that promotes the best interests of the Government. To keep pace with the growing needs of the nation's space programs, $10,000,000 is required for the fiscal year 1961, as follows:

Physical sciences: Research is required on numerous problems in the areas of physics, chemistry and mathematics. The investigation of the physics and chemistry of solids is of the first order of importance in the search for improved materials. Of equal importance is the investigation of the physical and chemical phenomena of high-temperature gases. At the speeds and densities encountered in space operations, the gases are subjected to a number of relatively unexplained phenomena such as dissociation and ionization. These and many other similar problems in the physical sciences should be extensively explored.

Cosmological sciences: The inaccessibility of space prior to the launching of satellites and space probes requires that investigations in the planetary sciences (astrophysics and astronomy) be accelerated. These are areas of great importance about which comparatively little is known. Although major efforts in these fields will be carried on by the space flight development programs of the NASA, there are numerous problem areas involving cosmic rays, planetary mapping by radar techniques, and trajectory calculations, to which the universities, the traditional centers of fundamental research in the nation, are in a position to make important contributions.

Bioscience: During the fiscal year 1960 an intensive study of the NASA's role in the biosciences is being undertaken. The problems confronting man in traveling through space are becoming well known and the first steps of the NASA to cope with this important problem area have been initiated. There are numerous problems in biophysics, bioengineering, metabolism, behavior, and space environment. The attention of the nation's biomedical scientists can be directed toward these problems through support of their work by research grants.

Engineering sciences: Engineering research in the field of energetics, electromagnetics, fluid mechanics, materials technology, mechanics, systems analysis and control, and flight operations is required to bring about urgently needed improvements in both the performance and the efficiency of the extremely complex systems required for space flight. For example, in the field of energetics, it is important that an increased effort be devoted to research on new means of energy conversion and utilization from nuclear or solar sources, or possibly from matter in space, if certain of the required space missions are to be performed.

Socio-economic studies: Man's exploration of space poses many social and economic problems that require study. The exploration of these problems is necessary to permit sound policy determinations to be made in future space age planning.

Miscellaneous: The NASA research associateship program administered by the National Academy of Sciences and the advice and counsel provided by the Space Science Board of the National Academy of Sciences are invaluable adjuncts to the NASA's space effort.

3. PROGRAM COSTS:

	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Physical sciences.....	$1,057,853	$1,000,000	$2,500,000
Cosmological sciences.....	638,164	900,000	2,000,000
Biosciences.....	---	1,250,000	2,000,000
Engineering sciences.....	1,796,275	1,050,000	2,500,000
Socio-economic studies.....	41,818	250,000	500,000
Miscellaneous.....	460,400	500,000	500,000
TOTAL.....	$3,994,510 1/	$4,950,000	$10,000,000

1/ Includes $966,510 provided under "Salaries and Expenses".

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

SOUNDING ROCKETS

Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
$3,556,170	$8,811,000	$8,000,000

1. OBJECTIVES:

To determine and understand the composition, structure, spatial distribution, dynamical behavior, and equilibria of the earth's atmosphere; to investigate the interactions of incident electromagnetic and particle radiations with the earth's atmosphere, including solar-terrestrial relationships; to determine and understand the relations between the earth's upper atmosphere and its surface meteorology; and to carry out exploratory geophysical and astrophysical investigations leading to later satellite and deep space probe experiments.

2. JUSTIFICATION:

A sounding rocket is a rocket used to carry a scientific payload to a height of up to one earth's radius, i.e. about 4,000 miles. The sounding rocket affords a means of investigating the earth's atmosphere in vertical cross section out to the distance at which the atmosphere merges with the medium of interplanetary space. Both exploratory and routine experimental programs are possible with relatively simple tracking ranges and launching sites. Many investigations of atmospheric structure, composition, ionization, motions, aurora, air glow, absorption of solar radiation, and interactions with cosmic rays and other particles can best be conducted by means of sounding rockets, particularly at altitudes below those at which satellites can remain in orbit. Moreover many sounding rockets are easily and quickly launched from shipboard or other special sites on short notice for the investigation of sporadic phenomena such as the aurora, magnetic storms, and solar flares. The

sounding rocket also provides a means of testing under actual operating conditions equipment intended for later use in satellites or deep space probes, thus providing a check on the equipment before it is committed to the much more expensive vehicles. The current NASA program is based on experience gained from 13 years of rocket soundings, and is a program designed to extend and to fill in the gaps in the knowledge so far acquired on the earth's upper atmosphere and in rocket astronomy.

Operationally, the NASA rocket sounding program divides into 3 parts: (a) "low altitude" soundings up to 100 kilometers (60 miles), (b) "medium altitude" soundings reaching to 400 kilometers (250 miles), and (c) "high altitude" soundings above 400 kilometers, extending to one or several thousands of miles. Part (a) is directed toward completing our knowledge of the lower atmosphere, and includes detailed measurements and synoptic studies of geographical and temporal variations in atmospheric properties, with particular interest in relations of the higher atmosphere to surface meteorology. Part (b) involves the study of the high atmosphere, with particular emphasis on the ionosphere and solar-terrestrial relationships. This portion of the program also includes rocket astronomy. Part (c) involves the study of the outer portions of the earth's atmosphere and the fringe regions where the atmosphere merges into interplanetary space. Work in this portion of the program is still in its beginning stages, and measurements in the immediate future will be of an exploratory and survey nature, laying the groundwork for more detailed and precise observations later on.

3. PROGRAM PHASING:

In the fiscal year 1959 a large part of the work was devoted to the analysis of data obtained during the International Geophysical Year. In addition, work was started on the development and preparation of advanced instrumentation for continuing the rocket sounding program. Examples of this instrumentation include the development of a new type of magnetometer and the development of new types of mass spectrometers, pressure gages, and ionospheric instrumentation. During this fiscal year about 35 sounding rockets of the low and medium altitude types were procured for the sounding rocket program. Both low altitude and medium altitude soundings were conducted.

During the fiscal year 1960 the analysis of data obtained from sounding rocket flights in continuing. The medium altitude sounding program is being greatly strengthened and the rate of soundings increased. The development of advanced instrumentation begun in the fiscal year 1959 is continuing. About 75 sounding rockets are being procured and their payloads funded. Most of these are of the fiscal year 1960 altitude range, but some high altitude rockets are included. By the end of the fiscal year 1960 the rate of rocket soundings will attain a level of about 90 rockets per year. A beginning is being made in the performance of outer atmosphere experiments, using such vehicles as the Jason and Javelin rockets.

The funds requested for the fiscal year 1961 will permit the continuation of the rocket sounding program at the level of about 90 rockets per year, including purchase of the necessary rockets, preparation of the payloads, and analysis of the results. Development of advanced instrumentation will continue. In addition to continuing the low and medium altitude work vigorously with about 70 rockets, the high altitude soundings will be stepped up, with particular emphasis on the outermost portions of the ionosphere, interactions between the ionosphere and the radiation belt, studies of the aurorae, and studies of the earth's magnetic field.

4. PROGRAM COSTS:

	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Advanced technical development:			
Scientific and technical studies.....	$220,000	$711,000	$500,000
Development of advanced instrumentation.....	420,000	2,100,000	1,300,000
Flight research program:			
Sounding rockets.....	1,380,000	3,100,000	3,200,000
Payloads.....	1,536,170	2,900,000	3,000,000
TOTAL.....	$3,556,170	$8,811,000	$8,000,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

SOUNDING ROCKETS

Objectives

A sounding rocket is a rocket which rises to a maximum altitude of 4,000 miles (one earth's radius) and then falls back to the earth. The primary use of sounding rockets is for the scientific exploration of the upper atmosphere. Tasks for which sounding rockets are particularly suited are:

1. Direct measurements of atmospheric conditions above the maximum attainable balloon altitude and below the minimum useful satellite altitude; that is 20 to 125 miles.

2. Measurements of vertical atmospheric cross-sections over any altitude range.

3. Simultaneous measurements (synoptic observations) above a number of selected locations, possibly timed to coincide with some unusual event such as a solar flare.

4. Upper air measurements which require a very large payload power level for only a short period of time.

5. Experiments which require the recovery of film after a short exposure at altitudes up to several thousand miles.

Sounding rockets are used to determine the nature, structure, and behavior of the atmosphere and its interactions with incident radiations and particles, particularly those from the sun; and to measure radiation arriving from other celestial bodies, from above the obscuring and distorting lower atmosphere which handicaps all earth-bound astronomers. In addition, sounding rockets are used for the extremely valuable purpose of testing equipment before its use in the far more costly

satellites and space probes. The relative simplicity of the launching facilities required by sounding rockets is a distinct advantage. Launchings are planned from the Arctic (Fort Churchill, Canada) and from the Southern Hemisphere (Australia), as well as from the NASA facility at Wallops Island, Virginia, to achieve better world wide coverage.

The $8,000,000 requested in the fiscal year 1961 budget for the Sounding Rockets program will provide for its continuation at about the level established during the International Geophysical Year and maintained in the NASA schedule for the second half of fiscal year 1960 and the first quarter of fiscal year 1961. This level of 90 to 100 rockets per year, as shown in the schedule, will provide for the continuation of the planned research program in the scientific areas of aeronomy (atmospheric physics) and astronomy, which each consume roughly one-third of the rockets; and in the areas of energetic particles, magnetic fields, and ionospheric physics, which each consume about one-tenth of the rockets. The special problems category includes rockets which are used for several scientific areas jointly, or for a project which does not fit into any one of those areas. This NASA space research program using sounding rockets is coordinated closely with the NASA scientific satellite and space probe research programs, and with the upper atmosphere research programs of other U. S. agencies, to form a unified national program of scientific space exploration.

Sounding Rocket Schedule

Scientific Area	Fiscal Year 1960 (Quarters)		Fiscal Year 1961 (Quarters)			
	3	4	1	2	3	4
Aeronomy.....	5	6	13	13	9	9
Astronomy.....	6	8	8	8	6	6
Energetic particles.....	2	6	2	1	3	2
Magnetic fields.....	-	5	1	-	2	3
Ionospheric physics.....	2	2	2	2	2	2
Special problems.....	10	3	3	1	2	2
Total.....	25	30	29	25	24	24

Scientific and Technical Studies

The sounding rocket program costs are divided between the advanced technical development and flight research programs. Under the former category is included $500,000 in the fiscal year 1961 for scientific and technical studies. These studies include long lead time theoretical and laboratory investigations of the probable nature of the upper atmosphere and the radiant energy incident upon it. They are based on past experimental and theoretical research, and lead to an increasingly accurate picture of this region of space and to new experiments based on this new knowledge. The funds for the fiscal year 1961 are to be devoted to the areas of upper atmospheric composition and circulation, and of the problems associated with mapping the celestial sources of ultraviolet radiation, which were just discovered during the IGY. It may be noted that the ionosphere and plasma investigations studies which were funded in the fiscal year 1960 have moved directly into the payload area in the fiscal year 1961, because the basic instrumentation development required prior to launching payloads in these scientific disciplines has been completed.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Composition upper atmosphere.....	$160,000	---	---
Energetic particles study.....	40,800	---	---
Gas composition study.....	19,200	$85,400	$174,500
Winds and diffusion (sodium).....	---	256,000	125,500
Plasma environment measurements.....	---	137,700	---
Ionosphere current measurements.....	---	40,000	---
Ultraviolet mapping experiment.....	---	100,000	200,000
Ionosphere propagation measurement.....	---	91,900	---
Total.....	$220,000	$711,000	$500,000

Development of Advanced Instrumentation

The second item under advanced technical development is the development of advanced instrumentation, for which $1,300,000 is being requested in the fiscal year 1961. The decreased amount in this category in the fiscal year 1961 reflects the fact that the fiscal year 1960 program funded much of the basic first generation scientific and technological support instrumentation. As shown in the table, five tasks will be completed with fiscal year 1960 funds, including the $561,000 development of the important nuclear emulsion recovery vehicle (Nerv). Only two new tasks, the development of upper atmospheric wind instrumentation and of an Aerobee rocket aspect control system, will be initiated with the fiscal year 1961 funds.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Neutron sensors	$100,000	---	---
Magnetometer	75,500	---	$80,000
Magnetic mass spectrograph	124,500	---	120,000
Video recorder	120,000	---	---
Telemetering and range instrumentation	---	$200,000	200,000
Antenna development	---	50,000	50,000
Dovap development	---	100,000	100,000
Dovap trailer	---	20,000	20,000
Development of photographic probe for meteorological study	---	68,000	30,000
Energetic particle instrumentation for micrometeorite detection system	---	250,000	70,000
Coronagraph	---	16,000	20,000
Rocket aspect control system (Aerobee)	---	---	50,000
FM transistor telemeters	---	50,000	50,000
Telemetering and range instrumentation integration	---	110,000	150,000
Development of ultra-high vacuum system	---	120,000	50,000
Development of total pressure gage	---	50,000	50,000

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Upper atmospheric wind instrumentation.....	---	---	$50,000
Gas diffusion pump.....	---	$40,000	---
Gas analyzer.....	---	20,000	---
Atmospheric structure instrument development	---	195,000	100,000
Sweep frequency receiver.....	---	50,000	---
Ultraviolet scattering densitometer.....	---	50,000	30,000
Design, development and construction of micrometeorite detection system.....	---	60,000	---
Rocket borne antenna development.....	---	50,000	50,000
Development of Nerv package.....	---	561,000	---
Development of electrometers.....	---	40,000	30,000
Total.....	$420,000	$2,100,000	$1,300,000

Sounding Rockets

The fiscal year 1961 amount of $3,200,000 requested for sounding rockets is at about the same level as the fiscal year 1960 allocation. It will be noted that instead of purchasing a few of each type of rocket every year, rocket purchases are concentrated to buying larger quantities of fewer types in any given year to secure the economics of purchasing in larger quantities. This is particularly applicable to the Arcon, Nike, Asp, and Cajun types, which cost less than $10,000 apiece, and which are kept "in stock" for use as needed. Approximately ten percent of the fiscal year 1961 sounding rocket funds are devoted to improvements of the Argo D-8, Aerobee 150A, and Arcon rockets which have been found to be necessary for their most efficient employment in the research program. The average cost per sounding rocket is $27,000, which will allow 120 rockets to be purchased with the requested funds. This number provides one backup rocket for every five launching attempts, to achieve about 100 successful launchings. The cost per individual rocket ranges from a low of $6,000 for the Arcon, which carries 30 pounds to 65 miles, to a high of $50,000 for the Javelin, which carries 90 pounds to 700 miles.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
20 Nike-Asp boosters	$50,000	---	---
X-248 A6 rockets	135,000	---	---
12 Honest John rockets	90,000	---	---
24 Nike rocket motors	60,000	---	---
5 Aerobee-100 rockets and boosters	160,000	---	---
7 Aerobee-300 third stages	50,000	---	---
15 Aerobee-Hi rockets and boosters	450,000	---	---
20 Aspan rockets	140,000	$3,900	---
5 Javelin rockets and 7 vehicles	245,000	68,900	---
15 Aspan rockets	---	103,500	---
22 Nike-Cajun rockets	---	123,200	---
2 Nike motors	---	5,000	---
47 Aluminum-plastic laminate Aspan rockets	---	279,500	---
4 Skylark rockets	---	150,000	---
4 Argo D-8 rockets	---	580,000	---
6 Argo D-4 rockets	---	300,000	---
25 Aerobee-Hi rockets and boosters	---	750,000	---
Development of aluminum-cased Nike-Asp vehicle	---	480,000	---
Improvement and modification of various sounding rockets	---	103,000	---
Development of Iris sounding rockets	---	141,500	---
Wind tunnel tests of Aerobee vehicles	---	11,500	---
35 Nike-Asp rockets	---	---	$332,500
24 Nike-Cajun rockets	---	---	137,500
5 Skylark rockets	---	---	180,000
4 Argo D-8 rockets	---	---	560,000
12 Argo D-4 rockets	---	---	600,000
10 Arcon rockets	---	---	60,000
30 Aerobee-Hi rockets and boosters	---	---	900,000

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Design and development of Argo D-8 payload housing.....	---	---	$30,000
Development of improved Argo D-8 fin.....	---	---	50,000
Development of motor shedding system.....	---	---	150,000
Incorporation of de-spin system for Aerobee 150-A.....	---	---	100,000
Development of aluminized grain super Arcon	---	---	100,000
Total.....	$1,380,000	$3,100,000	$3,200,000

Payloads

A total of $3,000,000 is required in the fiscal year 1961 to construct the payloads for the rocket sounding program. These payloads will permit a number of rocket firings in each of the major areas of research: (1) solar physics and astronomy; (2) energetic particles and magnetic field soundings; (3) ionospheric soundings; and (4) atmospheric soundings. A concentrated effort in solar physics and astronomy is necessary to collect the basic research information required to support the detailed design efforts on the orbiting astronomical observatories (future earth satellites). The rocket studies of primary particles will include investigation of the true nature of cosmic rays from galactic space and the search for new fundamental particles. Further investigations of the nature of the particles creating the aurora will be carried out with rocket flights from Fort Churchill. The payloads for these flights require accurate pointing controls and recovery systems to return films and photographic emulsions exposed to free space. The instrumentation for the ionospheric and atmospheric soundings will include accurate densitometers, ion probes, particle spectrometers and other experiments to probe the ionospheric region in a systematic manner. Some of these experiments will be selected to correlate with satellite experiments. Special perturbations relating to sudden ionospheric disturbances and explosive warming will also be investigated with rockets.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Solar physics and astronomy:			
Solar pointing controls.....	$99,700	$60,000	$60,000
Stellar pointing controls.....	---	51,000	154,000
De-spin mechanism (Nike-Asp).....	---	---	20,000
Ultraviolet spectrographs.....	---	---	90,000
Stellar structure instrumentation.....	---	50,000	80,000
Grating spectrometers for rockets.....	---	97,000	50,000
Aspect control systems.....	7,800	34,000	140,000
Photomultipliers and optical filters....	---	15,000	50,000
Synoptic solar radiation payload integration.....	---	69,300	47,000
High-speed electrometers.....	---	25,000	50,000
Ultraviolet detectors.....	---	34,000	50,000
Field services.....	---	---	20,000
Coronagraph.....	---	---	30,000
Solar radiation instrumentation.....	---	100,000	120,000
Rocket optical system.....	---	25,000	40,000
Detectors (photo emissive and ionization).....	---	75,000	45,000
Densitometer.....	---	10,000	---
Energetic particles and magnetic field sounding:			
Nuclear emulsion recovery vehicle (Nerv)	275,000	150,000	115,000
Engineering support for Nerv.....	62,700	200,000	150,000
Nuclear emulsions.....	---	69,500	95,000
Energetic particle instrumentation for Nike-Asp.....	---	250,000	70,000
Magnetometer fabrication.....	28,700	60,000	30,000

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Ionospheric soundings:			
Ionospheric probe equipment and fabrication	$86,100	$118,000	$117,000
Electronics and payload integration	82,300	---	40,000
Electrometers	---	40,000	---
Conductivity nose cones	---	50,000	---
Electric field meters	---	15,000	---
Atmospheric soundings:			
Rocket mass spectrometers	---	27,400	56,000
Photographic probe for meteorological study	---	68,000	30,000
E-region structure electronics	---	---	40,000
Coincidence micrometeorite detection system	---	20,000	20,000
Density gages	---	---	80,000
Payload engineering and support:			
Telemetry and tracking:			
Airborne antennas	49,900	---	---
Radar beacons	200,000	40,000	40,000
Dovap (receivers and service contract)	100,000	25,000	50,000
Telemeter (DKT-7, SMT-10)	49,600	89,400	120,000
PPM (telemeter and calibration)	50,000	50,000	50,000
Cut-off receivers	---	130,000	130,000
Engineering:			
Small rocket payload fabrication	101,000	100,000	100,000
High pressure valves	27,500	---	---
Payload structure integration	---	186,000	170,000

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Instrumentation integration.....	---	$56,400	$29,000
Aspect cells, commutators, and spare parts.....	---	50,000	42,000
Design and construction of rocket instrumentation sections.....	---	160,000	100,000
Data analysis:			
Magnetic tape recorders.....	$20,970	---	---
Data reduction and trajectory analysis..	294,900	300,000	280,000
Total.....	$1,536,170	$2,900,000	$3,000,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

SCIENTIFIC SATELLITES

Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
$21,305,114	$23,813,000	$41,700,000

1. OBJECTIVES:

To determine the nature, extent, and dynamical behavior of the earth's outer atmosphere, and its relation to the medium of interplanetary space; to determine and understand the nature, extent, dynamical behavior, and causes of the earth's ionsphere; to understand the nature, extent, and temporal variations in the gravitational, magnetic, and electric fields in the vicinity of the earth; to understand the origin, nature, motions, spatial distributions, and temporal variations of particles reaching the vicinity of the earth and having energies appreciably greater than thermal; to investigate the electromagnetic radiations in all wavelengths, from gamma rays to radio waves, that reach the vicinity of the earth from the planets, sun, stars, galaxies, and interstellar and intergalactic matter, and to use these observations to extend our knowledge of these bodies; to determine and understand the interrelationships among the above listed phenomena; to determine and understand the environmental conditions encountered in the upper atmosphere and in interplanetary space, and the effects on vehicles traversing these regions, including effects on materials, equipment, and living organisms; and to determine and understand possible departures from the laws of classical physics which may be demonstrated under conditions of satellite flight.

2. JUSTIFICATION:

The projects under this program support the above objectives by providing for the continuation of a series of exploratory measurements followed by more advanced experiments. The exploratory measurements in new areas are intended to give order of magnitude estimates of the quantities under investigation and to probe for new discoveries. The advanced ex-

periments are designed to make accurate measurements within the ranges indicated by the earlier investigations. The knowledge to be gained will lead to a better understanding of the earth and man's environment and consequently to a better use of the environment to man's benefit. In this connection, it must be recalled that the surface meteorology of the earth, the propagation characteristics of radio waves, the auroras, the radiation belts, and other geophysical phenomena are closely related to the sun and the interactions of the sun and the earth. The proper investigation of these interrelations requires observations and measurements at the outermost portions of the earth's atmosphere, for which the artificial earth satellite provides an indispensable and highly effective tool.

3. PROGRAM PHASING:

In the fiscal year 1959 the analysis of results obtained from Explorer and Vanguard satellites was continued. A Vanguard satellite designed to furnish cloud cover information was placed in orbit. The development of advanced instrumentation for the measurement of cosmic rays, the application of accurate clocks to relativity experiments, radio beacons, electron density Langmuir probes, and for the measurement of solar ultraviolet radiation was initiated. Funding was initiated for the purchase of seven Juno II vehicles and one Thor-Able to be used in the launching of satellites. The construction and testing of payloads for these vehicles was initiated.

The analysis of earlier satellite results is continuing in the fiscal year 1960. Development of instrumentation is being undertaken for the measurement of atmospheric pressures, densities, temperatures, composition, and winds; and work is continuing on the Langmuir probe instruments and on the development of special satellite magnetometers. Funding is being largely completed during the fiscal year 1960 for the Juno II vehicles and the one Thor-Able vehicle for which procrement was started in 1959. The preparation of payloads for these vehicles for launching in the fiscal year 1960 and early in the fiscal year 1961 is continuing along with the proparation of the payloads for the scientific satellites to be launched by Delta vehicles the last half of the the fiscal year 1961 and the first half of the fiscal year 1962. The Thor-Able satellite Explorer VI, the Vanguard III satellite, and the Juno II satellite Explorer VII were launched and have already yielded valuable scientific results on the Van Allen radiation belt, the magnetic field of the earth, cosmic rays, micrometeorites, and solar-terrestrial phenomena, and, in addition, an elementary one-line television scanner was checked out.

Fiscal year 1961 funds will be used to initiate the funding and procurement of two Atlas-Agena B and two Thor-Agena B vehicles and their payloads, and to procure seven Scout vehicles and four payloads. Three of the Scout vehicles are for the international program. The Thor-Able, Juno II, and Delta vehicles which have been used to this time are being replaced in the programming by the newer and more powerful Atlas-Agena B and Thor-Agena B vehicles. The Atlas-Agena B will be capable of launching satellites into very high altitude elliptical orbits and of launching heavier satellites into low altitude circular orbits. The Thor-Agena B will be used to launch lighter satellites into low and medium altitude orbits. The Scout is a versatile, solid propellant rocket capable of placing 200 pounds into a 300 mile orbit. The higher payload capacity of these vheicles makes it possible to install more scientific instrumentation in each payload for making more measurements simultaneously, thus increasing the value of each set of data.

The experiments planned for the fiscal year 1961 will provide information on atmospheric and ionospheric composition; atmospheric structure and dynamics; ionospheric structure and dynamics; the radiation belt and its associated magnetic field; the earth's magnetic field; and on meteoroid and other environmental factors affecting materials. An Atlas-Agena will be used to launch the orbiting astronomical observatory satellite into a circular orbit of about 500 miles altitude. This satellite will be stabilized in inertial coordinates and will be instrumented to perform astronomical observations not possible on the earth due to the interference presented by the earth's atmosphere. Another Atlas-Agena will be used to launch the orbiting geophysical observatory satellite into a highly elliptical polar orbit extending as far as 60,000 miles from the earth. This satellite will be instrumented with radiation counters, magnetic field instruments, and various detectors and equipment designed to obtain a description of the earth's atmosphere and environment from pole to pole and from a few hundred to 60,000 miles in space.

One Thor-Agena will be used to launch a solar geophysical satellite equipped with a pointing control and instruments for studying solar phenomena, and instruments for making terrestrial observations simultaneously. A Thor-Agena will also be used to launch the polar geophysical satellite into a low altitude circular polar orbit. This satellite will be instrumented for the determination and comparison of atmospheric and ionospheric structure, properties and composition, and for measurements of energetic particles and the magnetic field of the earth from equatorial to polar regions.

One Scout and its payload will be devoted to a detailed study of the radiation belt especially with respect to biological implications. Another Scout payload will be a satellite launched into a 300-mile polar orbit for studies of the interactions and interrelationships of the earth's atmosphere, magnetic field, and the energetic particles of cosmic rays, the radiation belt, and auroras. Other Scout payloads will probe the atmosphere and ionosphere to distances of 6,000 miles in studies of atmospheric composition and structure, and ionospheric charged particles distributions.

It should be pointed out in connection with program phasing that the purchase of vehicles and the initiation of preparation of payloads are both long leadtime items. Thus, vehicles purchased in one year are fired one or two years from the date of purchase. Similarly, the payloads for these vehicles must be started one or two years in advance of the actual launching.

4. PROGRAM COSTS:

	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Advanced technical development:			
Scientific and techincal studies.....	$1,155,114	$1,500,000	$2,000,000
Development of advanced instrumentation.....	1,520,000	3,061,000	6,000,000
Flight research program:			
Juno II vehicles.....	8,540,000	5,100,000	---
Thor-Able vehicle.....	2,120,000	727,000	---
Atlas-Agena B vehicles.....	---	---	3,000,000
Thor-Agena B vehicles.....	---	---	3,000,000
Scout vehicles.....	---	---	3,500,000
Satellite payloads.....	7,970,000	13,425,000	24,200,000
TOTAL.....	$21,305,114	$23,813,000	$41,700,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

SCIENTIFIC SATELLITES

Objectives

Scientific satellites are satellites launched into orbits about the earth for the purpose of performing scientific research investigations of the upper atmosphere and the phenomena of space. Satellites launched for technological applications or for highly specialized activities, such as meteorology or communications, are not included. Satellites offer the opportunity of performing investigations over large regions of space and for long periods of time, in excess of one year if required. Satellites also make it possible to perform many astronomical observations, including studies of our own sun, which were not possible earlier from ground-based or balloon-borne observations due to the absorbing effects of the earth's atmosphere.

The fundamental objective of the scientific satellite program is the expansion of human knowledge of phenomena in the atmosphere and space. This objective encompasses two fundamental questions of universal interest. One of these deals with the nature and origin of the universe, and the other is concerned with the major role that the sun exerts over the natural physical processes of the earth and its atmosphere. The sun is the principal source of energy for the earth. Daily and seasonal effects of the sun on the earth and its atmosphere have been observed for centuries. Satellites now offer the opportunity of studying the energy output of the sun before it reaches and is partially absorbed by the earth's atmosphere. Likewise, satellites make it possible to perform direct observations and measurements in the region of the upper atmosphere where the sun's energy produces some of its primary effects. In this connection, it must be recalled that the surface meteorology of the earth, the propagation characteristics of radio waves, the auroras, the radiation belts, and other geophysical phenomena are the results of interactions of the sun's energy with the earth and its atmosphere. Ultimately, the knowledge acquired through space research will lead to a better understanding of the earth and its relations to our solar system and the universe, and to a fuller understanding of the relations of man to his environment.

The research program is considered in terms of scientific disciplines for purposes of program planning. These disciplines are: (1) the atmosphere; (2) the ionosphere (the ionosphere is a region of electrically charged particles in the upper atmosphere produced by the sun and which exert a major role over radio communications); (3) energetic particles (auroral phenomena, cosmic rays, the radiation belts); (4) magnetic and electric fields; (5) astronomy. Each of these five major disciplines includes many separate research problems. Equally important are research investigations into the various relations that exist between and among these discipline areas. The scientific experiments and the payloads for the satellites are assigned under this discipline plan. The following table shows the launching schedule and the booster vehicles of the present program and that planned under this budget request. The next section describes the satellites to be initiated under this budget and also those for which work is already in progress. The total number of satellites involved is 22.

Scientific Satellite Schedule

Vehicles	Fiscal Year 1960 (Quarters)		Fiscal Year 1961 (Quarters)				Fiscal Year 1962	Fiscal Year 1963	Total
	3	4	1	2	3	4			
Juno II.....	1	-	1	2	-	-	-	-	4
Scouts.....	-	1	1	-	-	-	5	2	9
Delta.....	-	-	-	1	1	-	3	-	5
Thor-Agena B.....	-	-	-	-	-	-	1	1	2
Atlas-Agena B....	-	-	-	-	-	-	-	2	2
Total.....									22

Eight new satellites are planned under this budget. These will be launched in 1962 and 1962 and 1963. Four of these are quite large and require Atlas or Thor-Agena B boosters for launching. The remaining four, although considerably lighter in weight, are still heavier than any scientific satellite which NASA has yet launched. These four will be placed in orbit by Scout vehicles.

Superficially, the total of 22 scientific satellites from the last half of the fiscal year 1960 through the fiscal year 1963 seems to be quite large. However, an examination of the number of scientific areas to be explored, while remembering that the Juno payloads average less than 50 pounds, indicates that this is a very small program in view of the immensity and complexity of the task. Actually, no more than one major effort is made each year in any principal field of investigation. For instance, in one of the most important of these problems, the radiation belts around the earth, only three satellites with the major objective of investigating these recently discovered phenomena can be scheduled in these 3 1/2 years.

Four Juno II satellites, five Delta satellites, and two Scout vehicles and payloads are under way at this time. The Juno II satellites now under construction are:

Radiation belt satellite, Juno II, 3rd quarter, fiscal year 1960: This satellite is a continuation of the program of investigation of the radiation belts and will extend the results obtained by the earlier Pioneer probes and Explorer satellites. A light payload of 20 pounds is being used to extend the orbit to the highest possible altitudes to ensure that most of the depth of the belts can be reached.

Ionosphere direct measurements satellite, Juno II, 1st quarter, fiscal year 1961: This is one of 3 satellites in a program with the major objective of arriving at an understanding of the ionosphere through a concentrated program of determinations of the detailed nature and the phenomena of the ionosphere and the effects of the ionosphere upon space vehicles and radio transmissions. This satellite will contain instrumentation to determine the concentration and the spectrum of the charged particles forming the ionosphere and the effects of the ionosphere on the satellite and its radio transmissions. Payload weight - 85 pounds.

Gamma ray astronomy satellite, 2nd quarter, fiscal year 1961: This will be the first satellite experiment to measure cosmic gamma radiation. Later experiments in larger satellites will be based on the findings obtained by this exploratory experiment. Scientists hope that a better understanding of gamma rays will contribute to the solution of one of the mysteries of modern science, the nature and origin of cosmic rays. Payload weight - 80 pounds.

Ionosphere beacon satellite, 2nd quarter, fiscal year 1961: Analysis of the effects of the ionosphere upon radio signals generated by the satellite will be used to determine the spatial distribution and the variations with time of the charged particles forming the ionosphere. In addition, very valuable direct information about the composition of the ionosphere in the immediate region of the satellite will be obtained. Payload weight - 100 pounds.

Five Delta-launched satellites will follow the Juno program. As with the Junos, each satellite makes a strong attack upon a specific problem in one of the scientific disciplines:

Solar spectroscopy satellite, Delta, 2nd quarter, fiscal year 1961: The first major satellite with the objective of measuring the electromagnetic radiations of the sun from above the absorbing curtain of the earth's atmosphere. An automatic pointing control will be used to keep the scientific instruments trained on the sun during the periods of observation. Payload weight - 300 pounds.

Advanced radiation belt satellite, Delta, 3rd quarter, fiscal year 1961: This satellite will provide a continuation of the planned program for investigation of the radiation belts. In addition to the energetic particles detectors, this satellite will include magnetic and optical equipment to study the directional behavior of the radiation and to study the interactions of the earth's magnetic field with the radiation belts. Payload weight - 100 pounds.

Atmospheric structure satellite, Delta, fiscal year 1962: This will be the first satellite with the primary objective of studying the earth's upper atmosphere. Composition, density, pressure, and temperature will be measured, and variations of these properties with latitude and the time of the day will be determined. Payload weight - 400 pounds.

Geodetic satellite, Delta, fiscal year 1962: This satellite will be used to obtain more exact information about the earth itself rather than to study the atmosphere or space. It will carry an automatic flashing light of high

intensity. Very precise photographic tracking of this satellite will furnish data leading to a more exact knowledge of both the location of selected sites upon the earth's surface and the configuration of the earth. Payload weight - 150 pounds.

Topside sounder satellite, Delta, fiscal year 1962: This satellite will be equipped with complex electronic instrumentation designed to study the upper portions of the ionosphere. It will be an important "first" in the investigation of the ionosphere because it will obtain measurements not heretofore possible. Radio soundings of the lower portion of the ionosphere have been made from the ground for many years and much useful information has been obtained. The nature of the ionosphere and its effect upon radio waves prevents the use of this technique in obtaining information about the upper half of the ionosphere. The satellite will be designed to make these sounding measurements from above the main portion of the ionosphere. The information thus obtained, plus the results from the earlier ionospheric satellites and the sounding rocket program, should contribute materially to our understanding of the nature and phenomena of the ionosphere. Payload weight - 200 pounds.

Two Scout launchings are scheduled through the fiscal year 1961. The payloads for these early operational launches of the Scout vehicles include one for micrometeorite studies and one payload as a possible backup of the Juno program.

Four large satellites are to be initiated in the fiscal year 1961. Two Atlas-Agena B and two Thor-Agena B vehicles will be used as the launching vehicles. Seven Scout launches are planned. Three of these are intended for use in the NASA international program and the payloads will be built as a cooperative effort with the participating nations. The remaining four Scouts will be used to launch satellites averaging 150 pounds into specific orbits chosen for the scientific investigation of selected regions of the earth's atmosphere and ionosphere. These NASA payloads will be designed to make new discoveries with a major emphasis applied to the polar regions, areas so far not investigated by the scientific satellites of any nation. The brief description of four Agena launched satellites follows:

The orbiting astronomical observatory satellite: This satellite, to be funded under this budget for launching in the fiscal year 1963, will be a very important first-of-its-kind scientific experiment. It is intended

to make astronomical observations from above the obscuring and blanketing effects of the earth's atmosphere. The weight of instruments and stabilizing equipment for this satellite will be more than two tons. This will be the first satellite with stabilization and ground control of direction of orientation for the conduct of long-term stellar observations from above the earth's atmosphere. It is the logical follow-up of the early sounding rocket experiments in astronomy and of the solar spectroscopy satellite. The development of the stabilization and control equipment will provide a satellite system adaptable to all types of optical astronomical observations. The Atlas-Agena B will be used as the launching vehicle.

The orbiting geophysical observatory: This satellite will also be launched by an Atlas-Agena B during the fiscal year 1963. It will carry a large number and variety of experiments designed to study the upper atmosphere and space around the earth from pole to pole in the region from 150 miles in altitude to about 60,000 miles. Its general objective will be to make measurements of many different parameters of the environment of the earth, to obtain correlations of the interactions that occur, and to determine the variations that occur in these parameters and interactions at different altitudes, latitudes, times of day, and seasons of the year. The radiation belts and the magnetic field of the earth will receive intensive specific study, together with determinations of their mutual interactions. Micrometeorite detectors and other detectors and sensors will also be included to obtain as complete a picture as is possible of this entire region over a period of about one year of active satellite life. Payload weight - 575 pounds.

The solar geophysical satellite: This satellite, to be launched by a Thor-Agena B in the fiscal year 1963 will carry equipment to make simultaneous observations of solar and terrestrial phenomena with the objective of learning more about the role of the sun in determining and controlling geophysical events. A pointing control to keep observation instruments trained on the sun will be a significant portion of the payload. Payload weight - 600 pounds.

The polar geophysics satellite: This satellite will contain instrumentation to study the properties of the earth's upper atmosphere at a constant altitude and to determine the variations in properties that occur over the globe for a period of about one year. It will be launched by a Thor-Agena B in the fiscal year 1962. Atmospheric and ionospheric phenomena and interactions with energetic particles in the polar regions will be of major interest. Payload weight - about 1,000 pounds.

Of the four planned NASA Scout payloads, three will be satellite payloads, each one designed to perform detailed measurements in a different one of the three scientific disciplines--atmosphere, ionosphere, and energetic particles. A major emphasis will be place on the Artic and Antarctic regions. The fourth Scout will be used to make a study of the winds and diffusion phenomena in the upper atmosphere extending to a maximum altitude of over 5,000 miles.

It is worthwhile to compare the eight new satellite payloads to be started under this budget with previous space science satellites. The average payload weight for the four Agena B satellites will be roughly 1,500 pounds. Thus, the average Agena B satellite will be about three times the total weight of all scientific satellite payloads launched by NASA during calendar year 1959. The average Scout payload will be about the same as the 142-pound Explorer VI, the heaviest scientific satellite launched by NASA to date.

Thus, while the same number of scientific satellite launchings are scheduled for fiscal years 1961 and 1962, the total weight and number of scientific instruments to be flown has increased tremendouly from the fiscal year 1959, due primarily to increased vehicle capabilities. This increased activity in scientific measurements is relfected in the greater amount required for scientific payloads in this budget. This increased budget will support and continue work on satellites already under way for launchings in the fiscal years 1960 and 1961 as well as providing for the initiation of work for satellites to be launched in the fiscal years 1962 and 1963.

Scientific and Technical Studies

In this category are the studies in the various scientific disciplines of interest to NASA which are initiated and pursued in order to lay a firm foundation for the experimental and analytical programs in the space sciences. Before a specific payload can be assembled and launched, it is first necessary to review the state of knowledge in a given discipline and establish the

major gaps in the existing understanding. Then, a program for the development of advanced instrumentation, generally including a laboratory development followed by rocket tests, is started. If this program shows reasonable progress, then payload instrumentation effort and a specific flight schedule are established.

Several scientific and technical studies of this nature were initiated in the fiscal year 1959 to continue the support of research efforts which had been originally associated with the IGY. Other studies were recommended to NASA by the Space Science Board of the National Academy of Sciences. Typical of these were studies on the radiation balance of the earth, of the feasibility of the geodetic flashing light satellite, and the early studies for the orbiting astronomical telescope. The study of the orbiting solar observatory was also initiated in 1959. A number of the areas supported in the fiscal year 1959 do not appear in the fiscal year 1960 programs in the category of Scientific and Technical Studies. The conclusions reached in certain study areas resulted in the establishment of program effort for the fiscal year 1960 which is listed below either under Advanced Instrumentation or under Payloads. These are continuations in the scientific program area representing a step forward toward operational status. This will be true of the efforts on the orbiting astronomical observatory and the orbiting solar observatory. The fiscal year 1959 study on the topside sounder has also led directly to payload effort in the fiscal years 1960 and 1961.

Several studies, such as those bearing on the improvement of frequency standards and on the orbiting stabilized telescope are being continued. The ionosphere propagation studies are typical of those which are of a continuing nature and which also appear in the program for the fiscal years 1960 and 1961.

There is an appreciable lead time required for the establishment of satisfactory experiments to be flown in satellites. Thus, in the present fiscal year, studies are being supported on ultraviolet techniques, the investigation of the characteristics of the energetic particles and fields encountered in space, on radiation effects on components, on solar-terrestrial relations, and on studies related to relativity and gravitational fields. In all these areas, some directly related payload effort will be possible in 1961. In many cases it is impossible to complete such studies in a year, making incremental funding in succeeding years necessary. A number of purely theoretical studies which are complementary to the experimental program are supported to maintain balance within the overall effort.

In reviewing the program for the fiscal years 1960 and 1961 it will be seen that increases in funding are projected for studies of solar-terrestrial relations and for feasibility studies on new techniques and experiments.

Solar-terestrial studies will be particularly benefited by analysis of the results obtained in the IGY, the data from which is now collecting in the world data centers. Analysis of this data for correlation of the effects arising in the ionosphere as related to solar output and the fluctuations of the earth's magnetic field is typical of the research required. Such studies, utilizing the available data, are a prime necessity if well-founded flight experiments are to be planned. The NASA has found in its initial period of operation that many proposals of merit for exploratory or feasibility studies have had to be rejected for lack of funding. We have accordingly programmed more support in this area in the fiscal year 1961.

NASA will initiate funding in certain ionospheric research areas and for studies of very low frequency propagation to support the experimental work which will be carried out in satellite payloads in the forthcoming year. The orbiting radio astronomy satellite effort will be supported by the studies on the development of radio noise standards. These are needed to calibrate orbiting radio astronomy antenna-receiver systems.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Radiation balance studies.....	$39,631	---	---
Geodetic flashing light.....	19,650	---	---
Topside sounder.....	15,000	---	---
Solar pointing control study.....	247,000	---	---
Solar UV radiation studies.....	110,600	---	---
Reimbursement to AOMC for special research services.....	100,000	---	---
Special computations at NBS.....	80,000	---	---
Data analysis.....	19,320	---	---
Study for orbiting telescope.....	99,935	---	---
Study for UV telescope system.....	62,641	---	---
Research studies on stable telescope element.	30,000	$50,000	---
Improvement of frequency standards for relativity studies.....	50,000	50,000	---
Studies of flight paths.....	100,000	100,000	---

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Orbiting telescope studies	$24,917	$30,000	$30,000
Ionosphere propagation research	156,420	459,000	500,000
Solid state photo detectors	---	123,000	70,000
Theoretical studies in relativity	---	10,000	20,000
Theoretical studies in energetic particles	---	20,000	40,000
Charged particles and fields in space	---	114,000	150,000
Radiation effects on components	---	30,000	50,000
Compute electron densities	---	100,000	100,000
Studies of UV in vacuum	---	153,000	160,000
Kinetic aeronomy	---	50,000	60,000
Solar-terrestrial relations	---	40,000	200,000
Theoretical studies in solar and stellar physics	---	20,000	40,000
Sub-millimeter wave study	---	7,000	50,000
Coatings for temperature control	---	25,000	45,000
Space science abstracts	---	50,000	50,000
Payload dynamics studies	---	20,000	50,000
Feasibility studies of new techniques and experiments	---	49,000	150,000
VLF studies	---	---	100,000
Ionospheric studies	---	---	100,000
Radio noise standards	---	---	35,000
Total	$1,155,114	$1,500,000	$2,000,000

Development of Advanced Instrumentation

To continue the support of the projects which were transferred to NASA, and to expand the NASA space science activities, a number of contracts leading to the development of advanced instrumentation were initiated in the fiscal year 1959. Two of these were associated with the development of atomic frequency standards. These frequency standards or "clocks" would eventually be used in the experimental verification of the relativity theory prediction that the frequency of an atomic clock

should shift when the gravitational field in which the clock is placed is varied. This would occur when the clock is in an orbiting vehicle. The results of the initial contract effort on clock development will be determined in the fiscal years 1960 and 1961 when comparative tests of the clocks will be made. The continued development of the most likely system will then be supported. A major contract effort initiated in the fiscal year 1959 was for development of upper atmosphere instrumentation and for studies of the results already obtained by such investigations to aid in the determination of a new physical model of the upper atmosphere. This contract activity is programmed through the fiscal years 1960 and 1961 as the development of such instrumentation and the analysis of results of tests thereon is a continuing effort.

Studies on instrumentation for the measurement of the electronic density in the ionosphere and for the measurement of gamma rays were also funded in the fiscal year 1959. Efforts on a number of different optical elements for use in the ultraviolet wavelengths for application to the orbiting astronomical telescope were initiated. Studies were started on the measurement of radio noise above the ionosphere; for this purpose, special receivers and antennas must be developed and tested. Funding for the development of solid-state and scintillator-type detectors for the investigation of the characteristics of the energetic particles in the radiation belts was initiated.

In the fiscal year 1960, effort on the development of the instrumentation equipment for the orbiting astronomical observatories is being intensified. In addition to the work that has grown out of the technical studies category, a number of contracts have been initiated in instrumentation which will be carried on through the fiscal year 1961. These will include development of ultraviolet sensors, development of television techniques for telescopes, equipment for the ultraviolet sky survey, ultraviolet photometry, image tube development, and the development of photometric standards. Additional scientific groups have been brought into the program for the fiscal year 1960 for the development of instrumentation capable of determining the composition of the upper atmosphere. Cosmic ray and radiation belt detection studies have been funded at several universities. These studies result in specific flight proposals as instruments are proven out by laboratory, balloon or rocket tests.

The measurement of the magnetic fields in space is closely connected with the measurements of the flux of charged particles. Correlated studies are required, and these studies are dependent on an ability to measure the strength and direction of extremely weak fields. High sensitivity magnetometers with directional sensitivity are the objective of the work programmed in this area for the fiscal years 1960 and 1961.

First efforts on simple biological experiments and materials tests are included in the 1960 program. Additional support in these areas will be needed in the fiscal year 1961.

Two very important instruments in the experimental solar physics studies are the coronagraph and the ultraviolet spectrograph. As satellite payloads increase in size it becomes desirable to make effective use of the available capacity. The development of instruments of this type for the larger payloads is being started. Continued support at an increased funding level is anticipated for the fiscal year 1961 and eventual use in a specific payload in the fiscal years 1962 or 1963 is contemplated.

Approximately half of the increased funds requested for advanced instrumentation are presently programmed for the initiation of new effort on specific techniques or devices. Here again the possibility of scientific investigations on larger, attitude-stabilized payloads some two or three years from now makes it imperative that development be started now on those instruments which can study in detail the phenomena encountered in space flight.

For this objective, studies are outlined on detector and instrument assemblies for sampling the corona (in the vicinity of the earth); neutron, X-ray and gamma ray analyzers; and advanced energetic particle detectors. Also programmed are antennas for very-low-frequency radio astronomy satellites and introductory work on radio-ranging devices for gravitational and celestial mechanics studies. As the multi-experiment satellite design work progresses, it becomes obvious that an appreciable effort must be put into general engineering support studies on extendable elements, command control, and on dynamic tests.

With the larger satellites, interference between the experiments quickly becomes an item of major importance, and it is thus necessary to devise methods of separating particularly sensitive pickup devices from the immediate proximity of the sources of disturbance which are unavoidably built into payload. Gages for pressure measurements, mass spectrometers for composition determinations, magnetometers and energetic particle detectors are all subject to this difficulty. Command control is also a necessity if time-sharing of the the data transmission channel is to be used to permit efficient use of the large payloads. Dynamic testing, both mechanical and thermal, has been an effective tool in uncovering basic design difficulties in satellite instrumentation. A specific effort devoted to the establishment of the relative importance of the factors involved and the improvement of the testing technique is planned.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Infrared instrumentation	$18,300		---
Electron density instrumentation	110,900	---	---
Gamma ray instrumentation	68,000	---	---
Materials for UV filters	25,000	---	---
UV and X-ray astronomy	25,000	---	---
Ammonia beam maser	200,000	$70,000	---
Research on rubidium frequency standards	272,100	100,000	$250,000
Counter for cosmic radiation	63,100	63,000	75,000
Instrumentation and model atmosphere studies	450,000	404,000	440,000
UV solar spectrum instrumentation	76,000	200,000	200,000
Radiation detector development	100,000	75,000	75,000
Lightweight optical elements	30,000	15,000	40,000
Radio noise above ionosphere	81,600	50,000	200,000
Development of astronomical stabilized platform	---	200,000	---
Television techniques for telescopes	---	110,000	350,000
Low energy gamma ray telescope	---	40,000	40,000
Image tube development	---	130,000	100,000
Photometric standards and constants	---	35,000	50,000
UV photometry	---	124,000	350,000
Equipment for UV sky survey	---	225,000	400,000
UV sensors development	---	75,000	80,000
Development of atmospheric composition instrumentation	---	175,000	400,000
Upper atmosphere density instrumentation	---	50,000	60,000
Detectors for primary cosmic rays	---	250,000	300,000
Detectors for radiation belt studies	---	300,000	325,000
Development of advanced magnetometers	---	100,000	150,000
Radio astronomy receiver research	---	20,000	20,000
Instrumentation for biological experiments	---	20,000	50,000
Instrumentation for materials tests	---	50,000	100,000
Satellite coronagraph development	---	90,000	150,000

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Development of solar UV spectrograph.....	---	$90,000	$200,000
UV spectroheliograph.....	---	---	200,000
Corona sampling instrumentation.....	---	---	25,000
Neutron monitor.....	---	---	25,000
Planetary spectrograph.....	---	---	150,000
X-ray telescope.....	---	---	100,000
Solar gamma ray telescope.....	---	---	50,000
Soft gamma ray instrumentation.....	---	---	150,000
Development of VLF antennas for radio astronomy.....	---	---	125,000
Gravity monitor.....	---	---	50,000
Celestial mechanics probe.....	---	---	30,000
Development of advanced energetic particles detectors.....	---	---	150,000
Development of extendable elements.....	---	---	175,000
Command control for multi-experiment satellites.....	---	---	225,000
Dynamic testing of prototype instrumentation.	---	---	140,000
Total.....	$1,520,000	$3,061,000	$6,000,000

Flight Research Vehicles

In the conduct of the flight program with scientific satellites, five vehicles will see extensive use; Juno II, Atlas-Agena, Thor-Agena, Scout, and Delta.

The Juno II is programmed for use in the fiscal years 1959 and 1960. Funding was initiated for five Juno II vehicles in the fiscal year 1959 and will be completed with the fiscal year 1960 increment. This procurement will complete the use of the Juno II in the Scientific Satellites.

Funding of the Thor-Able vehicle used to orbit the Explorer VI is being complete in the fiscal year 1960.

The Atlas and Thor-Agena B vehicles are being pruchased on an incremental funding basis. In the fiscal year 1961 the initial increment for these vehicles has been indicated. First flights for the Atlas and Thor-Agena B are scheduled for the fiscal years 1963 and 1964, respectively.

The Scout vehicles which will be flown in the course of the fiscal years 1960 and 1961 are available to the program from the developmental series of vehicles, and as such, no direct funding from the Scientific Satellite program is required. The Scouts scheduled for launch in the fiscal years 1962 and 1963 are to be initially funded with fiscal year 1961 monies. Seven Scouts are involved, three of which have been tentatively earmarked for use in the international programs and four for the national space science programs.

Like the first Scouts, the Delta vehicles used in the Scientific Satellite program are being funded in the vehicle development program.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Juno II	$8,540,000	$5,100,000	---
Thor-Able	2,120,000	727,000	---
Atlas-Agena B	---	---	$3,000,000
Thor-Agena B	---	---	3,000,000
Scout	---	---	3,500,000
Total	$10,660,000	$5,827,000	$9,500,000

Satellite Payloads

Funding for payloads can be considered as being almost entirely directed to the support of specific flights. However, in the fiscal year 1959, some funding was devoted to the provision of general payload instrumentation. With this funding, the procurement of instruments which could be made available on a relatively routine basis to the general run of satellite payloads was started. It has already been found that if satellites intended for research in a specific scientific discipline weigh as much as 100 pounds or more, it is generally possible to introduce one or two

additional lightweight instruments to supplement the original project objectives. In these cases, such supplementary instrumentation is extremely valuable as it permits correlations in two or more associated research areas. This "add-on" process can appreciably increase the statistical value of the data being collected by putting similar detecting systems into a sequence of satellites so as to verify the initial data and then obtain an indication of the time and space variations which occur. Consequently, instrumentation effort on magnetometers, micrometeorite detectors, gamma ray detectors, radiation detectors, and the like is continuously being supported. In this way a number of payload instrument equipments for routine use are made available. Some of the general support is continued in the fiscal years 1960 and 1961 programming, while other areas have grown into major projects and are covered in specific payloads detailed in the tabulation.

Funding of Explorer VI, the "Paddlewheel" satellite, and Explorer VII will be completed in the fiscal year 1960. Explorer VII shows no fiscal year 1959 funding in the tabulation because the project was initially established by ARPA and was supported through the fiscal year 1959 by the original funding.

Payload instrumentation to measure the penetration and damage hazards of micrometeorites is being prepared for the third developmental Scout vehicle as a part of the fiscal year 1960 program.

Several satellite payloads were initiated in the fiscal year 1959. These were: the ionosphere beacon satellite; the ionosphere direct measurements satellite; the radiation belt satellite; the atmospheric structure satellite; the advanced radiation belt satellite; and the solar observatory satellite. In each case, the funding programmed in the tabulation reflects the lead time required to design, fabricate and launch a payload.

Funding for data acquisition and processing is introduced for those projects which require special handling of a type which cannot be supplied by the established network. Special equipment needed for a single payload, is included in the payload funding where appropriate.

Funding has been initiated in the fiscal year 1960 for the geodetic satellite, the topside sounder, the gamma ray astronomy satellite, the solar geophysical satellite, the orbiting geophysical observatory, and the orbiting astronomical observatory. For all of these, program costs in the fiscal year 1961 are indicated and there will be additional charges in 1962 to complete the flight programs.

It should be noted that, to meet the lead time requirements for a balance flight program, it is necessary to start payload work in the fiscal year 1960 for the launches scheduled for the last half of the fiscal years 1962 and 1963. Thus, the four payloads for the Thor-Agena and Atlas-Agena boosters are already being planned and worked on this year. The first large increment in the funding for these flights is shown in the fiscal year 1961 estimates. These estimates reflect the next increase in payload weight and associated complexity of experimentation. The polar geophysical satellite will probably weigh about 1,000 pounds. This marked increase in weight will make it possible to study in some detail, with coordinated instrumentation, atmospheric and ionospheric phenomena and their interactions.

The costs for the solar geophysical satellite reflect the introduction of an attitude control system and the fact that instrumentation for the detailed investigation of the sun's radiation is relatively more expensive than that for atmospheric or ionospheric studies.

The major single payload is that for the orbiting astronomical observatory. Study contracts and advanced instrumentation programs will continue while the payload effort is getting well under way. The payload for this project will weigh as much as 4,000 or 5,000 pounds. It will be fitted with both coarse and fine pointing controls, attitude stabilizers and a command system for directing the optical axis to a desired location in the heavens. The systems development is programmed for the fiscal years 1961 and 1962 and is expected to be accomplished in large part by contracts with industrial organizations. An acceleration of the effort on the instrumentation for this project is also programmed in the fiscal year 1961 to insure that both the experimental equipment and the stabilized satellite will be ready at the launch date in the fiscal year 1963.

There remain in the tabulation the seven Scout payloads; four of these are to be used in the national space science program as outlined in an earlier discussion. Payload sizes and complexities are comparable to the lighter units being built for the Delta boosters. Funding for these payloads is programmed for the fiscal year 1961 in order to get the projects under way with sufficient lead time to afford adequate planning and testing.

Three of the vehicles are presently expected to be assigned to the international space science program and the programmed costs have consequently been reduced to reflect the fact that the cooperating nation will provide the scientific instruments and NASA will provide the remainder. Completion of the funding for these payloads will occur in the fiscal year 1962.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
General payload instrumentation:			
Cosmic ray detectors	$75,000	---	---
Magnetometer testers (mobile equipment)	50,000	---	---
Magnetometer tester (fixed)	160,000	---	---
Magnetically shielded enclosure	100,000	---	---
Micro-ammeters	90,000	---	---
Optical design and ultraviolet detectors	50,000	---	---
Photomultiplier (ultraviolet) ruggedization	195,000	---	---
Solar pointing controls	80,000	---	---
Solar ultraviolet detector elements	120,000	---	---
Tracking beacons	90,000	---	---
Rubidium vapor magnetometers	170,000	$60,000	---
Spectrophotometer assemblies	96,000	100,000	---
Gamma ray detectors	32,000	60,000	$100,000
Micrometeorite detectors	160,000	160,000	160,000
Air density instrumentation	---	99,000	---
Explorer VI:			
Payload effort and field support	5,000,000	1,290,000	---
Data reduction	---	363,000	---
Scout micrometeorite payload	---	150,000	---
Explorer VII:			
Payload effort and field support	---	2,000,000	---
Data acquisition - Pacific stations	---	50,000	---
Data processing	---	300,000	---

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Ionosphere beacon satellite:			
Payload system design and fabrication....	$557,000	$300,000	$270,000
Ionosphere direct measurements satellite:			
Instrumentation.....	220,000	292,000	56,000
Structures, including antennas.....	---	585,000	150,000
Data processing.....	---	---	50,000
Advanced radiation belt satellite:			
Cosmic ray detectors.....	30,000	60,000	60,000
Solid state radiation detectors.....	15,000	95,000	30,000
Magnetometers.....	15,000	95,000	50,000
Pulse height analyzers.....	30,000	165,000	60,000
Signal processing circuitry.....	---	20,000	25,000
Telemetry.....	10,000	40,000	35,000
Power supplies.....	20,000	63,000	20,000
Structures, including antennas.....	---	144,000	192,000
Testing services.....	---	50,000	140,000
Payload for test on Scout.....	60,000	110,000	---
Data processing.....	---	---	100,000
Atmospheric structure satellite:			
Mass spectrometers and pressure gages....	60,000	300,000	100,000
Signal processing circuitory.....	10,000	40,000	80,000
Telemetry.....	20,000	80,000	100,000
Power supplies.....	10,000	40,000	80,000
Structures, including antennas.....	45,000	174,000	295,000
Testing services.....	---	50,000	110,000

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Radiation belt satellite:			
Design and construction at AOMC.....	$150,000	$700,000	---
Analysis of orientation and temperature..	---	75,000	---
Data processing.....	---	50,000	$100,000
Solar observatory satellite:			
X-ray spectrographs.....	30,000	250,000	---
Photomultiplier detectors.....	---	50,000	---
Gamma ray detectors.....	---	40,000	---
Signal processing circuitry.....	---	20,000	---
Telemetry.....	10,000	80,000	---
Power supplies.....	---	70,000	---
Structures, including antennas and pointing controls.....	90,000	679,000	---
Testing services.....	10,000	100,000	---
Pointing controls for rocket test.....	20,000	80,000	---
Spectrographs for rocket test.....	30,000	100,000	---
Payload fabrication for rocket test.....	60,000	10,000	---
Data acquisition equipment.....	---	---	200,000
Data processing.....	---	---	200,000
Data analysis.....	---	---	150,000
Geodetic satellite:			
Flashing light system.....	---	250,000	100,000
Timing units.....	---	40,000	40,000
Earth sensors.....	---	30,000	20,000
Tracking beacons.....	---	25,000	50,000
Ranging transponder.....	---	35,000	100,000
Telemetry.....	---	35,000	50,000
Power supplies.....	---	40,000	80,000

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Geodetic satellite: (continued)			
Antenna systems development.....	---	$40,000	$30,000
Prototype structures.....	---	200,000	150,000
Testing services.....	----	50,000	100,000
Data acquisition equipment.....	---	50,000	350,000
Data processing equipment.....	---	---	150,000
Topside sounder:			
Project coordination.....	---	34,000	87,000
Payload design and fabrication.....	---	270,000	725,000
Testing services.....	---	---	100,000
Gamma ray astronomy satellite:			
Design, fabrication, and test at AOMC....	---	690,000	470,000
Gamma ray instrumentation.....	---	225,000	---
Tape recorder for data storage.....	---	22,000	---
Data processing.....	---	---	50,000
Polar geophysical satellite:			
Scientific instruments.....	---	90,000	350,000
Payload structural prototype.....	---	60,000	250,000
Prototype dynamic tests.....	---	40,000	160,000
Signal processing circuitry.....	---	20,000	80,000
Telemetry.....	---	20,000	200,000
Antenna systems design.....	---	20,000	80,000
Power supplies.....	---	10,000	70,000
Flight structures.....	---	80,000	400,000
Testing services.....	---	10,000	100,000

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Orbiting geophysical observatory:			
Scientific instruments	---	$140,000	$350,000
Payload structural prototype	---	60,000	250,000
Signal processing circuitry	---	20,000	80,000
Telemetry	---	20,000	200,000
Antenna systems design	---	20,000	80,000
Power supplies	---	10,000	70,000
Flight structures	---	80,000	400,000
Testing services	---	10,000	150,000
Solar geophysical satellite:			
Geophysical sensors	---	150,000	200,000
Solar radiation detectors	---	100,000	150,000
X-ray spectrographs	---	80,000	100,000
Signal processing circuitry	---	20,000	80,000
Telemetry	---	20,000	200,000
Antenna systems design	---	20,000	60,000
Power supplies	---	10,000	100,000
Flight and prototype structures	---	80,000	650,000
Testing services	---	10,000	200,000
Pointing controls for rocket test	---	40,000	60,000
Spectrograph for rocket test	---	50,000	80,000
Payload fabrication for rocket test	---	20,000	50,000
Orbiting astronomical observatory:			
Instrumentation:			
Photoemissive detectors	---	125,000	200,000
Photomultiplier detectors	---	60,000	120,000
Filters	---	60,000	80,000
Crystalline optical components	---	40,000	80,000

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Orbiting astronomical observatory: (continued)			
Instrumentation: (continued)			
Image intensifiers	---	$80,000	$175,000
Optical system design	---	75,000	250,000
Ion chambers	---	---	75,000
Solid state detectors	---	---	45,000
Spectroscopic gratings	---	---	30,000
Construction of optics	---	---	200,000
Optical test equipment	---	---	190,000
Stabilization, structure, and control:			
Basic structure	---	---	450,000
Attitude sensors	---	---	350,000
Servo stabilizers	---	---	500,000
Coarse pointing unit	---	---	250,000
Fine pointing unit	---	---	400,000
Command system	---	---	200,000
Electronic processing circuitry	---	---	180,000
Telemetry	---	---	200,000
Power supplies	---	---	200,000
Antenna systems design	---	---	100,000
Testing services	---	---	200,000
Ground control equipment	---	---	250,000
Checkout and test sets	---	---	200,000
Four Scout payloads:			
Scientific instruments	---	---	1,300,000
Signal processing circuitry	---	---	400,000
Telemetry	---	---	600,000
Power supplies	---	---	600,000

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Four Scout payloads: (continued)			
Antenna design	---	---	$320,000
Structural design and fabrication	---	---	1,400,000
Testing services	---	---	800,000
Three Scout payloads - international program:			
Signal processing circuitry	---	---	300,000
Telemetry	---	---	450,000
Power supplies	---	---	450,000
Antenna design	---	---	290,000
Structural design and fabrication	---	---	1,000,000
Testing services	---	---	600,000
Total	$7,970,000	$13,425,000	$24,200,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

LUNAR AND PLANETARY EXPLORATION

Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
$31,882,607	$49,000,000	$45,000,000

1. OBJECTIVES:

To acquire fundamental physical and chemical information on the moon and planets; to investigate space phenomena and their variations over the range of lunar and interplanetary distances; to explore the surface and nearby environment of the moon and to measure and describe in detail its characteristics, for example, the surface composition, radioactivity and structural features, and the magnetic and gravitational fields; to investigate the constituents, processes, and characteristics of the interplanetary regions so as to understand how and why they vary with time and location within the solar system; to extend these investigations to the detailed study and exploration of the planets; to develop improved means and techniques for the conduct of lunar, interplanetary and planetary investigations and explorations.

2. JUSTIFICATION:

As our nearest major body in the solar system, basically unchanged for billions of years, the moon itself offers unique potentialities for better understanding of historic and contemporary phenomena of the solar system and for clarification of basic physical, chemical, and biological concepts that are fundamental to modern science. It can be hoped that the moon will provide the first answers that will unlock the secrets of the origin and evolution of the solar system. Until now, progress along these lines has been subject to the limitations imposed by remote observations and indirect measurements. The understanding which can be gained from direct measurements and observations will be far greater. Space flight vehicles now offer research capabilities for overcoming many of these limitations.

In particular, it will be possible to utilize appropriate instrumentation to determine by direct measurement, lunar, planetary, and interplanetary characteristics, and thus provide a wealth of fundamental information on the nature, magnitude, distribution, and variations of the electromagnetic radiations, energetic particles, electric and magnetic fields, cosmic dust particles, lunar, planetary and solar atmospheres which are continuously interacting within the solar system. These interactions are already known to markedly influence the earth's atmosphere and fields, and a knowledge of their mechanisms will clarify our understanding of terrestrial phenomena.

The advancedment of scientific knowledge obtained from early lunar explorations and space probes and the experience that will be gained from the operation of space flight systems hundreds of thousands of miles from earth, will provide the basis for the appropriate design of instrumented spacecraft which will eventually explore the planets and deep space.

3. PROGRAM PHASING:

During the fiscal year 1959, lunar and cislunar space probes permitted evaluation of initial problems associated with the placing of vehicles into lunar trajectories and provided preliminary information on environmental characteristics of cislunar space. Work was initiated on advanced instrumentation and measurement techniques, including, for example, a lunar seismograph system, a plasma probe, a magnetometer to be used in lunar probe flights, and instruments for measuring lunar radioactivity. Pioneer IV, which was initiated by ARPA and transferred to NASA, was placed in permanent orbit around the sun. The instrumentation in Pioneer IV furnished valuable new data on the radiation belt and its extent into space, showing for one thing that the outermost portions of the radiation belt vary quite markedly with activity in the sun. Funding was initiated for an Atlas-Able vehicle to be used in placing a scientific payload in orbit about the moon, and a Thor-Able vehicle to launch a deep space probe. Development, construction, and testing of payloads for both lunar and deep space probe missions were initiated.

Work is being started during the fiscal year 1960 on the development of instrumentation and vehicle systems with improved capabilities for investigating cislunar space and beyond. The development of advanced instrumentation started in the fiscal 1959 is continuing. A lunar orbiter payload was designed and constructed for the Atlas-Able vehicle for which funding was started in the fiscal year 1959. A pre-flight failure of the vehicle made it necessary to pro-

vide a second booster system. This launch attempt was unsuccessful. Additional lunar orbiters and probes are planned for launching in the fiscal year 1960 and in the fiscal year 1961. Work will also be started on planetary probe payloads. The Thor-Able vehicle funded in the fiscal year 1959 will be used to launch a deep space probe; its payload is being completed during the fiscal year 1960.

The funds requested under this program for the fiscal year 1961 will provide for the design and development of measurement techniques, scientific instruments, and spacecraft for use in lunar and planetary investigations. Work will continue on the construction and testing of advanced systems to observe, study, explore, and investigate the lunar environment, surface, and interior. Studies and preliminary research and development projects will be extended in the fiscal year 1961 to acquire needed technology for spacecraft with a capability for precise circumlunar orbits and instrumented soft landings. Terminal orientation devices and landing controls and propulsion units for spacecraft will be investigated. Design and construction of prototype instrumentation will be initiated for a lunar seismograph and gravimeter system, advanced penetrometers, thermistor probes, and fluorescence spectroscopes.

Beginning in the fiscal year 1961 the Atlas-Agena will be utilized for launching of lunar probe spacecraft. Construction and environmental testing will start on payloads for lunar impact missions with the objective of providing knowledge necessary for the proper design of soft lunar landing vehicles. These payloads will be instrumented to transmit data on the surface characteristics of the moon.

Typical projects included in the advanced development program for lunar, planetary, and interplanetary instrumentation will be: studies of infrared sensors and penetrometers for the investigation of lunar and planetary surface structures; improvement of plasma probes, geiger and scintillation counters for measurements the interplanetary medium; improvement of magnetometers to be used in particle flux-magnetic field correlations; beta and gamma ray detectors and spectral analyzers for studies of lunar surface radioactivity; and improvements of television type image transmission equipment for lunar studies.

An interplanetary space probe will be launched during the fiscal year 1961 by means of a Delta vehicle funded under the Delta development program. Design and development effort on the payloads for use in an initial pair of planetary probes will be carried forward with the expectation that Atlas-Agenas will be used as booster vehicles.

4. PROGRAM COSTS:

	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Advanced technical development.....	$8,102,607	$5,223,000	$9,000,000
Flight research program:			
Completion of Pioneer IV vehicle system operations.....	2,140,000	---	---
Thor-Able vehicle.....	2,843,000	---	---
Atlas-Able vehicles.....	4,097,000	3,446,000	---
Atlas-Agena vehicles.....	3,500,000	7,360,000	9,500,000
Design, development, fabrication, and launch of spacecraft and payloads.....	11,200,000	32,971,000	26,500,000
TOTAL.....	$31,882,607	$49,000,000	$45,000,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

LUNAR AND PLANETARY EXPLORATION

Objectives

The NASA has established a sound program for the exploration of the Moon, Mars and Venus which is designed to provide leadership in acquiring scientific knowledge about these bodies. The program is far from an extravagant one. Rather, it is soberly conceived to exploit an orderly evolution of launching vehicles, spacecraft, and scientific payloads to the achievement of several selected goals. Within the next half decade these goals may be simply illustrated by their related missions, which are:

1960	Interplanetary probes
1960	Lunar orbiters
1961-62	Lunar impacts (reconnaissance)
1962	Planetary probes to Mars and Venus
1963-64	Lunar soft landings
1965	Planetary orbiters to Mars and Venus
1965	Lunar soft landing with mobile vehicle

The scientific objectives of these missions are no less exciting than the spectacular flights themselves. As our nearest major body in the solar system, unchanged by winds and rain in the several billion years of its (and the Earth's) existence, the Moon offers unique opportunities for a better understanding of the solar system. The discovery of some form of life on Mars and Venus could prove far more than a scientific curiosity. Just as the planned missions constitute an orderly sequence of technological and scientific development, so do they lay the groundwork for the more difficult missions to follow. The program is now in its formative stages.

The actual programmed flight schedule which must be considered tentative beyond 1962, follows:

Lunar Missions	Launch Vehicle	Year
Orbiter	Atlas-Able	1960
Orbiter	Atlas-Able	1960
Impact - spacecraft development	Atlas-Agena	1961
Impact - spacecraft development	Atlas-Agena	1961
Impact-reconnaissance	Atlas-Agena	1961
Impact-reconnaissance	Atlas-Agena	1962
Impact-reconnaissance	Atlas-Agena	1962
Soft landing	Centaur	1963
Soft landing	Centaur	1963
Soft landing	Centaur	1963
Soft landing	Centaur	1964
Soft landing	Centaur	1964
Soft landing	Centaur	1964
Soft landing	Centaur	1965
Soft landing - mobile	Saturn	1965
Planetary and Interplanetary Missions		
Interplanetary probe	Thor-Able	1960
Interplanetary probe	Thor-Delta	1960
Venus probe	Centaur	1962
Mars probe	Centaur	1962
Venus probe	Centaur	1964
Mars orbiter	Saturn	1965
Venus orbiter	Saturn	1965

This mission schedule has been developed in accord with the following principles:

1. Select the most important goals and pursue them with determination.

2. Establish an evolutionary sequence of missions where each step paves the way for the more difficult phase to follow and which makes full use of increased technological capability as it becomes available.

Lunar Missions

These missions are clearly oriented toward the achievement of controlled lunar landings. It is the feeling of the NASA that this approach will yield the maximum scientific results and will pave the way for more ambitious manned lunar missions at some later date. The series begins with two attempts to place an instrumented payload in orbit about the Moon using the Atlas-Able booster. These missions represent the best current capability and are, in fact, the third and fourth attempts at this mission following two failures in 1959.

These missions utilize a spin stabilized payload with rudimentary but effective midcourse guidance, without which the mission could not be accomplished at this time. The payload contains a variety of radiation detection experiments to make measurements in the lunar environment. As an "anchored" space station away from the Earth's influence, the payload assumes additional importance when its long-term measurements are compared with related measurements in the vicinity of the Earth.

In 1961 the NASA will begin the second phase of the lunar program. The Atlas-Agena B will be used to launch a new spacecraft to achieve a controlled lunar impact with survivable equipment.

A "spacecraft" is a vehicle designed to fly through space carrying a useful payload and maneuvering as required to maintain the desired course and orientation. In earlier days the scientific payload and telemetry equipment were packaged into a structure which was little more than a can and which either tumbled freely or was spin stabilized. In contrast, the soft landing lunar spacecraft of the future may be likened to a fighter aircraft in complexity and cost. This is readily understandable when one considers that this remote descent to the lunar surface is without benefit of an atmosphere and that the total deceleration and landing is dependent on rocket braking and appropriate electronic sensing equipment to guide and control this braking.

Returning to the sequence of Agena B launchings, the first two in the first half of 1961 will actually not be directed toward the Moon but rather into orbit about the Sun to test vital spacecraft components and at the same time conduct selected scientific experiments. Toward the end of 1961 the first of three attempts at the complete lunar mission will be ready. The spacecraft for this mission will consist of two sections. The main section will contain guidance and control, telemetry, and propulsion equipment which will make it possible to impact the Moon within a predetermined area and with attitude control during the entire flight. In addition to carrying scientific instruments for measurements in cislunar space, this section of

the payload will carry a television camera capable of transmitting during the final moments of flight pictures of the impact area having optical resolutions of less than ten feet. The spacecraft is also being designed to carry a capsule which will be slowed by a retro-rocket from about 8,000 feet per second so that its impact velocity will be less than 500 feet per second. Survivable equipment within the capsule may include instrumentation to study the lunar surface consistency, structure, and temperature.

In 1963 the availability of the powerful Centaur should make possible the first true lunar soft landing of a spacecraft carrying television, a seismograph, a spectrometer, and radiation detection devices among other relatively fragile scientific instruments to observe and analyze the lunar surface and subsurface properties. Telemetry and an electric power supply must also be included in the same 600 pounds of structure and equipment which can be deposited relatively gently on the lunar landscape. The television reconnaissance of the terrain obtained in the preceding Agena series should facilitate the selection of design criteria for the Centaur spacecraft landing structure. A long service span is predicted for this spacecraft since spot investigations of many lunar areas will be conducted over a period of years.

The Saturn soft landing spacecraft will be required for those areas of the Moon which are to be explored intensively, either for purely scientific reasons or to lay the groundwork for manned landings. This spacecraft will weigh at least several times that of the Centaur. This vehicle, planned for 1965 with a three to four year lead time for development, is planned to be self-powered for mobility over the lunar surface. By this technique the actual area which may be explored and sampled will increase many fold. Here again, television will play a key role in this remote exploration.

Planetary and Interplanetary Missions

A Thor-Able and a Thor-Delta probe will be launched this year to obtain scientific measurements of magnetic fields and of particle and electromagnetic radiation fields deep into interplanetary space. The first capability of launching probes into the vicinity of Mars and Venus will come in 1962 when it is planned to use the Centaur launch vehicle and a variation of the spacecraft designed for use on the Atlas-Agena lunar missions. These planetary probes are designed to pass close enough to the planets to permit critical scientific measurements to be made and transmitted back to Earth. Television and/or spectrographic observations are being considered, although difficult to achieve due to guidance problems and uncertainties in the position of the planets.

In 1964 another favorable opportunity to fire at Venus will occur. This flight will probably be used to test stellar navigation equipment planned for operational use aboard the Mars and Venus orbiting spacecraft scheduled for launch with the Saturn in 1965. These latter spacecraft will weigh several thousand pounds and are conceived as ejecting instrumented capsules to penetrate the atmosphere of the two planets.

Advanced Technical Development

The exploration of the moon and planets involves complex payloads containing instruments for the measurement of a wide variety of phenomena. The program was initiated in the fiscal year 1959 by the procurement of relatively simple, first-generation instruments; either off-the-shelf items or those requiring a minimum of research for development. The funds required for the fiscal year 1960 thus could be decreased over the initial fiscal year 1959 procurement level when completed payloads become available for space probe launchings. At the same time, necessary research studies were started for the development of more complex, second-generation instruments for later flights. Building up from this basic level of effort, the development and procurement costs for this type of advanced instrumentation are contained in the fiscal year 1961 requirements.

The complexity of physical phenomena in space necessitates the use of numerous scientific instruments, each requiring for its successful development the highest technical talent available. Two principal categories of flight instrument are needed to achieve the objectives of the Lunar and Planetary Exploration program: (1) specialized instruments for specific measurements, such as analyses of the surface of the moon or planets, which frequently require long lead times for intensive research on many problems facing the experimenter; and (2) instruments to measure interplanetary phenomena while the payload is on its way to a target such as the moon or other planets. These instruments measure cosmic rays, magnetic fields, meteorites, solar radiation, and similar space phenomena. While initial space probes were able to measure the basic values of these quantities, consecutive developments, increased sensitivity, and progress in measuring techniques are required to measure the same quantities at vast distances away from the earth deep in interplanetary space.

For example, the development of lunar seismograph systems for measurements of the interior of the moon was started early in the fiscal year 1959. It was continued during the fiscal year 1960 and a simplified system will be continued in the first payload impact on the moon. Concurrently, the development of an advanced seismograph system is under way for later flights to

the moon which will deposit a seismograph for sustained operation on the lunar surface. Another example is the development of television systems for obtaining pictures of the lunar surface as well as of Mars and Venus. Initial instrumentation consisted of simple scanning devices which relayed crude pictures from outer space. To obtain high-resolution pictures of the lunar surface, a necessary preview to selection of landing sites, an advanced television system is under development. For planetary exploration, different requirements will be placed on the capabilities of television systems to transmit information over millions of miles. And finally, the analysis of lunar surface samples will be greatly aided by systems which obtain and transmit microscopic pictures back to earth. These vastly different television systems require and are receiving study and development.

As the payload weight capabilities of space probes increase, current progress in the development of scientific instrumentation will lay the basis for the future employment of greatly advanced instrumentation to enhance our knowledge of the solar system.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Cosmic ray instrumentation - development...	$74,951	---	---
Lunar data recording system - development..	75,000	---	---
Study of lunar soft landing systems.....	150,000	---	---
Lunar radioactivity instrument development.	150,000	---	---
Coherent radar explorations.....	126,000	---	---
Radiation instruments - development.....	150,000	---	---
Studies of radiation belt properties.....	311,420	---	---
Studies of primary cosmic radiation.....	300,280	---	---
Magnetic calibrations.....	27,000	---	---
Coincidence telescope - development.....	63,140	---	---
Special computations at NBS.....	50,000	---	---
Television for space vehicles - development	300,000	---	---
Study of deep space system requirements....	50,000	---	---
Supporting research on lunar mission problems.....	90,000	---	---
Lunar and planetary exploration studies....	1,300,000	---	---
Development and construction of lunar orbiter and space probe payloads.....	4,522,616	---	---

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Plasma instrumentation - development.....	$97,200	$75,000	---
Lunar seismograph system - development, CIT.	125,000	150,000	$90,000
Advanced lunar seismograph system - development, Columbia University.....	125,000	150,000	250,000
Lunar photogrammetry - development.....	15,000	72,370	90,000
Spectral lamps - development.....	---	30,000	---
Lunar map studies.....	---	67,630	---
Instruments to measure atmospheric pressures between Earth and Moon - development	---	50,000	---
Study of lunar surface characteristics.....	---	115,000	---
Electromagnetic investigation of lunar surface properties.....	---	50,000	---
Space radar equipment - development.....	---	50,000	---
Micrometeorite simulation studies.....	---	50,000	---
Ionosphere of Jupiter - studies.....	---	50,000	---
Detection of planetary microorganisms - studies.....	---	4,500	---
Ultraviolet sensors - development.....	---	215,500	---
Photo-diode system for planetary surface light - development.....	---	368,000	---
Lunar photographic system - development.....	---	500,000	---
Cosmic ray and magnetometer - development...	---	450,000	---
Development of impact-proof payload components.....	---	105,000	---
Spacecraft sequence timer - development.....	---	445,000	---
Development of lunar retro-package.....	---	1,500,000	---
Sterilization of space payloads - study.....	---	30,000	80,000
Lunar penetrometer - development.....	---	80,000	125,000
Mass spectrometer - development.....	---	75,000	105,000
Lunar surface gravity meter system - development.....	---	55,000	155,000
X-ray fluorescent spectrometer - development	---	135,000	195,000

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Surface sampling complex X-ray development	---	$100,000	$150,000
Heavy cosmic ray detectors.....	---	75,000	100,000
Interplanetary gas and dust - studies.....	---	50,000	75,000
Gamma ray spectrometer - development.....	---	20,000	150,000
Infrared photography of moon.....	---	105,000	125,000
Photogrammetric interpretation of lunar composition - study.....	---	---	110,000
Instruments for measuring lunar atmospheric characteristics - development.....	---	---	220,000
Solar corpuscular detector - development...	---	---	100,000
Photoconductive particle detector - development.....	---	---	400,000
Rubidium vapor magnetometer - development..	---	---	100,000
Coincidence detectors - development.....	---	---	400,000
Ion chamber - development.....	---	---	100,000
Lyman alpha scanner - development.....	---	---	200,000
Micrometeorite dectector - development.....	---	---	100,000
Vehicle electrostatic charge - development.	---	---	275,000
Environmental testing of instrument assemblies.....	---	---	325,000
Advanced vidicon - development.....	---	---	750,000
Skin temperature sensors - development.....	---	---	115,000
Ion trap - development.....	---	---	80,000
Procurement of 2 service-test instruments:			
Vidicons.....	---	---	780,000
Gamma ray spectrometers.....	---	---	200,000
Seismographs.....	---	---	260,000
Penetrometers.....	---	---	130,000
Temperature sensors.....	---	---	80,000
Ion traps.....	---	---	80,000
Magnetic and electric field instruments, Venus - development.....	---	---	125,000

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Energetic particle instruments, Venus - development	---	---	$275,000
Atmospheric instruments for Venus - development	---	---	100,000
Ionospheric instruments for Venus - development	---	---	100,000
Spectroscopic photometer - development	---	---	450,000
Development of television for Mars probe	---	---	400,000
Magnetic and electric field instruments, Mars - development	---	---	100,000
Spectroscope, Mars - development	---	---	150,000
Advanced magnetometer - development	---	---	30,000
Surface thermal measuring instruments - development	---	---	35,000
Advanced plasma probe - development	---	---	55,000
Remote controlled TV - development	---	---	185,000
Advanced instruments for solar probes:			
High resolution spectroscope	---	---	200,000
Colomagraphic equipment	---	---	100,000
Temperature and pressure devices	---	---	100,000
Mass spectrometer	---	---	100,000
Total	$8,102,607	$5,223,000	$9,000,000

Vehicle Procurement

The Pioneer IV operations are now completed. The Thor-Able deep space probe is now scheduled for early 1960. The fiscal year 1959 funds will complete the operation. The Atlas-Able vehicles referred to were launched during 1959 with the indicated expenditure of funds now completed.

The Atlas-Agena B vehicles are being incrementally funded. This funding plan is based on cost estimates from BMD and the vehicle contractor.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Completion of Pioneer IV vehicle system operations.....	$2,140,000	---	---
Thor-Able vehicle for deep space probe.....	2,843,000	---	---
Procurement of 2 Atlas-Able vehicles.....	4,097,000	$3,446,000	---
Procurement of 5 Atlas-Agena B vehicles....	3,500,000	7,360,000	$9,500,000
Total.....	$12,580,000	$10,806,000	$9,500,000

Design, Development, Fabrication and Launch of Spacecraft and Payloads

Completion of Able payloads: These costs, which do not carry into the fiscal year 1961, reflect the NASA contract with BMD-STL for the development and procurement of payloads for two Atlas-Able and one Thor-Able launch. The Thor-Able interplanetary probe will be launched in 1960 to complete the series.

Construction of magnetometer probe payload: This payload is being prepared for the Thor-Delta interplanetary probe scheduled for the second half of this year.

Completion of two electron density probe payloads: These probes will be launched using Scout vehicles to an altitude of 6,000 to 8,000 miles.

Procurement of nuclear emulsion recovery payload: This payload will also be completed within fiscal year 1960 funds. The payload, again launched with a Scout, is designed to expose an emulsion to the Great Radiation Belt and cosmic rays before recovery for subsequent analysis.

Procurement of two lunar orbiter flight systems: Negotiations are currently under way with BMD-STL for the two Atlas-Able lunar orbitor attempts in 1960. This will be a "package" contract including launch vehicles, launch services, and payloads (3). The project constitutes a continuation of the Atlas-Able lunar program of 1959.

Design, development, and fabrication of five Agena and two Centaur spacecraft and payloads: This grouping of line items constitutes the spacecraft and payloads to be used by the NASA in the lunar and planetary program in 1961 and 1962. The lunar impact missions have been previously described as directed toward reconnaissance prior to impact and survival of some scientific equipment. The planetary missions will conduct experiments in interplanetary space and

will study the planets at their point of closest contact. These expenditures began in the fiscal year 1959 with a largely in-house effort at the Jet Propulsion Laboratory directed toward the development of a planetary spacecraft for the Vega. In 1960 the missions were more clearly defined and the level of effort increased commensurate with an early 1961 launching date. The change from Vega to Atlas-Agena as the launch vehicles has caused remarkably little disruption to the effort. It is expected that the majority of the spacecraft and payload expenses for these seven missions will be completed with the fiscal year 1961 funding. The funds cover development of flight hardware from the early research phase, through the "breadboard" and prototype equipment, to the flight articles. A minimum amount of prototype (nonflight) equipment is included for adequate environmental testing prior to the actual missions.

General program support: The analyses and studies funded here are necessary to determine the most desirable trajectories to fly and the optimum equipment required to fly them. Without this effort it would be virtually impossible to "freeze" on a mission, a configuration, or the subsystem equipment with any degree of confidence.

Design study and preliminary engineering for Centaur and Saturn spacecraft: The relatively short lead time before the Centaur lunar soft landing mission requires that specifications be prepared and preliminary engineering accomplished as rapidly as possible so that the critical subsystems (navigation, guidance and control) can be contracted for at the earliest possible date. This work is now under way and will continue in fiscal year 1961. The contract monies for Centaur guidance and control are listed under the Vehicle Systems Technology program.

The situation with the Saturn spacecraft is somewhat less pressing although with a lead time of 3-1/2 to 4 years required, coupled with a 1965 launch date, the indicated funds are considered the minimum to carry out preliminary study contracts prior to a hardware contract in the fiscal year 1962. The extreme complexity of the mobile spacecraft for the Saturn lunar soft landing as well as the complexity of the planetary orbiter with landing "probes" dictate very careful planning for these projects.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Completion of Pioneer payloads	$2,460,000	---	---
Completion of Able payloads	3,740,000	$2,289,000	---
Construction of magnetometer probe payload:			
Magnetic field probe	---	174,900	---
3 nontracking telemeter antennas	---	150,000	---
Special data processing	---	9,900	---
Electronic systems	---	88,400	---
Radio-frequency systems	---	168,300	---
Mechanical systems	---	272,200	---
Thermal systems	---	11,300	---
Component and payload testing	---	59,000	---
Completion of 2 electron density probes:			
Radio frequency systems	---	265,500	---
Thermal systems	---	11,800	---
Mechanical systems	---	208,700	---
Procurement of nuclear emulsion recovery payload	---	600,000	---
Procurement of 2 lunar orbiter flight systems	---	10,000,000	$3,500,000
Design, development, and fabrication of 5 Agena and 2 Centaur spacecraft and payloads:			
Structures	100,000	1,300,000	1,600,000
Flight telemetry	12,000	1,400,000	1,200,000
Ground telemetry and data reduction	637,000	1,000,000	986,000
Radio command system	250,000	550,000	500,000
Solar power system	770,000	1,670,000	1,450,000
Attitude control system	310,000	1,533,000	1,260,000
Payload communications system	895,000	2,350,000	2,300,000
Payload communications system testing	200,000	250,000	350,000
Electronics module packaging	36,000	340,000	353,000
Spacecraft system integration	54,000	350,000	350,000

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Spacecraft environmental reliability design and testing	$388,000	$892,000	$900,000
Special environmental test equipment	290,000	450,000	420,000
Special ground electronics equipment	32,000	290,000	326,000
JPL launch crew at AMR	30,000	360,000	400,000
Mission control center operation	5,000	101,000	276,000
Midcourse guidance rockets	25,000	242,000	237,000
Payload radiation instruments	---	240,000	330,000
Payload lunar photographic system	---	200,000	1,100,000
Payload cosmic ray counter and magnetometer	---	---	560,000
Spacecraft sequencing timer	---	100,000	600,000
Impacting retro-package	---	100,000	2,500,000
Technical documentation of Agena system	71,000	323,000	535,000
General program support:			
Analysis of lunar and planetary trajectories	200,000	324,000	324,000
Analysis and evaluation of guidance methods	500,000	1,045,000	600,000
Analysis of scientific missions	195,000	752,000	793,000
Design study and preliminary engineering for Centaur spacecraft	---	1,500,000	1,500,000
Design study and preliminary engineering for Saturn spacecraft	---	1,000,000	1,250,000
Total	$11,200,000	$32,971,000	$26,500,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

METEOROLOGY

Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
$987,550	$7,930,000	$20,700,000

1. OBJECTIVES:

To establish a meteorological satellite capability for world-wide coverage and for providing observations of atmospheric elements required by the meteorologist in order to understand atmospheric processes and predict the weather. These elements include cloud cover, storm location, precipitation, temperature, wind direction, heat balance, water vapor and other constituents. To achieve this objective will require: (a) the development of stabilized satellites for polar orbits of 500- to 1,000-mile altitude and "stationary" satellites for equatorial orbits of 22,000-mile altitudes; (b) the development of suitable on-board detection equipment, including television, infrared detectors, radar and spectroscope; and (c) the development of adequate data storage, handling and communications equipment and techniques.

The long range objective is to develop the principles of a system of instrumented orbiting satellites and communications network by means of which world-wide meteorological information may be transmitted to the National Meteorological Center of the Weather Bureau for its operational use.

2. JUSTIFICATION:

The earth satellite represents a new observational tool which promises to be of great value to the science of meteorology and to the practice of weather forecasting. Although it would be a mistake to imply that such a device will eliminate our meteorological

limitations, there is no doubt that it will supply a tremendous amount of useful meteorological data not now obtainable. It will do this not only because of its ability to give world-wide coverage to some meteorological parameters, in contrast to the current five to ten percent coverage, but also because of its unique vantage point above the atmosphere which will make new measurements possible. Improved basic scientific understanding of atmospheric processess and a more comprehensive knowledge of world and regional climatology will result and these should assist in producing advances in weather forecasting and in approaches to weather modification and control.

The benefits to be derived from these improved capabilities in meteorology include convenience in planning personal activities, protection of life and property from weather disasters; safeguarding transportation; crop planning, control and protection; industrial planning of weather-dependent products, outdoor enterprises, and heating and cooling loads; eventual limited weather modification and control; and good will in return for providing current global meteorological data to other nations. In addition, the same meteorological data required for world-wide civilian needs can, by proper handling, be made to meet special military needs as well.

3. PROGRAM PHASING:

Project TIROS was initiated by ARPA and transferred to NASA in April, 1959. In addition to the support provided by ARPA in payload and booster development, NASA purchased the following items with fiscal year 1959 funds: (a) radiation detection equipment and associated ground equipment for a meteorological satellite (TIROS) to be launched once during the fiscal year 1960 and again during the fiscal year 1961; and (b) tracking, telemetering, data processing, and data analysis equipment and services for the satellites.

The fiscal year 1960 funds provide for the continuance of this program at an accelerated rate with strong emphasis on the development of equipment for a series of stabilized follow-on meteorological satellites. These include a radar feasibility study, the development of an electrostatic tape recorder, the development of a vidicon camera, optics and controls, radiation scanning heads, low resolution heat budget instrumentation, attitude control development, spectroscope development studies, the development of recorders, programmers, transmitter controls and receivers for the satellite. A substantial effort in basic meteorological research for the utilization of meteorological satellite data is also

being conducted. Studies using data from rocket probes, aircraft reconnaissance, and the current meteorological observation sources simulate the kind of information that will be available from satellites and develop techniques to be applied to the analysis of actual satellite data from TIROS. In the fiscal year 1960 TIROS I (containing TV to map cloud cover) will be launched.

The fiscal year 1961 funds have been programmed (a) to maintain basic research at approximately the same level; (b) to allow for some increased activity in the development of advanced instrumentation (specifically in the development of stabilized vehicle control systems, and in the further development of IR detectors, TV systems, radar, and spectroscope; (c) to launch TIROS II (containing both TV and IR sensing instruments); (d) to allow for increased activity in the analysis of data acquired from the meteorological satellites (TIROS I and II); and (e) to initiate payload development, booster vehicle purchase and launch of the follow-on meteorological satellite.

4. PROGRAM COSTS:

	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Advanced technical development:			
Atmosphere, radiation, and data systems research.....	$158,550	$1,250,000	$1,400,000
Development of advanced instrumentation.	11,000	3,099,000	4,400,000
Flight research program:			
Payloads.....	818,000	3,581,000	9,200,000
Booster vehicles.....	---	---	5,700,000
TOTAL.....	$987,550	$7,930,000	$20,700,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

METEOROLOGY

Objectives

The over-all objective of the NASA meteorological satellite program is to establish the technological background needed for operation of a system of satellites to provide world-wide observations of atmospheric elements required by the meteorologist in order to understand atmospheric processes and predict the weather. These elements include cloud cover, storm location, precipitation, temperature, wind direction, heat balance, water vapor and other constituents. To achieve this objective will require: (a) the development of stabilized satellites for polar orbits of 500- to 1,000-mile altitude and "stationary" satellites for equatorial orbits of 22,000-mile altitudes; (b) the development of suitable on-board detection equipment, including television, infrared detectors, radar and spectroscope; and (c) the development of adequate data storage, handling and communications equipment and techniques.

Flight Program

Two Tiros satellites will be launched the calendar year 1960 -- one during the first quarter and one during the third quarter. These satellites will be spin stabilized and so will have a fixed orientation in space and an intermittent coverage. They will be launched on an inclined orbit thus further limiting the coverage of the Earth's surface to between 50° N and 50° S latitude. Tiros I will have a vidicon television system for determining cloud cover as its principal instrumentation. Infrared radiation sensors will be added in the Tiros II payload.

The Tiros experiments will be followed by a series of advanced meteorological satellites to be known as the Nimbus series. This will be a family of satellites with many common components (data storage, controls, orientation, stabilization, data transmission, structure, etc.) but with a flexible capability for accepting new or improved

sensory systems, as required. Nimbus will be polar launched from the Pacific Missile Range and hence will be able to traverse the entire globe. It will be Earth oriented, so that the sensors will face the Earth at all times. Thus the actual data coverage of Nimbus will be much larger than with Tiros.

The first Nimbus satellite will be launched during the third quarter of calendar year 1961. Succeeding satellites will be launched at approximately six month intervals with improved or new instruments.

The meteorological data from the Tiros and Nimbus satellites will be analyzed and correlated by the U. S. Weather Bureau. In addition to their basic value, these data will be used to develop improved techniques of handling and interpretation so that requirements for an operational system can be developed.

Atmosphere, Radiation, and Data Systems Research

Basic studies are required to assist in the design of meteorological satellite experiments and apply satellite data to forecasting. Examples of the work being conducted by the U. S. Weather Bureau under NASA support are: the analysis of cloud pictures obtained from rockets; the study of the general circulation of the atmosphere and its relation to the atmospheric heat balance as measured from satellites; the study of the feasibility of and the method of approach to making satellite measurements, such as precipitation, by radar and atmospheric temperature and composition by spectrometers; basic radiation studies and calculations to develop methods of determining meteorological parameters from satellite infrared measurements.

At the University of Michigan, studies are being conducted with rocket launched grenade experiments for determining temperature and winds in the 20- to 60-mile altitude region, by measuring the travel time to the ground of the grenade explosions' sounds. In addition, at the University of Michigan, balloon and rocket-borne measurements will be made of the radiation properties of the Earth as observed from high altitudes. Specific measurements are intended to aid in the interpretation of satellite measurements.

A study will be directed to the question of how to present, in analog form, the very large quantity of data transmitted by the satellite so that the meteorologist can make the best immediate use of it. Since the results of this study are desired within a year, the level of effort of this study will be substantial.

The transmission of the large quantity of data from the satellite to the ground is a limiting factor in the experimental meteorologist's ability to use the information. A study will be supported to explore the problems and methods of integrating and digitalizing the data aboard the satellite with a view to reducing the amount of information transmitted.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Basic studies by Weather Bureau.....	$140,000	$600,000	$400,000
Basic radiation studies, University of Wisconsin.....	18,550	---	---
Basic radiation studies, University of Michigan.....	---	270,000	350,000
Research in dynamics of atmosphere, Texas Western University.....	---	80,000	---
Research in dynamics of atmosphere, University of Michigan.....	---	300,000	---
Study of data presentation systems.....	---	---	350,000
Study of on-board data analysis.....	---	---	300,000
Total.....	$158,550	$1,250,000	$1,400,000

Development of Advanced Instrumentation

NASA is maintaining an active instrument development program to improve the performance and reliability of existing flight instruments and for developing new instrumentation to provide additional meteorological data not yet available.

An engineering test model of an electrostatic tape recording camera is being developed from basic laboratory principles. It is expected to lead to equipment which is to be incorporated on board Nimbus I. By means of the electrostatic tape recording camera subsystem, it will be possible to obtain better quality pictures and of higher resolution than now possible. When perfected, this system may replace the vidicon picture taking system.

By including image enhancement techniques to image orthicon television systems, it may be possible to obtain TV cloud pictures under very low light levels. This capability makes such a system applicable to the problem of obtaining cloud pictures of the night side of the earth under moonlight or perhaps star light conditions. In a single contractual effort, there will be developed a rigidized, simplified orthicon and the application of image enhancement will be investigated.

Until other systems such as the electrostatic tape recording camera or the image orthicon television systems are perfected, the vidicon camera system remains the best all-around system applicable to satellites at this time. The present Tiros vidicon camera systems, however, are limited in resolution, reliability and recording capability. The use of such vidicon systems in the earth oriented Nimbus satellite will require considerable developmental work to improve the resolution and stability of the vidicon tube, the reliability of the electronic sweeps and controls, and the capacity and flutter and wow characteristics of the tape recorder.

Radiation measurements are fundamental to the meteorological satellite program and a continued study and development of sensor and scanning systems are most essential. In particular, increased activity in detector development is required.

In the fiscal year 1960, a feasibility study will be undertaken to determine the general specifications required to produce satellite-borne radar equipment for the identification and tracking of precipitation areas over the earth. There will be a continuation of this effort in the fiscal year 1961 directed toward the development of prototype equipment. The performance of this equipment will first be demonstrated in balloon flights.

A series of developmental contracts are under way for electronic and mechanical devices for present and future satellite use. Improvements in these devices will contribute to the efficiency of processing, storing, and transmitting data from the meteorological sensors to the read out stations. In addition, the desired performance of the satellite places special requirements on the electronic components included in the various subsystems. Continued vigorous development of special electronic components will be pursued along the lines dictated by the specific requirements of the flight program.

Of major importance to the Nimbus flight program, is the development of a suitable stabilization subsystem capable of pointing the sensors toward the earth throughout the life of the satellite. A modest effort has been begun in the fiscal year 1960 in the development and production of a prototype stabilization subsystem. To meet the launch-schedule requirements an immediate and intensive program in the development and production of such a prototype needs to be undertaken in the fiscal year 1961.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Studies of advanced radiation methods.....	$11,000	$100,000	$100,000
Tape recorder for Tiros radiation experiments	---	154,000	---
Electrostatic tape recording camera.....	---	350,000	---
Advanced vidicon camera systems.....	---	500,000	---
Radiation scanning heads and detectors:			
Scanning systems studies.....	---	100,000	100,000
Uncooled detectors for region beyond 6.3m...	---	80,000	150,000
Dielectric and related bolometer studies....	---	100,000	100,000
Detector cooling techniques.....	---	50,000	50,000
Electronic and mechanical instrumentation:			
2w, 240 mcs wide band transmitter.....	---	50,000	---
Special 5 channel telemetry.....	---	30,000	---
Control electronics for special tape recorder	---	25,000	---
Clocks, programmer, controls and switching system.....	---	120,000	---
Tape recorders.....	---	25,000	100,000
Secure digital command system.....	---	100,000	100,000
5w, 1700 mcs, wide band transmitter.....	---	50,000	100,000
Special telemetry beacon and switch.....	---	50,000	50,000
VHF, UHF, and microwave antenna systems.....	---	50,000	50,000
Infrared radiation satellite systems:			
Special supplies and materials.....	---	560,000	410,000
Support services.....	---	125,000	340,000
Attitude control components and system.....	---	380,000	1,500,000
Satellite-borne radar.....	---	100,000	400,000

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Electronic components:			
Constant beta, low-noise transistor.....	---	---	$70,000
1000 mcs, 1 watt transistor.....	---	---	100,000
High-resolution electron gun.....	---	---	80,000
Far infrared imaging device.....	---	---	100,000
Image orthicon system.....	---	---	300,000
Advanced data transmission study.....	---	---	100,000
Spectrometer.....	---	---	100,000
Total.....	$11,000	$3,099,000	$4,400,000

Payloads

When the meteorological satellite program, Tiros, was transferred to NASA from the Department of Defense in April 1959, some $7,977,000 had been provided by ARPA for payload development either directly to the contractor or through NASA. The funding by NASA since the transfer has been for completing the development and production of five basic payloads in the Tiros series, the modification of equipment at read out stations, special support operations involved at these stations and the analysis of the data acquired by the satellite.

With the availability of data from Tiros I and Tiros II, the major effort of the Meteorological Satellite Section of the U. S. Weather Bureau will turn to the problem of satellite data analysis and interpretation. The scanning radiation data acquired by Tiros II will be converted from analog to digital information and processed for Weather Bureau use. The data will also be analyzed for application to future satellite-borne radiation measurements.

The follow-on satellite to the Tiros series will be the Nimbus satellite. One of the basic problems in Nimbus is the development of a suitable spaceframe whose structure and components are compatible with the structure and components of the terminal stage of the launch vehicle. In the fiscal year 1960, the basic hardware and test equipment will be acquired for the spaceframe development. Nimbus is a large and complex satellite with a number of meteorological sensory systems, a stabilization system, and a power supply system. The selected contractor

for the Nimbus satellite payload development and integration will provide through approved and appropriate subcontractors the structures, television subsystem components, the electrostatic tape recorders, the radiation measurement equipment, the electronic controls (timers, transmitters, receivers, beacons, tape recorders) and other mechanical parts that will constitute the satellite. In addition, there will be a single contractual effort for the development and production of the solar cell power supply intended for the satellite.

The proof of the reliability of a finished satellite is the most difficult and most critical phase of the satellite development effort. The testing program will include vibration, acceleration, vacuum-thermal and life testing of each of the seven basic Nimbuses developed. A three-month life test program will be carried out for each of the five flight models.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Tiros I:			
Completion of payload development and construction	$278,000	$1,555,000	---
Modification of equipment and station operation for data acquisition:			
Deal, New Jersey	260,000	---	---
Kaena Point, Hawaii	280,000	155,000	---
Atlantic Missile Range	---	30,000	---
Quick demodulation equipment	---	28,000	---
Data analysis	---	300,000	---
Tiros II:			
Payload modification	---	400,000	---
Station operation for data acquisition	---	113,000	---
Pre-launch payload operations	---	---	$500,000
Data analysis	---	---	800,000
Special radiation analyses	---	---	100,000
Analog to digital data conversion	---	---	200,000

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Nimbus:			
Terminal stage structure and hardware....	---	$350,000	---
Stabilization components.....	---	150,000	---
Stabilization subsystem structure construction.....	---	250,000	---
Special test equipment for stabilization system.....	---	250,000	---
Payload development and construction.....	---	---	$5,000,000
Environmental testing of payload.....	---	---	2,000,000
Payload power supply, development and construction.....	---	---	600,000
Total.....	$818,000	$3,581,000	$9,200,000

Booster Vehicles

The Tiros I vehicle (Thor-Able) was funded by the Department of Defense during the period of inception of the program in that agency. The Tiros II vehicle (Thor-Delta) was funded under the Delta vehicle development program. Consequently, no booster vehicle costs are indicated in the meteorological satellite program in the fiscal years 1959 and 1960.

The funding during the fiscal year 1961 will partially cover the cost of two Thor-Agena B launch vehicles.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Procurement of four Thor-Agena B launch vehicles (partial funding).....	---	---	$5,700,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

COMMUNICATIONS

Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
$3,574,806	$3,170,000	$5,600,000

1. OBJECTIVES:

To develop communications satellites and operating techniques for use in a world-wide communications system using satellites as relay stations for ground-to-ground, ground-to-satellite, and satellite-to-ground transmission of messages, data, voice and television; to develop communications systems for the transmission of scientific data from deep space probes to earth and of commands from earth to deep space probes; and to conduct studies of the application of active relay satellites to civilian and commercial communications.

2. JUSTIFICATION:

Long-range communications in the form of telephone, telegraph, and television networks are now accomplished by means of land lines, cables, long and short wave radio, and microwave relay stations. The total bandwidth of land lines, cables, and low-frequency radio is limited. Short-wave radio bands are crowded and are unreliable because of atmosphere interference and ionospheric irregularity. Ultra-short-wave or microwave radio is usually limited to line-of-sight range; long distance communication at these frequencies is commonly achieved by means of repeater stations.

Satellites offer the possibility of world-wide communications by ultra-short-wave or microwave radio because the line-of-sight range at satellite altitudes is very large. The bandwidth or channel capabilities at these wave lengths is sufficient for television and most other foreseeable communications needs.

The scientific exploration of outer space is accomplished by the use of deep space probes. The data these probes accumulate must be transmitted to earth, and the earth stations must be able to send commands to the probes at various points along their paths. This requires a two-way communications link between the earth and the probe.

3. PROGRAM PHASING:

During the fiscal year 1959, work was initiated on Project Echo - a project to place several 100-foot diameter inflatable spheres into circular orbits about the earth. These spheres will be used to reflect passively electromagnetic energy from one ground station to another. Part of the project is the development of the sphere itself, its packaging into a payload, and methods of inflating and ejecting the sphere from the final booster stage. A 12-foot diameter version of this sphere, which was also to furnish data for air density studies, was launched in August 1959 but failed to achieve orbital velocity. The development of a beacon to aid in the tracking of the satellites was started in the fiscal year 1959. Improvements were also made to the JPL Goldstone transmitter and receiving sites at the Jet Propulsion Laboratory.

In the fiscal year 1960, the large-sphere flight research program will be initiated. Several 100-foot diameter inflatable sphere payloads will be ejected from boosters in vertical sub-orbital shots to test ejection and inflation techniques. Following this, a 100-foot sphere will be launched to orbit. Communication experiments will be conducted between east and west coast transmitting and receiving stations, using the sphere as a passive relay.

Research and development will be conducted in the fiscal year 1960 in several areas. In the area of inflatable structures for use as passive reflector satellites, work will be done on radio propagation characteristics, the feasibility and development of larger structures, and on regidization techniques. Studies will be undertaken in the field of world communications needs, of communication satellite system requirements to fulfill these needs, and of the ground support systems required for their use. These studies will be directed toward providing recommendations for the optimum communications satellite system.

The fiscal year 1961 program is a continuation and broadening of the 1960 program. Additional 100-foot spheres will be launched for further communications experiments. Since a world-wide passive satellite communications system will require several satellites simultaneously in orbit, the development of a multi-sphere payload for launch by a single vehicle will be started.

One of these will be launched in 1962. Data transmission requirements will be studied, with emphasis on a data relay for meteorological satellites. The advanced equipment development program will result in prototype models of a high-gain antenna and mount. Development of suitable modulation systems will be initiated.

During the fiscal years 1960 and 1961, work on active relay satellites will be limited to studies on the civilian and commercial applications of these satellites, the requirements imposed by commercial needs on such satellites, and the application of pertinent developments resulting from the Department of Defense program.

During the fiscal year 1959, work in the area of deep space communications was carried out by the Jet Propulsion Laboratory as part of its Juno II program. Their work included the design of a space vehicle communications and tracking system for the Pioneer III and IV experiments and the evaluation and improvement of elements of existing systems.

In the fiscal year 1960 studies will be made to determine the requirements for deep space communications, and the development of new components will be continued. Fiscal year 1961 will continue studies and component development, and will provide for communications equipment for use in planned deep space experiments.

4. PROGRAM COSTS:	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Advanced technical development:			
Communications satellite studies and equipment development.....	$284,806	$740,000	$1,100,000
Deep space communications studies and equipment development.....	---	400,000	350,000
Flight research program:			
Boosters.....	2,150,000	---	---
Payload development, procurement, and operation.....	1,140,000	2,030,000	4,150,000
TOTAL.....	$3,574,806	$3,170,000	$5,600,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

COMMUNICATIONS

Objectives

One of the major objectives of the NASA is to investigate the utility of satellites for providing global communications. Communications satellite systems show great promise and almost unlimited capacity for the instantaneous transmission of voice, teletype, television and telemetry data throughout the world. In addition to providing ground-to-ground communications, such satellite systems can provide ground-to-satellite or space vehicle communications on a continuous basis. The NASA communications satellite program has as its objectives the research and development on one form of communications satellite system, the passive satellite system, and on the supporting technology necessary to the use of such satellites. To achieve these objectives will require (a) the development of techniques for erecting large, light-weight structures in space, (b) the development of techniques for rigidizing these structures once erected, (c) the development of the optimum shape for such satellites to effect minimum transmission losses, (d) development of satellite stabilization techniques to take advantage of more efficient satellite designs, (e) development of satellite tracking and antenna pointing techniques, and (f) the development of high powered ground transmitters and very sensitive receivers.

The advanced technology which must be provided for passive communications satellites (so that the very weak signals which are reflected may be received) very closely parallels that required for communicating over the very large distances of space. As planetary and space probes become larger and more sophisticated, so will the requirements on communications for these probes increase in volume and distance. For this reason the program also calls for the extension and application of this advanced technology to the deep space communications problem.

Flight Program

Three Project Echo launches are scheduled -- one during the second quarter of calendar 1960, one in the second quarter of calendar 1961, and one in the first quarter of calendar 1962.

The satellites in this series of launches will be 100 foot diameter inflatable spheres made of thin mylar plastic and covered with vapor-deposited aluminum to provide reflectivity. The purpose of this series of flights is to develop the technology required for erecting and insuring the durability of such structures in space and to utilize these satellites in communications experiments to demonstrate feasibility and to develop the ground equipment necessary for communications via passive satellites.

Following this series of Project Echo satellites there will begin a program of research and development on the elements of an operation system. In the fiscal year 1961 there will begin the development of a capability for launching a number of communication satellites with a single booster. Since an operational system may require as many as 26 satellites in orbit to achieve 99 percent availability for communications it is desirable to put as many as possible in orbit at one time with the large boosters that will be available in this time scale. The first launching of this payload, using an Atlas Agena-B vehicle, will occur in the third quarter of calendar 1962.

Communications Satellite Studies and Equipment Development

The studies and equipment developments initiated in the fiscal year 1959 were all associated with the system represented by the first Echo configuration.

In the fiscal year 1960, the scope of the program has been increased to a consideration of reflector shapes other than the simple sphere, and to the associated problems of regidization, stabilization, and radio-propagation characteristics of these more complex structures. This work will continue through the fiscal year 1961.

Two studies are also being initiated in the fiscal years 1960 and 1961. These will consider the operational requirements of satellite communications systems for integration into potential commercial systems (radio, telephone, television) and for integration into other space flight activities as a link in the scientific data transmission from spacecraft to earth control and data centers.

Developments of high-gain antennas are also being undertaken starting in the fiscal year 1960. These efforts will be aimed at the development of antenna that can be electrically, rather than mechanically, "pointed". Such antenna are needed for airborne as well as ground installations.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Echo computer program requirements - study..	$40,000	---	---
Radio beacon - development.....	44,000	---	---
Inflatable space structures facilities - development and modification.....	70,806	---	---
Echo transmitter - development.....	130,000	45,000	---
Digital antenna pointing equipment - development.....	---	70,000	---
Influence of ultimate communications system on satellite design and orbit - study.....	---	200,000	200,000
Larger sphere and other forms of passive satellites - study.....	---	50,000	200,000
Rigidization techniques for space structures - development.....	---	150,000	150,000
Propagation characteristics of reflector designs - development.....	---	75,000	100,000
Electrically steerable antenna array - development.....	---	50,000	150,000
Passive satellite stabilization system - study.....	---	100,000	200,000
Communications satellite's requirements for scientific data transmission - study..	---	---	100,000
Total.....	$284,806	$740,000	$1,100,000

Deep Space Communications Studies and Equipment Development

In the fiscal year 1960, a one-year study will be undertaken to determine the required rate of information transmission for communications with advanced deep space and planetary probes and to specify those areas in which available communications techniques cannot meet these needs. Already begun in the fiscal year 1960, and continued in the fiscal year 1961, are developments in sensitive receivers with low-noise amplifiers, investigations for increasing the efficiency of the Goldstone antenna by operation at higher (X-band) frequencies and the development of more

efficient modulation techniques. All of these developments will assist in increasing the rate of information transfer for use by both deep space probes and communications satellite systems.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
NASA requirements for deep space communications - study.....	---	$100,000	---
Parametric amplifier development, modulation techniques development, and X-band antenna investigations.....	---	300,000	$350,000
Total.....	---	$400,000	$350,000

Boosters

Boosters for communications satellite payloads in the fiscal year 1960 and the fiscal year 1961 will be funded under the Delta vehicle development program.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Juno II procurement and launch.....	$2,150,000	---	---
Total.....	$2,150,000	---	---

Payload Development, Procurement, and Operation

The Echo I payload development program was completely funded in the fiscal year 1959. As part of the development program, four ballistic flights from Wallops Island were scheduled to test the satellite ejection and inflation techniques. Necessary rocket motors and associated flight hardware and ground facilities were provided.

Echo II and III will incorporate improvements to provide for structural rigidity using techniques resulting from the rigidization development program. Ballistic flights will also be used to test these payloads. Although these payloads will be more advanced than Echo I, development costs will be substantially the same inasmuch as a great portion of the basic development for this type structure was performed in the Echo I program.

To meet the flight schedule for a multiple rigidized sphere launch in the third quarter of the current year, payload development is partially funded in the fiscal year 1961. The balance of this development will be funded in the fiscal year 1962.

Operation and improvement of ground facilities and data reduction for the communications experiments to be performed with the Echo satellites will continue.

Item		Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Echo I payload.....		$1,094,000	---	---
4 Sergeant rocket motors.....	$161,069			
4 X-248 rocket motors.....	40,000			
8 recruit rocket motors.....	32,604			
Stabilizing fins.....	80,000			
Nose fairings.....	20,000			
Spin tables.....	140,000			
Balancing equipment.....	25,138			
Instrumentation.....	39,075			
Assembly hardware.....	70,400			
100-foot diameter spheres.....	107,334			
Payload containers.....	48,777			
Fabrication and folding facility.....	16,647			
Instrumentation and de-spin mechanism.....	178,238			
Miscellaneous hardware.....	26,759			
Type approval and flight checkout.....	66,622			
Launching preparations.....	41,837			

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Echo II payload	---	$734,000	$300,000
Echo III payload	---	---	1,100,000
Multiple rigidized sphere payload	---	---	1,450,000
Design and systems engineering 250,000			
Sphere development 350,000			
Dispersing system development 270,000			
Attitude sensors and control system 230,000			
Beacon and instrumentation 200,000			
Satellite air frame development 150,000			
Operation of Holmdel transmitter and receiver site	$46,000	126,000	200,000
Operation of Goldstone transmitter and receiver site	---	378,000	400,000
Operation of Milstone radar site	---	50,000	100,000
Modifications of Goldstone transmitter equipment	---	277,000	---
Data reduction	---	200,000	250,000
Ground communications equipment modifications	---	265,000	350,000
Total	$1,140,000	$2,030,000	$4,150,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

MANNED SPACE FLIGHT

Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
$46,416,333	$87,162,000 1/	$107,750,000

1. OBJECTIVES:

To provide a capability for accomplishing advanced space flight missions with vehicles where on-board human intelligence and operations are required; to rationalize and refine the technology of manned space flight vehicles and associated systems; to achieve successful orbital flight and the recovery of a manned satellite with an ICBM booster and drag-reentry system; to evaluate the physiological and psychological effects of a space environment on man; to establish his capabilities and limitations for performing useful missions in space; and to devise and develop improved manned vehicles with increased capabilities for performing important advanced missions.

2. JUSTIFICATION:

The ultimate benefits that might accrue from manned space flight are, in a large measure, unknown. It is clear, however, that instrumentation alone will not tell us as much about the moon, or the planets, as man himself will be able to report once he has visited those distant places. Man contributes observational, analytical, and decision-making ability concerning both expected and unanticipated problems. He provides a vast flexibility of action for operation, correction, and maintenance of scientific and technological instrumentation and equipment that characterize his present usefulness in airplanes and in the scientific laboratory.

1/ Includes $12,200,000 requested in fiscal year 1960 supplemental estimates.

In order to provide the capability for the manned exploration of space, a progressive program of research and development has been undertaken. A broad range of investigations, directed to the solution of basic technological problems concerning vehicular configurations and construction, human factors, life-support equipment and accommodations, launching systems, stabilization and control, reentry and recovery systems and techniques, operational and scientific instrumentation, and other vehicular subsystems, is under way. These investigations are presently directed towards solution of the problems associated with the nation's first manned venture into orbit - Project Mercury. On the basis of extensive studies, it was determined that Project Mercury should be based on the use of an ICBM booster launching system and on a ballistic type of reentry into the atmosphere. The use of ballistic reentry offers the best potentiality for early success because of the relative simplicity and reliability of this approach. However, ballistic reentry pays for its simplicity with landing point dispersions that will be operationally and economically unacceptable for extended use. As Project Mercury nears completion, extensive studies and configuration tests in wind tunnels and free flight will be undertaken as part of a program to develop the capability for landing point control.

A crucial part of the system for attaining landing point control is the stabilization and control system. It is important that this system be capable of both manual and automatic operation, in order to enhance reliability through human back-up and in order to allow for the use of on-board human judgment to vary the landing site choice. A comprehensive study, including flight simulators for pilot training, will be required to provide this capability.

In order to meet the foremost objective of Project Mercury - the attainment of manned orbital flight at the earliest practicable date - additional funds in the amount of $12,200,000 have been requested as a fiscal year 1960 supplemental estimate. The additional $12,200,000 is required to pay for contractor overruns, changes in capsule design and construction, and for added capsule requirements. The design changes and added requirements have arisen as a result of development tests and a continuing analysis of safety requirements. The compressed time-phasing of Project Mercury between inception and scheduled flight has required that research, development, design, and fabrication be undertaken simultaneously. Under these conditions, experience has required that modifications to design, arrangement, and structure, be made during the conduct of the program. Efforts to make the Project Mercury system as safe as humanly possible have inevitably added to the cost, as detailed analyses have uncovered new schemes for enhancing the safety and reliability of the system.

3. PROGRAM PHASING:

During the fiscal year 1959, much of the pre-flight research and development effort for Project Mercury was accomplished and contracts were let for major components of the system. Specifications for the world-wide radio tracking network were prepared and sent out to prospective contractors.

During the fiscal year 1960, the major part of the Mercury pre-flight and flight development program will be completed, and component qualification and astronaut training flights will be initiated. The tracking network will near completion during this period.

During the fiscal year 1961, it is anticipated that the Mercury qualification programs will be essentially completed and that the tracking network will become operational. Large expenditures for the recovery operations and for the operation of the tracking network will be added to flight hardware purchases.

Systems for achieving landing point control will also be under study during the fiscal year 1961. In this connection, two major problem areas require immediate attention: the use of lift to reduce the landing area, and guidance and control methods for piloted landings. Extensive analyses will be made, and scale models of controllable reentry vehicles will be evaluated in wind tunnels. Flight simulators will be used to evaluate the pilot's capability to fly such vehicles.

4. PROGRAM COSTS:

	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Advanced technical development:			
Biological and human engineering studies	$170,000	$2,180,000	$2,090,000
Mercury development program	3,100,000	5,270,000	4,050,000
Advanced reentry configuration	---	---	800,000
Manual and automatic guidance and control systems for advanced reentry configuration	---	100,000	200,000

	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Flight research program:			
Atlas and Redstone boosters.....	$20,840,000	$23,460,000	$25,650,000
Mercury capsules, support equipment, and support services.....	22,299,333	47,212,000 1/	35,290,000
Tracking network operations and equipment.....	7,000	5,410,000	24,670,000
Recovery operations.....	---	3,530,000	15,000,000
TOTAL.....	$46,416,333	$87,162,000 1/	$107,750,000

1/ Includes $12,200,000 requested in fiscal year 1960 supplemental estimates.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

MANNED SPACE FLIGHT

Objectives

Our long-range plans for the exploration of space are based on the premise that man will actively participate in many of our space missions. These plans, therefore, strongly depend on the assumption that manned space flight is feasible, and that man will indeed be able to perform useful functions in space. Much of our future effort depends on the validity of this assumption, and it is therefore imperative that man's capabilities in space be determined as soon as possible.

Project Mercury was conceived, and is being carried out, in a manner that will attempt to achieve manned orbital flight at the earliest practicable date. Its primary objective is to determine man's capabilities in a space environment.

In the Mercury mission, a satellite capsule will be launched into a 120-mile orbit, using an Atlas booster. The capsule will be fitted with an escape system, designed to separate it from the Atlas in case of a booster malfunction. In a normal mission, the satellite will circle the globe three times; at the end of three orbits, the capsule's retro-rockets will be fired to initiate its descent toward the atmosphere. During its flight within the atmosphere, it will be slowed down, by the drag of the air through which it flies, to a speed where the landing parachutes can safely be deployed. After a parachute landing in the Atlantic Ocean, the capsule will be picked up by recovery ships that are standing by.

The accomplishment of Project Mercury will mark a tremendous step forward; putting a man into space will immeasurably extend the frontiers of manned flight. The speed of flight will be increased by a factor of eight over present achievements, and the altitude by a factor of five; the environment encountered in space flight will be one that heretofore has not even been approached.

Research and Development Program

Because the ultimate achievement of manned orbital flight will constitute a stretching of the existing state-of-the-art, its accomplishment requires a logical and methodical build-up of capability. As a part of this build-up, broad scientific and engineering investigations have been undertaken, using a wide variety of technical equipment, to determine a suitable shape for the manned satellite capsule.

Following these investigations, a flight program was initiated to develop and qualify the various components of the capsule. A Mercury flight schedule is shown on a following page. The flight program includes airplane drop tests, in which full-scale capsule models were dropped from large cargo aircraft at high altitude. The tests were used to develop a highly reliable parachute system, and to determine procedures to be used in the recovery operations. In other tests, capsule models were released from fighter aircraft at supersonic speeds, to develop and qualify the capsule's drogue parachute. The escape system was perfected by launching full-scale capsules with the escape rocket as the only means of propulsion.

Rocket-boosted flight tests were required to check the capsule and its components over a range of speeds and altitudes. A solid-propellant rocket booster, nicknamed "Little Joe", was designed and fabricated especially for Project Mercury. This booster, which develops 2-1/4 million pounds of thrust at take-off, was used on a number of occasions to further aid in the qualification of the all-important emergency escape system.

The validity of the Mercury design concept was demonstrated in the fall of 1959 during an Atlas-boosted capsule test, called "Big Joe". In that test, a capsule was made to re-enter the Earth's atmosphere, after being accelerated to nearly orbital speed. The Big Joe capsule, which survived the scorching heat of reentry, was later recovered many hundreds of miles from Cape Canaveral.

To date, more than 100 wind tunnel tests of the Mercury capsule have been performed; and 122 capsule models have been dropped from airplanes in the parachute development program. The escape system has been tested three times in simulated off-the-pad abort maneuvers, and four more escape system tests were performed in connection with four successful Little Joe flights. A small monkey was carried along on two of the Little Joe flights, in an attempt to gain further physiological data on the effects of space flight. And, as mentioned earlier, a single Atlas-launched capsule flight has been made.

All flight tests to date were made with so-called "boiler plate capsules". These capsules simulate the shape and weight of the Mercury capsules, but do not contain many of the systems and subsystems that will be required for manned operation. Boiler plate capsules are of simple construction, utilizing heavy, welded sheet metal.

Mercury Capsules

In January 1959, the McDonnell Aircraft Corporation was selected as the prime contractor to design and construct the Mercury production capsules. The selection was based on an industry-wide competition; twelve firms submitted proposals based on NASA specifications for the capsule.

The Mercury capsule is by no means a simple device. It has been a major engineering task to design a satellite that can withstand the heat and forces of reentry, and yet is light enough to be boosted into orbit. All of the components of the satellite - the environmental system, the attitude control system, the communications system - constitute major developments of currently available equipment. The complexity of the device is perhaps best illustrated by the fact that seven miles of electrical wiring are interwoven into the capsule, in order to control the many valves, rockets, explosive volts, and electronic systems.

The compressed time-phasing of the project, between inception and scheduled flight, has required that research, development, design, and fabrication be undertaken simultaneously. Inevitably, under these conditions, experience has required that modifications to design, arrangement, and structure be made during the conduct of the program. To date, a large number of capsule changes have been made, as a result of potential trouble areas that have been uncovered in the research and development program; further changes were incorporated to insure the safety of the pilot.

A total of 24 capsules will be required for the various phases of the flight program. Currently, a number of capsules are nearing completion, and delivery of the first capsule is scheduled for March, 1960.

Qualification Flight Tests

Immediately after delivery of the first capsules, a qualification flight test program will be initiated. In this program, the production capsules will be flown on successively more difficult missions, culminating with the design mission of orbital flight.

In the first tests, to be carried out in the first half of calendar year 1960, the escape sequence will be tested in a simulated off-the-pad abort flight, and in another Little Joe flight.

Redstone Ballistic Flights

Starting in about the middle of this year, an important series of ballistic flights will be started, using the Redstone booster.

The Redstone will carry the capsule to an altitude of 125 miles, and to a distance of 200 miles from Cape Canaveral. The flight will last 16-1/2 minutes. During that time, the capsule will be accelerated to a speed of 4,000 miles per hour and will withstand g-forces as high as 6-1/2 during exit, and 11 during reentry. A weightless time of 5-1/2 minutes will be sustained.

Initially, the Redstone-boosted capsules will contain only instruments. Later on, a capsule containing a chimpanzee will be flown along the same trajectory, and, when all systems are sufficiently reliable, manned ballistic flights will be made. In these flights, man will be subjected to more than five times the period of weightlessness that had heretofore been possible. The experience gained by the astronaut in the operation of the capsule in these relatively short flights will be exceedingly valuable as part of the training program for the latter manned orbital flights.

Atlas Ballistic Flights

Capsule qualification at speeds higher than those possible with the Redstone will be carried out with the Atlas. The Atlas will launch the capsule along a series of ballistic trajectories before it is employed in the orbital mission. In these flights, the capsule will be subjected to the speeds, forces, and heating that will be encountered in orbital flight. All of the Atlas ballistic flights will be unmanned. The Atlas flight test program will start in the middle of this year.

Orbital Flights

After completion of the ballistic flight tests, the capsule and its launch vehicle will be ready for the first orbital flight. The altitude of the orbit will be 120 miles, and the speed 17,500 miles per hour. Each orbit will last 90 minutes. It is planned to keep the capsule aloft for three orbits, or 4-1/2 hours.

The first time the capsule is sent into orbit, it will contain only instruments so that the functioning of all the equipment can be checked. Later on, a capsule containing an animal will be flown to check the life-support system, the biological instrumentation on board, and to determine the physiological effects of long-term exposure to weightless flight.

Only after successful instrumented and animal flights have been completed, will the first manned flight take place.

Advanced Reentry Configurations

Project Mercury is only the first step in our long-range program for the manned exploration of space. Long-range goals in our program include manned landings on the moon, and still later, on the planets. Manned flight around the moon will be a prerequisite for a lunar landing.

The Mercury capsule is not suitable as a return vehicle for a lunar mission. Instead, a capsule capable of reentering the atmosphere at higher speeds will be required. Our studies also indicate that a lunar-return vehicle must be capable of generating some aerodynamic lift, in order to minimize the midcourse-guidance requirements. Aerodynamic lift may also be applied to control the landing point upon return from a satellite or space mission.

During fiscal year 1961, two major areas of advanced reentry configurations will be considered: the use of lift to facilitate reentry from space, and guidance and control methods for piloted space flight. Extensive analyses will be made, and scale models of various configurations will be evaluated in wind tunnels. Flight simulators will be used to evaluate the pilot's capability to fly such vehicles.

Mercury Flight Schedule

Vehicles	Fiscal Year 1959 (Quarters)		Fiscal Year 1960 (Quarters)				Fiscal Year 1961 (Quarters)				Fiscal Year 1962
	3	4	1	2	3	4	1	2	3	4	
Beach abort.....	1	1	1	-	-	1	-	-	-	-	
Little Joe.....	-	-	1	3	1	1	-	-	-	-	
Mercury Redstone...	-	-	-	-	-	-	2	3	2	1	
Mercury Atlas.....	-	-	1	-	-	1	2	2	2	2	5
	← Research and development capsules →						← McDonnell capsules →				

Biological and Human Engineering Studies

This portion of the budget provides for:

Development, evaluation, and acquisition of specialized personnel equipment such as pressure suits and life-support systems: The pressure suit procurement was initiated in the fiscal year 1960. During the fiscal year 1961, extensive evaluation of the suit will be made under simulated space conditions. Acquisition of suit testing equipment and apparatus will be required during this period. Similarly, the life-support system of the Mercury capsule will be evaluated under simulated space conditions during the fiscal year 1961. Procurement of testing apparatus and instrumentation, and development and procurement of alternate system components were initiated in the fiscal year 1960 and will be continued in the fiscal year 1961.

Personnel training, acquisition of training aids, such as motion-simulators, and provision for installation and operation of procedures trainers: The training activities will be conducted within existing NASA, military, and civilian facilities including the U. S. Navy Aero-Medical

Acceleration Laboratory, and the Moorehead Planetarium. Acquisition of console equipment for training of network monitoring personnel is provided for in this category, as is procurement of air-bearing motion simulators and displays. The motion simulators carry the astronaut, move in response to astronaut action, and thus provide a degree of simulation that is not attainable with the fixed base procedures trainers.

Research and development on physiological tolerance to stress: This phase of the program provides for support of animal flight and ground test programs, and for procurement of animal handling supplies and equipment for use at Wallops Island and Cape Canaveral. Also included is the development and procurement of animal task-performance equipment for in-flight use. Procurement of test equipment for evaluation of water-impact and land-impact physiological effects are also included in this category.

Much of the biological and human engineering program was completed in the fiscal year 1960; however, a substantial effort remains to be completed in the fiscal year 1961.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Personnel equipment:			
Pressure suit program	---	$230,000	$210,000
Restraint system program	$75,000	20,000	50,000
Life-support system program	25,000	75,000	360,000
Astronaut transfer equipment	---	125,000	30,000
	100,000	450,000	650,000
Training and training aids:			
Military facility program support	---	375,000	200,000
Civilian facility program support	30,000	25,000	25,000
Training aids	---	100,000	100,000
Network operation training	---	290,000	220,000
Navigation and piloting training	---	350,000	545,000
	30,000	1,140,000	1,090,000

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Tolerance studies:			
USAF-SAM animal program support.....	---	$40,000	---
Holloman AFB animal program support.....	---	135,000	$100,000
Animal handling supplies and equipment.....	---	365,000	170,000
Other tolerance tests.....	$40,000	50,000	80,000
	40,000	590,000	350,000
Total.....	$170,000	$2,180,000	$2,090,000

Mercury Development Program

This portion of the budget provides for general research and development effort on Project Mercury systems. Specifically, the following items are covered in the fiscal year 1961 request:

Wind tunnel and laboratory tests of the various booster and model configurations: Over 100 different model configurations are being used in this phase of the program which was initiated in the fiscal year 1959 and continues through the fiscal years 1960 and 1961.

Completion of the parachute system development and qualification by means of air drop tests and investigation of alternate parachute systems.

Development and qualification of capsule pyrotechnic and solid propellant rocket systems through tests at various NASA and military test facilities.

Structural development tests: Provision is made in the fiscal year 1961 for developments to correct structural deficiencies which show up during flight tests.

Development and analysis of the stabilization and control systems for the capsule: In the fiscal year 1961, altitude chamber tests of the reaction jet system and analytical studies of capsule motion will be completed. Provision is made for procurement of alternate components of the control system and for post-flight tests of equipment to correct deficiencies discovered in flight tests.

Tests of capsule on-board recovery equipment and investigation of capsule handling and retrieval methods: These tests will be particularly concerned with the effects of the recently-added landing impact absorbing bellows system which appreciably alter the capsule's hydrodynamic characteristics.

Communication and instrumentation systems development and evaluation: Included here is procurement of special purpose test apparatus and development of improved components for the systems. Provision is also made for correction of deficiencies after initial flight tests.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Configuration and systems tests:			
Models and equipment for AEDC, ARC, LRC tunnel tests	$80,000	$130,000	$90,000
Models and equipment for scale model flight tests	20,000	120,000	200,000
Components and equipment for structures, impact, and vibration tests of Mercury systems	15,000	170,000	180,000
Models and equipment for hydrodynamic tests	25,000	30,000	---
	140,000	450,000	470,000
Escape system development:			
Beach abort development tests	80,000	200,000	---
Support of MAC beach abort test	---	200,000	---
	80,000	400,000	---
Parachute tests:			
Components for preliminary airdrop tests	40,000	200,000	50,000
Closeout costs, balloon drop tests	---	110,000	---
Air-launched drogue tests at NASA-FRC	10,000	55,000	---
Eglin AFB rocket-launched parachute tests	---	80,000	---

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Parachute tests (continued):			
Sandia test support.....	---	$185,000	$75,000
Investigation of parachute deployment in orbit as an emergency means to initiate reentry.....	---	150,000	150,000
Alternate parachute system tests.....	---	100,000	100,000
	50,000	880,000	375,000
Retrograde, posigrade, escape motor and pyrotechnic tests:			
Posigrade rocket tests at Lewis Research Center.....	---	140,000	---
Retrograde rocket tests at OAL-Daingerfield	---	80,000	---
Escape rocket tests at USAF-AEDC and NASA-LRC.....	$70,000	60,000	---
Squib and igniter tests.....	10,000	40,000	185,000
Other rocket and pyrotechnic tests.....	20,000	100,000	365,000
	100,000	420,000	550,000
Structures and impact tests:			
Instruments and equipment for Atlas noise test.....	---	35,000	---
Capsule shingle tests at OAL-Daingerfield..	---	140,000	---
Crushable materials tests.....	5,000	40,000	80,000
Landing shock absorption tests.....	15,000	70,000	50,000
Other capsule shingle and coating tests....	10,000	85,000	125,000
Capsule reentry heating tests.....	20,000	300,000	125,000
Structures and impact tests necessitated by flight test results.....	---	100,000	350,000
Altitude chamber tests.....	---	150,000	---
	50,000	920,000	730,000

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Navigation, stabilization and control programs:			
Reaction jet tests at Lewis Research Center	---	$25,000	$50,000
Motions analysis and navigation services (Princeton University).....	---	65,000	25,000
Alternate control system components.....	---	75,000	175,000
Control system evaluation and test apparatus.....	---	125,000	225,000
Post-flight tests of stabilization and control equipment.....	---	50,000	275,000
	---	340,000	750,000
Recovery equipment tests:			
Preliminary water-borne capsule handling tests.....	$80,000	110,000	75,000
Preliminary capsule beacon tests.....	30,000	40,000	100,000
Alternate retrieval methods tests.....	10,000	50,000	100,000
	120,000	200,000	275,000
Communication and instrumentations systems hardware and tests:			
Magnetron development.....	---	40,000	50,000
Alternate components evaluation.....	35,000	110,000	350,000
Post-flight evaluation and tests of equipment.....	---	50,000	250,000
Test apparatus.....	65,000	60,000	250,000
	100,000	260,000	900,000
Little Joe program:			
Airframe development and procurement.....	1,170,000	540,000	---
Instrumentation and data handling equipment.	---	555,000	---
Capsule construction.....	---	105,000	---
Flight control system development.....	---	100,000	---
	1,170,000	1,300,000	---

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Big Joe program:			
Capsule construction, proof testing, and check out	$460,000	$60,000	---
Instrumentation and data handling equipment	680,000	40,000	---
Flight control system development and procurement	150,000	---	---
	1,290,000	100,000	---
Total	$3,100,000	$5,270,000	$4,050,000

Advanced Reentry Configuration

Project Mercury is only the first step in our long-range program for the manned exploration of space. Long-range goals in our program include manned landings on the moon, and still later, on the planets. Manned flight around the moon will be a prerequisite for a lunar landing.

The Mercury capsule is not suitable as a return vehicle for a lunar mission. Instead, a capsule capable of reentering the atmosphere at higher speeds will be required. Our studies also indicate that a lunar-return vehicle must be capable of generating some aerodynamic lift, in order to minimize the midcourse guidance requirements. Aerodynamic lift may also be applied to control the landing point upon return from a satellite or space mission.

During the fiscal year 1961 two major areas will be considered: the use of lift to facilitate reentry from space, and guidance and control methods for piloted space flight. Extensive analyses will be made, and scale models of various configurations will be evaluated in wind tunnels. Flight simulators will be used to evaluate the pilot's capability to fly such vehicles.

Development of a suitable guidance and control system for the advanced reentry configuration will also be initiated in the fiscal year 1961.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Advanced Reentry Configuration:			
Wind tunnel tests:			
Models and equipment for ARC, LRC, and AEDC tunnels.....	---	---	$235,000
Models and equipment for ballistic range tests.....	---	---	65,000
	---	---	300,000
Structures tests:			
Models and equipment for OAL-Daingerfield tests.....	---	---	90,000
Simulated reentry heating and load tests...	---	---	60,000
	---	---	150,000
Subsystem development:			
Actuator system for control surfaces.....	---	---	200,000
Instrumentation and display equipment.....	---	---	150,000
	---	---	350,000
Total.....	---	---	$800,000
Manual and Automatic Guidance and Control Systems for Advanced Reentry Configuration:			
Inertial components development.....	---	$100,000	$200,000

Major Boosters

This category includes:

The procurement of eight Redstone boosters, to be used in capsule qualification and pilot training flights: These boosters are being procured from

ABMA. The total cost for the eight vehicles, including launching costs, is $16,770,000, or approximately two million dollars per booster.

Somewhat more than one-third of the Redstone booster costs covers a contract cost incurred by ABMA, the remainder being for work performed at the Huntsville facility. In the fiscal years 1959 and 1960, NASA reimbursed ABMA for "in-house" expenses. In the fiscal year 1961, however, only contractual costs will be required, because the Huntsville facility will be operating under the NASA funding. Because of the long lead time required, the Redstone purchase was initiated in the fiscal year 1959, and nearly completed in the fiscal year 1960, even though none of the flights will take place until 1961.

The small additional funding for fiscal year 1961 is for electrical, mechanical, hydraulic, guidance and control, and telemetry components for the last of the eight boosters; for the completion of the fabrication and assembly; and for launching operations costs.

The procurement of 13 Atlas boosters, used in ballistic development and qualification flights, and in the orbital mission: These boosters are being procured through the Ballistic Missile Division of the Air Force's Air Research and Development Command. The total cost for 13 vehicles, including launching costs, is $45,550,000, or approximately three and one-half million dollars per booster.

One of these Atlases was launched in September 1959; another one will be launched during the current fiscal year. Eight more will be required in the fiscal year 1961, and the remaining three in the early part of the fiscal year 1962. In spite of this launching schedule, nearly one-half of the costs for these boosters were incurred in the fiscal years 1959 and 1960, because of the long lead times required.

The Atlas costs can generally be divided into two categories: basic booster and launch costs, and "peculiar" booster and launch costs. The basic costs are those that apply to unmodified launching vehicles, exactly as they

would be used in the missile program. The peculiar costs cover the modifications that are incorporated to make the booster adaptable and safe for manned operation.

In the fiscal years 1959 and 1960, approximately two-thirds of the basic and peculiar booster costs were incurred; the remaining one-third is required in 1961. To date, only one-quarter of the launch costs have been expended, with three-quarters remaining to be funded in the fiscal year 1961. Fiscal year 1961 funding will also be required for spare parts and miscellaneous costs to USAF-BMD; and for anticipated additional costs for services within the scope of the Air Force development plan, such as, for example, the testing of the Mercury abort sensing system on scheduled ballistic missile flights.

Initial funding for the two remaining Atlases required for Project Mercury: These boosters will be launched during the fiscal year 1962. The funds will be made available to USAF-BMD for the initial hardware purchases for two Atlas boosters; the funding will be completed in the fiscal year 1962.

Atlas launch guidance modification. The Atlas guidance computers at Cape Canaveral are designed for ballistic missile flights, and not for manned satellite operation. Certain computer modifications, alterations, and additions are required in order to make the computer compatible with Mercury requirements, and to permit real time predictions of whether or not the Atlas has injected the capsule into a safe satellite orbit. One-fifth of the required funds in this category were allocated in the fiscal year 1960, with the remainder being funded in 1961. Funds will be made available to USAF-BMD.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Redstones (8):			
Hardware	$2,435,000	$3,053,000	$290,000
Fabrication, assembly and checkout	1,206,000	2,327,000	156,000
Design, development and engineering of system	2,849,000	2,799,000	---
Launch operations	---	951,000	304,000
Special tooling and instrumentation	---	400,000	---
	6,490,000	9,530,000	750,000
Jupiters (2 - cancelled):			
Hardware	2,237,000	---	---
Fabrication and checkout	260,000	20,000	---
Design, development and engineering of system	243,000	20,000	---
	2,740,000	40,000	---
Atlases (13):			
Basic boosters	7,572,000	10,572,000	10,425,000
Basic launch	---	2,050,000	5,800,000
Spare components	267,000	246,000	675,000
Peculiar missile engineering modification and studies	789,000	478,000	1,300,000
Anticipated additional costs for services within scope of present development plan	---	---	3,500,000
Peculiar launch costs	75,000	105,000	825,000
Miscellaneous costs to USAF-BMD	57,000	239,000	575,000
	8,760,000	13,690,000	23,100,000
Little Joe rockets:			
XM19E1 rockets (24)	110,000	---	---
TX33-20 and 22 rockets (28)	2,190,000	---	---

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Little Joe rockets (continued):			
TX33 Hardware.....	$70,000	---	---
Special development, tooling, and handling equipment.....	480,000	---	---
	2,850,000	---	---
Atlases (2):			
Initial funding.....	---	---	$1,000,000
Atlas launch guidance modification:			
Computer alterations and additions to suit manned flight requirements.....	---	$200,000	800,000
Total.....	$20,840,000	$23,460,000	$25,650,000

Mercury Capsules, Support Equipment and Support Services

The funds allocated in this category cover the costs of the Mercury capsules, and of the support services and support equipment procured from the McDonnell Aircraft Corporation. Specifically, the following items are covered:

Procurement of an initial quantity of 12 capsules: The costs associated with these capsules consist of approximately 50% outside procurement from subcontractors by McDonnell, and approximately 50% McDonnell in-house effort. The McDonnell in-house effort is divided among engineering, tooling, and construction labor with associated overhead expense. The contractor's original estimate of the cost-plus-fixed-fee for this part of the work was $19,450,000. Most of this cost was funded in the fiscal years 1959 and 1960, with only a small amount to be funded in the fiscal year 1961. As of August 1959, the contractor's costs were determined to be approximately $10,000,000 greater than his original estimate. This added cost was largely due to increased costs for subcontractor-supplied equipment, and the increased cost of McDonnell in-house labor. This additional cost was funded in the fiscal years 1959 and 1960.

On the basis of the costs incurred as of August 1959, an accelerated contractor effort since that date, and a continuing need for this level of effort throughout the remainder of the fiscal year 1960 and through most of the fiscal year 1961, it has been estimated that the cost of the original procurement will increase further by about $17,000,000, $9,350,000 of which will require funding in the fiscal year 1961. These additional costs again are divided among subcontract procurement and in-house labor categories.

Training simulators: Early in the Mercury program, the scope of the McDonnell contract was increased to include provision of two operating mock-ups of the capsule, suitably outfitted for use in training the astronauts and ground crews in flight operating procedures prior to actual flight. These procedures trainers will be of the fixed-base type - that is, the capsule does not move in response to the astronaut's actions - only the instruments and indicators move. In addition to these fixed-base simulators, McDonnell is supplying couches, restraint systems, and accessory equipment for use with other simulator equipment used in the Mercury training program. The training simulator equipment was largely funded in the fiscal year 1960; approximately $550,000 is required to complete the procurement in fiscal year 1961.

Capsule changes: As the Mercury research and development program has proceeded, changes in the Mercury capsule design have been found to be necessary. In order to enhance safety and reliability, provisions have been made for astronaut emergency egress, improved astronaut visibility, improved heat protection, additions of alternate or back-up systems for use in case of prime system failure, and other similar changes. Continuing changes of this nature will require funding in the fiscal year 1961.

Spare parts: Provision of spare parts for the capsule systems was largely funded in the fiscal year 1959. However, additional spare parts to take care of capsule changes and additions will require additional funding in the fiscal year 1961.

Additional capsules: As the detailed Mercury program was formulated, it was determined that a total of 24 capsules would be required to accommodate the various phases of the flight program, and a decision was made to procure additional capsules rather than attempt refurbishing and reuse of the original 12 capsules. One capsule will be used in an off-the-pad simulated abort flight, one in a Little Joe flight, eight for Redstone flights, and 14 for Atlas flights. These capsules will be configured for unmanned, animal, and manned flights, as required. Initial funding for the 12 additional capsules was undertaken in the fiscal year 1960, and will be completed in the fiscal year 1961.

Ground support equipment, for handling, servicing, and checking out the capsule, prior to flight and monitoring capsule systems during flight: This equipment will be used at Huntsville where the capsules will first be mated to the Redstone, and at both the Redstone and Atlas pads at Cape Canaveral. The equipment includes electronic devices to check the operation of each of the capsule systems and subsystems, and telemetry receiving equipment to monitor the capsule equipment during the countdown and early stages of flight. Some of this gear will be housed in trailers, so that it can be utilized in several locations, such as the assembly building and the launching pads at Cape Canaveral. Other equipment will be installed in the assembly hangar, the blockhouse, and the gantry. This category also includes capsule handling equipment, and ground cabling. Funding was initiated in the fiscal year 1959, continued in the fiscal year 1960, and will be essentially completed in the fiscal year 1961.

The flight test support services provided by the capsule contractor: When the Mercury operations reach the peak of activity, between 100 and 200 contractor personnel will be required in the field to support these operations. These activities will be carried out at Wallops Island, Huntsville, and Cape Canaveral. The crews will perform final assembly and checkout functions, and will maintain the capsule's equipment in working order during the countdown prior to flight. Costs in this category will be incurred initially in the fiscal year 1960, and will continue to be incurred during the fiscal year 1961.

Equipment and support for the research and development program: This is McDonnell production-type equipment used in the research and development program, as opposed to the actual Mercury missions. It includes, for example, the capsule-Atlas adapter for the "Big Joe" test, and the escape towers and rockets used in the "Little Joe" tests. Other typical equipment in this category includes special capsule equipment for the animal program, and on-board communications equipment to be installed in airplanes that will be used to check out the world-wide tracking and communications network.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Basic contract - 12 identical capsules:			
Engineering	$2,640,000	$1,400,000	$113,000
Tooling	807,000	429,000	36,000
Experimental construction	1,327,000	705,000	53,000
Capsule, system, and subsystem construction	6,850,000	3,640,000	300,000
Fee	716,000	386,000	48,000
	12,340,000	6,560,000	550,000
Contractor additional costs:			
Engineering	930,000	801,794	---
Tooling	-18,400	-16,007	---
Experimental construction	-204,000	-174,363	---
Capsule, system, and subsystem construction	3,960,000	3,347,357	---
Capsule delivery change	800,000	200,000	---
Inspection	167,601	107,151	---
	5,635,201	4,265,932	---
Anticipated additional costs for services within present scope of work:			
Engineering	---	2,030,000	2,170,000
Experimental construction and production	---	620,000	765,000
Capsule, system, and subsystem construction	---	4,720,000	6,132,000
Inspection	---	230,000	283,000
	---	7,600,000	9,350,000

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Training simulators:			
Procedures trainer	---	$1,839,903	$418,000
Couches, restraint systems	---	175,000	47,000
MAC personnel services and minor changes	---	75,000	38,000
Air bearing trainer equipment	---	25,000	47,000
	---	2,114,903	550,000
Capsule changes	359,389	8,528,701	4,750,000
Spare parts	1,565,212	---	360,000
Additional capsules:			
Two additional capsules	---	3,228,427	330,000
Six additional capsules	---	6,060,273	5,590,000
Four additional capsules	---	---	8,400,000
	---	9,288,700	14,320,000
Ground support equipment	1,094,890	5,689,375	1,630,000
Flight test support	---	820,000	2,300,000
R&D support equipment and services	1,304,641	2,344,389	1,480,000
Total	$22,299,333	$47,212,000 1/	$35,290,000

1/ Includes $12,200,000 in pending fiscal year 1960 supplemental estimates.

Tracking Network Operations and Equipment

The success of a Mercury mission will depend to a large extent on the operation of the world-wide tracking and communications network being prepared for this project. The Mercury network consists of 16 stations dispersed throughout the world, a control center located at Cape

Canaveral, and a computing and communications center located at the Goddard Space Flight Center near Washington, D. C. A detailed description of the network is presented in the Construction and Equipment section of the estimates. Although the construction of the Mercury network is funded under the C&E appropriation, the operational expenses incurred in connection with the operation of the network are funded under the R&D appropriation.

The funding required for network implementation and operation through the fiscal year 1961 is $30,087,000. A minimal amount was expended in 1959, approximately one-sixth will be required in the fiscal year 1960, and the remaining five-sixths in the fiscal year 1961 when the majority of Mercury flight operations will take place.

Specifically, the following items are included in the fiscal year 1961 estimates:

Station transportation equipment: Fork-lifts, tractors, and similar equipment items are required in the operations of some remote tracking stations.

Consulting services: The services of highly competent technical groups, in the areas of operational procedures, equipment selection, communications, flight simulation, and safety and reliability of operations are required. In fiscal year 1961, approximately 95 percent of these funds will be allocated to the Lincoln Laboratory of the Massachusetts Institute of Technology.

Shipping costs: Costs will be incurred in shipping all types of network equipment, such as radars, antennas, and communications gear to the remote network stations. Approximately one-half of these funds will be required in fiscal year 1960, and the remainder in 1961.

Computing equipment services at the Bermuda station: This computing equipment will be used to obtain real-time trajectory data immediately after Atlas burnout. Based on these data, a decision will be made as to whether or not to abort a given mission. The Bermuda station will thus perform one of the key functions in the Mercury operation.

Transportation services: These services, required during the operational period, include for example, the rapid shipment of data and magnetic tapes from all remote stations after every flight.

Spare parts, supplies and materials: Included here are the spare parts required to keep all stations operational prior and during each Mercury mission. A prolonged breakdown of equipment at some stations could have catastrophic effects on a manned Mercury flight. Also included are supplies and materials such as magnetic tapes, power, and utilities.

Maintenance and operations personnel training: This item covers the expenses incurred in training the station personnel prior to their assignment to the various stations.

Station operation services by contractor personnel at all network stations: Contractor operating personnel requirements range from 74 required at Cape Canaveral, to 8 required at the station on Grand Bahama Island. A total of 575 contractor personnel will be needed to man the 16 stations, and the Control and Communications Centers. During the fiscal year 1961, these men will be assigned to their duty stations for the largest part of the year.

Reimbursement to the Department of Defense for military range contractor personnel: Many of the Mercury stations will be located at existing military network stations. Maintenance and operation of these stations will, in part, be done by the existing military range contractor, although additional personnel will be required. A total of 160 men in this category will devote full time to Mercury operations.

Factory equipment services and modifications: Included is the repair, at the factory, of malfunctioning equipment, and the modification of certain network components, as dictated by operational experience. The electronic devices required at the various network stations are exceedingly complex. The breakdown rate, and required repairs for this equipment, were based on past experience with similar equipment.

Special support for Mercury operations by the Atlantic Missile Range contractor: This category includes special cabling and circuitry services between the Mercury control center and the Redstone and Atlas blockhouses,

and at downrange stations. It includes also supplies and materials required at Cape Canaveral, such as hydrogen peroxide for the capsule control system, breathing oxygen for the life-support system, the support of the capsule assembly building, and minor modifications to the gantry and other Cape Canaveral facilities. Transportation and communication services at the Cape, peculiar to Mercury operations, also fall into this category.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Relocation of FAA equipment at Bermuda.....	---	$160,000	---
Reactivation costs of network ships.....	---	210,000	---
Communications equipment alterations at Canton Islands and Hawaii.....	---	300,000	---
Station transportation equipment.....	---	90,000	$20,000
Consulting services.....	$7,000	650,000	940,000
Equipment shipping services.....	---	800,000	780,000
Computing equipment services.....	---	490,000	1,800,000
Transportation services.....	---	160,000	600,000
Spare parts, supplies, and materials.....	---	720,000	2,100,000
Maintenance and operations personnel training.....	---	300,000	880,000
Station operation.....	---	520,000	11,500,000
Military range contractor reimbursement....	---	660,000	2,900,000
Factory equipment services and modifications.....	---	---	2,050,000
AMR-PAA operations support.....	---	350,000	1,100,000
Total.....	$7,000	$5,410,000	$24,670,000

Recovery Operations

This category covers the costs associated with capsule recovery planning and the costs that will recur with each flight mission, including consulting contract costs for trajectory calculations and recovery planning; costs of data acquisition by aircraft and telemetry ships for each flight; costs of data reduction and analysis for each flight; costs of operation of the mid-Atlantic and Indian Ocean tracking ships; development of improved recovery aids and beacons; development and construction of special shipboard and helicopter capsule handling equipment and the costs of capsule search and recovery following each flight mission.

Part of these expenses will be incurred by U. S. Navy ships and aircraft. An agreement has been negotiated with the Navy, whereby NASA will be billed only for the direct expense incurred during recovery operations. In calculating this direct expense, it was agreed that military pay and ship overhaul costs would not be included. Based on the methods of calculation agreed upon, the U. S. Navy has estimated the direct reimbursable costs associated with each flight operation scheduled during the fiscal year 1961. The U. S. Navy estimated costs are indicated in the following table for the 16 Redstone and Atlas flights during the fiscal year 1961.

In addition to U. S. Navy recovery expense, provision is made for Military Air Transport Service air rescue service stand-by and data transport for each Atlas flight.

During manned Redstone or Atlas flights, special provisions must be made for astronaut rescue in case of aborted flights, wherein the capsule may come down on land. Such provision has been made for the appropriate Redstone and Atlas flights in the fiscal year 1961. Expendable recovery supplies and materials, communications expense, technical motion picture coverage and post-recovery analysis costs are also provided for each of the 16 flights scheduled during the fiscal year 1961.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Operations planning:			
Trajectory calculations - aeroneutronics.....	---	$40,000	---
Trajectory calculations - Bureau of Standards	---	125,000	$180,000
Abort calculations.....	---	50,000	---
Alternate recovery methods study contracts...	---	145,000	150,000
	---	360,000	330,000

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Aircraft and shipboard data acquisition facilities:			
Big Joe flights	---	$220,000	
Redstone flights	---	240,000	1,260,000
Atlas ballistic flights	---	290,000	510,000
Atlas orbital flights	---	---	1,040,000
	---	750,000	2,810,000
Data reduction and analysis services:			
DAMP ship and trajectory data - RCA Moorestown	---	200,000	520,000
FPS16 and other tracking data - RCA-PAA	---	220,000	700,000
Other contractors	---	200,000	260,000
	---	620,000	1,480,000
Tracking ship operation services	---	---	1,500,000
Shipboard and airborne beacon receiver equipment	---	250,000	250,000
Improved beacon and recovery aid development	---	210,000	250,000
Special shipboard and helicopter capsule handling equipment - development and construction	---	80,000	160,000
Miscellaneous beach abort, airdrop, beacon evaluation and other test support:			
Navy operations	---	100,000	100,000
Other expenses	---	50,000	50,000
	---	150,000	150,000

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Little Joe test support and capsule recovery:			
Navy ship, plane, and helicopter operations	---	$107,000	---
Supplies, materials and other expense.....	---	43,000	---
	---	150,000	---
Big Joe test support and capsule recovery:			
Navy ship, plane, and helicopter operations	---	255,000	---
Supplies, materials, communications, and other expense.....	---	65,000	---
	---	320,000	---
Redstone test support and capsule recovery:			
Provision for pad abort land rescue.....	---	100,000	$180,000
Navy ship, plane, and helicopter operations.....	---	84,000	756,000
Supplies, materials, communications, and other expense.....	---	86,000	554,000
	---	270,000	1,490,000
Atlas ballistic test support:			
Navy ship, plane, and helicopter operations	---	231,000	1,075,000
MATS air rescue stand-by.....	---	---	121,000
MATS equipment and data transport.....	---	30,000	125,000
Supplies, materials, communications, and other expense.....	---	109,000	279,000
	---	370,000	1,600,000
Atlas orbital test support:			
Navy ship, plane, and helicopter operations	---	---	2,910,000
MATS air rescue service stand-by.....	---	---	250,000
MATS equipment and data transport.....	---	---	250,000

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Atlas orbital test support (continued):			
Land rescue team.....	---	---	$100,000
Supplies, materials, communications, and other expense.....	---	---	1,470,000
	---	---	4,980,000
Total.....	---	$3,530,000	$15,000,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

VEHICLE SYSTEMS TECHNOLOGY

Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
$1,903,651	$6,737,000	$21,200,000

1. OBJECTIVES:

To conduct studies and to develop materials, components, subsystems, and systems which will provide the optimum structure, configuration, guidance, control, and orientation and auxiliary power systems for space investigations such as deep space missions, lunar missions, and earth satellite projects.

2. JUSTIFICATION:

Space exploration depends upon guidance, control, attitude, and stabilization equipment for placing vehicles into the desired trajectories and with the desired orientation. Much of the guidance and stabilization technology which has been developed for the ballistic missile is applicable to space exploration. For example, injection guidance for space missions may be directly appropriated from ballistic missile experience, with only the additional developments required to produce lighter weight systems and to adapt existing knowledge and guidance technology to larger boosters such as the Saturn. However, the total requirements generated by space missions are different in both kind and degree. Consequently, development effort is required to provide vehicle and component control at great distances from the earth. These developments relate to components and systems for sensing and modifying the velocity of spacecraft in a manner to follow prescribed trajectories. They also are needed for stabilizing spacecraft and components with respect to known coordinate systems such as those involved in establishing a proper propulsion thrust vector, controlling temperature through heat absorption or radiation, or in collecting solar energy. Further system developments are needed for sensing

position and orientation of spacecraft, subsystems or components, and for providing reaction forces to modify the orientation required in such applications as maintaining communication through the use of high-gain antennae.

Successful space missions also depend upon the protection of scientific instruments from the hostile environment of space. The pursuit of this objective leads to research on materials to provide protection through the fabrication of durable but light-weight structures or by the development of resistive materials from which components or instruments can be assembled.

In the area of vehicle engineering, emphasis is on structural aspects and integration aspects of the variety of subsystems which compose the spacecraft. As a part of this effort there is a study on types of propulsion systems which should be used under different conditions; studies on landing techniques; and a look at the general problems of entry and reentry.

3. PROGRAM PHASING:

Guidance and control activities during the fiscal year 1959 were restricted to research on components and to a study of NASA space mission requirements, with the objective of defining a productive guidance approach. During the fiscal year 1960, the first steps outlined in the guidance study are being undertaken: (1) the start of work on a first generation, or Phase I, inertial injection guidance system utilizing analog techniques and guiding all stages of the launch booster, (2) start on a Phase II inertial guidance system utilizing digital techniques and possessing great flexibility in programming, and (3) the development of a completely digital precision autopilot for use in earth satellite missions which require supervison through burnout of the final booster stage but which can be accomplished with less expensive control mechanisms. Radio guidance techniques were extended to the post injection, or mid-course, portion of space flight. Efforts at first generation vehicle-contained mid-course guidance, terminal guidance and attitude control will be undertaken during the fiscal year 1960 in the spacecraft developed as the connecting link between the capability of the Agena B booster and the desired circumlunar, or rough lunar landing missions.

In the fiscal year 1961 a start will be made on vehicle-contained capability for trajectory corrections. Terminal guidance and attitude control will be continued in conjunction with the development of more sophisticated spacecraft to be carried ton advanced boosters.

Guidance and control equipment will be designed to provide the capability of circumnavigating a celestial body, establishing precise orbits, circularizing elliptical orbits at prescribed altitudes, controlling the approach and let down for soft landings, and providing a means for sample return from the moon and reentry into the earth's atmosphere either from escape velocity or from a satellite orbit. This will be accomplished through the evolutional development of vehicle-carried systems. Component development for controls and sensors must be carried on at a parallel rate.

Materials research will require increased emphasis during the fiscal year 1961 to provide knowledge relating to the behavior of materials under the three conditions of thermal equilibrium, namely, space flight, the cold lunar night, and the lunar day with its high level of infrared reflection; to thermal shocks resulting from transitions between these stages of equilibrium; and relating to the effects on materials during reentry from either escape velocity or satellite orbits.

4. PROGRAM COSTS:	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Advanced technical development:			
Development of injection guidance systems.....	---	$3,804,000	$1,800,000
Development of mid-course guidance systems.....	---	50,000	1,300,000
Development of terminal guidance systems.....	---	---	250,000
Development of attitude control systems.....	---	---	200,000
Development of guidance and control system for Centaur-boosted spacecraft..	---	---	13,000,000
Development of guidance and control system for Saturn-boosted spacecraft...	---	250,000	1,650,000
Vehicle engineering.....	---	1,708,000	1,000,000
Advanced technical developments, components, and materials.....	$1,903,651	925,000	2,000,000
TOTAL.....	$1,903,651	$6,737,000	$21,200,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

VEHICLE SYSTEMS TECHNOLOGY

Objectives

In order to accomplish any space mission it is necessary to have a container or structure which integrates the variety of subsystems, components and instrumentation required to achieve the mission objectives. It is also necessary to control the orientation of this flight package so that instruments relying on solar energy constantly point toward the sun and so that components which must be kept cool find themselves on the shaded side of the structure. Additionally, some missions require space maneuvers after the flight package has been separated from the booster which has carried it from the surface through the Earth's atmosphere. To accomplish these space maneuvers it is mandatory that the rocket nozzle be pointing in a manner which will give the desired direction when it starts to push.

In the initial flights into space elementary procedures were followed. For instance, the structures or containers for the flight package were little more than cans. This was so because the weight-lifting capability of the boosters available to the United States was severely limited. In these initial flights orientation was maintained by relying upon the gyroscope principle; that is, spinning the package to keep the axis pointing in a given direction.

With the advent of boosters of greater weight-lifting capability such as the Centaur and the Saturn it now becomes possible to undertake more sophisticated and complex missions utilizing active elements of guidance and control. Such advanced integrated structures and control systems have been given the terminology of spacecraft.

Because a spacecraft may be thought of as a bus to carry scientific equipment to the point in space where it is to be used, and then align it with respect to celestial bodies so the equipment can perform as designed, it takes on a functional aspect which has many elements common to all space missions whether they are Earth-circling satellites, Moon probes or planet missions.

Another area where all space missions find a common meeting ground is in the guidance equipment which is used to control the flight path of the booster from the surface of the Earth to the point where booster fuel burns out.

These areas of universal application, which have to be developed for any and all space missions regardless of flight schedule, have been grouped under a general heading of vehicle systems technology. This program then embraces that research and engineering development which is required on a given time scale but is not identified in terms of a specific flight program.

Development of Injection Guidance Systems

The term injection guidance is applied to the system of components which makes it possible to balance a booster on its jet and then cause the booster to accurately follow a predetermined path from the launch pad through the atmosphere to a point where all booster fuel has been burned. During the first years of the space age, guidance systems developed by the military for use in ballistic missiles were modified and used with the military vehicles for which they were developed serving as the booster in the space mission.

Although every effort is made to employ the current state of the art in guidance and control, each new booster introduces problems which are peculiar to itself. Among these problems there are such things as different bending modes as the length or the diameter of the booster is changed. Therefore guidance equipment must be capable of sensing different bending and must have the capacity to swing the engine nozzle in a manner to compensate for such bending. Essentially this means that the guidance system platform with its gimbal structure, which permits the platform to remain level as the booster tosses about, can be adapted from one vehicle to another; but such things as the autopilot, the computer program, and the interaction of sensor signals, are peculiar to the specific booster under development. It therefore becomes necessary to initiate new work for the new classes of boosters as they come along. The work done in the fiscal year 1960 forms the basis for the fiscal year 1961 program. The Agena series of vehicles will be in use by the end of the fiscal year 1961 and it will be imperative that its guidance systems be thoroughly appropriate to the various missions. The Saturn vehicle poses more stringent lead time requirements in that it is the most ambitious booster development yet undertaken and its guidance must have both very high precision and very great reliability if the booster's full potential is to be utilized.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Guidance system platform and gimbal including testing	---	$1,250,000	---
Test, check-out, and alignment equipment	---	380,000	---
Gyroscope, accelerometer, and torquer system development	---	414,000	---
Roll control system development	---	120,000	---
Vehicle controller and timer development	---	350,000	---
Analog guidance computer development	---	400,000	---
Terminal stage autopilot development	---	810,000	---
Pitch and yaw control system development	---	80,000	---
Phase II - injection guidance system modification for Saturn	---	---	$1,000,000
Precision autopilot modification for Agena	---	---	150,000
Precision autopilot modification for Saturn	---	---	150,000
Agena radio guidance system development	---	---	500,000
Total	---	$3,804,000	$1,800,000

Development of Midcourse Guidance Systems

In space applications, a midcourse guidance system may be thought of as the device which effects the extensions of control of the spacecraft after it has separated from the booster. For short distances this control could be effected by radio commands from the Earth. When the distances become large, as in travelling to a planet, it is necessary to have aboard the spacecraft equipment which can look at the stars and planets, decide where it is, and determine what should be done to place it where it should be.

NASA was fortunate in being able to extend and reorient at a very modest cost a generalized study of vehicle-contained navigation initiated by the Department of Defense. The results of this study already indicate that such a system should be developed. The fiscal year 1961 estimates include an incremental payment on a system which is expected to take a few years in its development. To completely exploit such a system, further studies on application, techniques, and limitations of midcourse guidance are desirable.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Midcourse navigation system requirements study.....	---	$50,000	---
Midcourse navigation system development..	---	---	$1,000,000
Midcourse guidance applications, techniques and limitations - study.....	---	---	300,000
Total.....	---	$50,000	$1,300,000

Development of Terminal Guidance Systems

With a combination of injection and midcourse guidance as discussed in previous sections it should be possible to hit the Moon but not to select a specific spot on the Moon. To accomplish this latter maneuver it is necessary to have still a third guidance system which depends upon information acquired from sensors looking toward the destination. Also, in the case of planetary missions, possible errors in the value of the astronomical unit would make it sheer luck if the spacecraft came as close as 50,000 miles to Venus or Mars. A third application of terminal guidance deals with the problems of looking at another spacecraft as the target and trying to effect a rendezvous for purposes of refueling, transferring equipment, making repairs, etc. Since the first two applications of terminal guidance are being treated in terms of specific spacecraft developments, this section deals only with the rendezvous problem.

It is already apparent that boosters of the capability of Saturn will provide new technological horizons. To fully exploit the Saturn capability it will be necessary to solve the problem of rendezvous in space. Since development of the rendezvous technique is a long lead time item it is necessary to initiate a study during the fiscal year 1961.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Space rendezvous guidance requirements study	---	---	$250,000

Development of Attitude Control Systems

Attitude control embraces the sensing and control of angular orientation of the vehicle or spacecraft as required for maneuvering, for guidance measurements, for obtaining data, for communicating from one point to another, and for similar applications. Sensing may be accomplished by radiation from light, heat, or radio, or by inertial references. Control may be by means of reaction jets or by flywheels. In some applications the difference in the pull of gravity on one part of the spacecraft as compared to another part of the spacecraft can be utilized either for sensing or for control. A wide variety of sensors and controllers are theoretically available to the experimenter in space. It is intended to undertake a study to permit a better understanding of the factors which make one system preferred over another in a specific application.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Attitude control requirements for spacecraft, components, and subsystems - study.....	---	---	$200,000

Development of Guidance and Control System for Centaur-boosted Spacecraft

A spacecraft to be used with the Centaur booster is being developed primarily for soft landings on the Moon. A later version or modification of this spacecraft will make it suitable for missions to the planets Venus and Mars. Such a spacecraft will be considerably more sophisticated than anything previously employed and will require subsystems of midcourse guidance, terminal guidance, and attitude control whose functions, while similar to those described in the several preceding sections, are sufficiently peculiar to this vehicle to require separate development.

The midcourse guidance is a precision vehicle-borne system which has as its function the correction of flight path after separation from the booster, and navigation between the point where booster fuel burns out and the position in space where the terminal guidance takes over. The components would be star trackers; planet seekers; sun seekers; equipment to issue commands for steering, thrust initiation and cut off; computers; precision timekeepers; radio

overrides; and necessary power supplies.

The attitude control system to go with the spacecraft boosted by the Centaur has as its function stabilization of pitch, roll, and yaw of the vehicle, determination of the vertical, component orientation and stabilization, thrust orientation and antenna pointing. Equipment would be torquers, autopilot, radiation sensors, gyro platform, and programmer.

The terminal guidance in this spacecraft is designed to position the vehicle on the surface of the Moon to within ± 50 miles, to circularize the orbit, to sense forward velocity and horizontal drift with respect to the surface so as to effectively slow the spacecraft from about 8,000 feet-per-second to a soft vertical landing, and to accommodate hitting the proper corridor for a successful return through the atmosphere to the Earth. Equipment needed is thrust controllers to slow the spacecraft, three-axis doppler to detect drift with respect to a point on the surface as well as altitude above the surface, TV monitors, radio override, vehicle-contained computers, inertial platforms, radio program changer, and associated power supplies.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Midcourse startracker system	---	---	$1,000,000
Planet seeker	---	---	600,000
Sun seeker	---	---	100,000
Power supply	---	---	20,000
Cutoff and steering command generator	---	---	50,000
Vehicle-borne computer	---	---	2,000,000
Precision low-drift oscillator	---	---	30,000
Thrust controller	---	---	200,000
Three-axis doppler system	---	---	2,000,000
Terminal stage power supply	---	---	30,000
Television monitor	---	---	4,000,000
Radio command overrider	---	---	200,000
Program change decoder and servo system	---	---	270,000
Torquers	---	---	1,000,000
Autopilot	---	---	500,000
Radiation sensor	---	---	500,000

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Programmer.....	---	---	$100,000
Systems Integration.....	---	---	400,000
Total.....	---	---	$13,000,000

Development of Guidance and Control Systems for the Saturn-boosted Spacecraft

As in the case of the Centaur-boosted spacecraft already described, the Saturn-boosted spacecraft will have unique requirements for guidance and control. The concept in the engineering of these guidance and control subsystems is to provide for an evolutional development from an earlier system through each succeeding system. By following this concept components can be utilized as previously developed but advantage can be taken of the greater weight-lifting capability of the Saturn to provide additional capability such as hovering above the surface of the Moon while instruments aboard the spacecraft examine the surface below and decide whether such a location is suitable for a soft landing of a scientific package.

During the current year an intensive study of the optimum utilization of the Saturn booster in lunar missions has pointed to a need to start the development of the guidance and control system peculiar to the Saturn-boosted spacecraft during the fiscal year 1961. This start is exclusively in the area of terminal guidance and specifically those portions of the terminal guidance which require the longest lead time. Among such items are computers capable of taking sensor information and determining and generating the proper command to meet pre-set criteria for an acceptable landing site in such terms as steepness of the hillside, irregularities due to boulders or craters.

Complementing such vehicle-contained equipment would be TV monitoring on the part of an Earth-based operator. To carry out this function it is necessary for the Earth-based display to give depth perception, a sense of speed, and a feeling of where the vehicle is going and how soon it will get there. Looking forward to the presence of man in the spacecraft, it will be necessary to have light-weight vehicle-borne display equipment to aid the human pilot.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Saturn lunar landing study.....	---	$250,000	---
Adaptive computer development for landing site selection, position and orbit determination.....	---	---	$1,000,000
Earth-based operator display development	---	---	500,000
Manned vehicle astronaut display development.....	---	---	150,000
Total.....	---	$250,000	$1,650,000

Vehicle Engineering

Here the word vehicle is a generic term which would include either the spacecraft or the booster. Several of the studies being conducted under this heading will be concluded at the end of the fiscal year 1960. However, wind tunnel testing and studies will continue to be necessary to insure that each new vehicle has the proper aerodynamic characteristics to survive the flight from the Earth's surface. This is particularly true for the spacecraft which must be designed to travel through the air before it reaches the environment where it will be used even though it will spend most of its useful life beyond the Earth's atmosphere. This wind tunnel work at JPL will be particularly applied to the Agena, Centaur, and Saturn spacecraft under current development.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Optimization of structures - study.....	---	$300,000	---
Vehicle-borne instrument engineering....	---	258,000	---
Vehicle data handling - study.....	---	150,000	---
Spacecraft wind tunnel testing.....	---	1,000,000	$1,000,000
Total.....	---	$1,708,000	$1,000,000

Advanced Technical Developments, Components, and Materials

In this category are investigations into the fundamental physical laws relating to improvements in electronic and communication materials, such as, radio frequency sensor development; antenna systems research; solid state developments in circuit components, and Masers, cryogenic and other research efforts to reduce the noise levels in circuits.

Another group of studies deals with improved materials for space vehicles, with particular emphasis on nozzles and other hot parts of the rocket.

A third group examines the effects of the space environment: specifically, such things as the weight loss in high vacuum with the resulting effect on mechanical elements, and the problems affecting lubrication and servo systems in space.

The increased level of effort indicated for the fiscal year 1961 is required to keep the accomplishments in this area in balance with the flight programs that are the ultimate beneficiaries of this work.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Optical sensor development	$85,000	---	---
Infrared sensor development	67,000	---	---
Angle encoder and coordinate computer development	84,000	---	---
Teletype code converter and time comparator development	113,000	---	---
Servo analog error generator	105,000	---	---
Solar cell orienter and follower development	72,000	---	---
Booster recovery system development	500,000	---	---
Radio frequency sensor development	51,800	$50,000	$100,000
Antenna systems research	76,000	75,000	125,000
Solid state single crystal development	67,500	65,000	125,000
Solid state metallic whisker development	37,400	40,000	120,000
Maser research	43,000	50,000	125,000

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Cryogenics research	$45,000	$45,000	$110,000
Long-life, low-noise circuit research	60,000	70,000	150,000
High temperature graphite research	57,000	60,000	125,000
High temperature ceramics research	48,000	50,000	100,000
High temperature metals research	89,000	90,000	200,000
Ablation research	30,000	40,000	100,000
Vacuum effects on mechanical elements research	45,000	50,000	125,000
Vacuum effects on lubrication research	78,000	80,000	175,000
Servo systems research	55,000	60,000	150,000
Airborne computer research	67,500	70,000	140,000
Information processes research	27,451	30,000	30,000
Total	$1,903,651	$925,000	$2,000,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

SOLID ROCKETS

Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
$615,898	$3,785,000	$2,800,000

1. OBJECTIVES:

To establish, on an experimental basis, the background which will allow exploitation for space vehicle use of the high reliability, simplicity, and economy of solid propellant engines; demonstrate advanced techniques in the use of very high performance solid rockets as upper stages and as auxiliary rockets for space vehicles; develop techniques for improving the utility and versatility of solid propellant rockets by devising improved and advanced methods for thrust vectoring, modulation, and termination; conduct studies and experimental programs to establish the application of solid propellant motors as first stage high thrust boosters for space vehicles; and to explore techniques for exploiting the properties of solid rockets for sounding vehicles to obtain greater simplicity and economy.

2. JUSTIFICATION:

Solid propellant rockets have several inherent advantages. From a logistic and handling standpoint, they are storable for extended periods of time, they utilize simple operating principles, they involve essentially no complex machinery, they are generally transportable in the loaded condition, and they offer advantages of simple firing techniques for relatively untrained launching crews. These general characteristics make for high reliability and, in general, lower costs in development and use compared to liquid rocket systems. The basic characteristics of solid rockets also allow them to be fabricated readily in different sizes on a short development time scale.

From a performance standpoint, solid propellant rockets have two inherent characteristics which can be exploited to great advantage for propulsion in space booster vehicles. First, the physical properties of solid rockets allow them to be constructed to very high ratios of propellant to inert parts when employed as upper stages in a vacuum environment. The second advantageous performance characteristic is the ease with which thrust levels can be varied. It is not distinctly more difficult or expensive to develop thrust levels of 1,000,000 pounds as compared to the 100,000 to 500,000 pound thrust levels now employed.

The utility of solid rockets is limited by the present cumbersome and relatively inefficient techniques for controlling thrust level during burning, for terminating thrust, and for obtaining thrust directional control. In addition, the inability to reignite a solid motor after initial termination decreases its utility as a terminal stage or as a retro-rocket. While high propellant-mass ratios of .96 to .97 are achievable in solid rockets, little has been done to demonstrate on a significant size scale the achievement of such performance.

The proposed program will aim at improvement of the deficiencies discussed above and at the demonstration of some of the performance, reliability, and logistic advantages of solid rockets. A program will be continued to evaluate and develop new propellants for space propulsion as new ingredients and propellant materials become available.

3. PROGRAM PHASING:

The solid rocket program is divided into four parts as follows:

High performance motors: In the fiscal year 1959, work was initiated to demonstrate the feasibility of rocket motors with a propellant to loaded motor weight ratio of .96. In the fiscal year 1960, a limited number of static firings are being conducted to prove out these designs. In the fiscal year 1961, work will be continued on advanced techniques for achieving ratios of .96 and beyond, and for solving associated propellant geometry, case, and nozzle design and development problems. Advanced techniques for achieving economical sounding rockets of high performance will also be explored. Sufficient data should be available by the fiscal year 1961 to conduct design studies and initiate development of very high performance terminal stages for specific space vehicles.

Advanced thrust modulation and vectoring systems: Limited work was initiated during the fiscal year 1959 on exploring the feasibility of thrust modulation by ultra-sonics. The 1960 program is expanding the effort on thrust modulation and includes work on the exploration of new techniques for thrust vectoring and thrust termination. In the fiscal year 1961 work will be continued on the most promising programs. Studies to apply some of the advanced techniques to specific solid motors will also be initiated.

High performance propellant systems: In the fiscal year 1959 work was initiated on the evaluation of new propellants and ingredients, and on their incorporation into propellant systems for application to the unique needs of space propulsion systems. This effort will be continued in the fiscal years 1960 and 1961 with particular emphasis on exploiting the new ingredients and materials that are being synthesized and developed under programs sponsored by the Department of Defense.

Improved motor materials and manufacturing techniques: Solid rockets for space applications require manufacturing techniques of high reliability and precision. Fiscal years 1959 and 1960 programs were initiated on non-destructive inspection techniques, inspection criteria, and on advanced methods of fabricating rockets, such as building a loaded rocket motor in separate sections and then assembling them. These programs will be continued, and the non-destructive testing techniques and inspection criteria developed will be applied to motors actually being manufactured for application to space vehicles.

4. PROGRAM COSTS:

	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Advanced technical development:			
High performance motors.....	$260,898	$1,515,000	$1,300,000
Advanced thrust modulation and vectoring systems.....	90,000	930,000	500,000
High performance propellant system....	175,000	910,000	700,000
Improved motor materials and manufacturing techniques.....	90,000	430,000	300,000
TOTAL.....	$615,898	$3,785,000	$2,800,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1962 ESTIMATES

SUMMARY - SALARIES AND EXPENSES

	NASA Headqtrs.	Langley Center	Ames Center	Lewis Center	Flight Center	Goddard Center	Wallops Station	Marshall Center	Western Office	AEC-NASA Nuclear Office	Life Science Facility	Total
Estimated end of year employment	951	3,330	1,437	2,824	494	2,668	299	5,960	85	23	51	18,122
	$8,976,346	$25,301,240	$11,392,000	$22,592,445	$3,567,139	$22,477,595	$2,014,146	$46,482,024	$748,790	$254,125	$459,285	$144,265,135
10 Personal services and benefits	9,523,000	27,507,000	12,327,000	24,704,000	3,788,000	24,150,000	2,608,000	55,298,000	842,000	204,000	445,000	161,396,000
21 Travel and transportation of persons	1,368,000	643,000	160,000	312,000	165,000	2,960,000	90,000	2,550,000	117,000	5,000	25,000	8,395,000
22 Transportation of things	50,000	12,000	15,000	25,000	20,000	540,000	5,000	30,000	20,000	1,000	2,000	740,000
23 Rent, communications, and utilities:												
Rent	120,000	2,185,000	1,231,000	900,000	235,000	7,480,000	125,000	6,551,000	90,000	---	---	18,917,000
Communications	400,000	105,000	55,000	100,000	25,000	374,000	80,000	595,000	35,000	1,000	4,000	1,774,000
Utilities	---	1,719,000	2,331,000	2,233,000	30,000	140,000	200,000	---	---	---	---	6,653,000
24 Printing and reproduction	616,000	26,000	15,000	10,000	5,000	40,000	10,000	275,000	3,000	---	---	1,000,000
25 Security investigations	1,115,000	---	---	---	---	---	---	---	---	---	---	1,115,000
42 Insurance claims and indemnities	110,000	---	---	---	---	---	---	---	---	---	---	110,000
Total	$13,302,000	$32,197,000	$16,134,000	$28,284,000	$4,268,000	$35,684,000	$3,118,000	$65,319,000	$1,107,000	$211,000	$476,000	$200,100,000
Anticipated reimbursements												-3,414,000
Total appropriation												$196,686,000

Opposite Page 173-1:

Work being done primarily for space applications.
This year's funds 80% obligated.

High mass ratio motor:	Work now going on at Grand Central Rocket Co.
Light weight nozzles:	Rocketdyne.
Very large booster design:	2 RFB's gone out for FY 1960 work. FY 1961 design study to point of fabrication.
Combined attitude and velocity control:	4 movable jets which add thrust when not vectoring.
Advanced thrust vectoring:	Injecting gases in exhaust stream - FY 1960 - NOTS.
Sonic thrust modulation:	Acoustica.
Nozzle chamber insulation:	All at JPL. Now can get 4800° - 5500°. Need 7000°. Carbides.
Mfg. Methods study:	Conical segmented design. United Technology Corp.

	Funds	Personnel
Hq	1.3	3
JPL	1.5	30
Total	2.8	33

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

SOLID ROCKETS

Objectives

Solid propellant rockets have many inherent advantages in terms of reliability, development and fabrication lead time, in handling and storage, and in relatively simple firing techniques. The purpose of this program is to establish the background and techniques which will allow exploitation of the high reliability and simplicity of solid propellents for space vehicle use.

This program is being carried out under four major categories: high-performance motors, advanced modulation and vectoring systems, high performance propellant systems, and improved motor materials and manufacturing techniques. Specific projects designed to improve techniques and eliminate deficiencies in such areas as thrust termination, reignition, thrust vectoring, and control of thrust levels during propellant burning are being conducted. As improvements in performance are accomplished, they will be applied to scheduled rocket development.

High Performance Motors

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
High mass ratio motor development for upper stage purposes (maximum percentage of propellant for a given total weight.....	$176,000	$600,000	$700,000
"End burner" concepts for sounding rockets and high mass ratio upper stages; end burners have maximum flexibility of thrust levels and burning times, least wasted volume.....	---	200,000	---

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Light-weight nozzle systems which minimize nozzle dead weight; liquid metal cooling systems are of special interest	---	$200,000	$200,000
Very large booster design studies for investigation of potential applications in NASA vehicles.....	$84,898	80,000	100,000
Jet Propulsion Laboratory work in this area, including development of rockets for Juno and Explorer vehicles and such advanced ideas as the autophage (consumable) rocket.....	---	435,000	300,000
Total.....	$260,898	$1,515,000	$1,300,000
Advanced Thrust Modulation and Vectoring Systems			
Combined attitude and velocity control unit; a package which may be added to a basic rocket for control purposes.	---	$200,000	$200,000
Advanced thrust vectoring techniques; methods of diverting rocket exhausts will be studied.....	---	300,000	100,000
Sonic thrust modulation; studies are in process to determine whether application of sonic energy to a burning propellant can effect rocket thrust....	$90,000	200,000	---

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Thrust termination and re-ignition; study of new and more efficient means of terminating rocket thrust and re-igniting the motor at a later time.....	---	$230,000	$200,000
Total.....	$90,000	$930,000	$500,000
High Performance Propellant System			
Unique propellant systems and basic work to improve the characteristics of solid propellants; includes improved methods of testing propellants non-destructively; includes basic and applied research at the Jet Propulsion Laboratory in the fiscal years 1960 and 1961.....	$175,000	$910,000	$700,000
Improved Motor Materials and Manufacturing Techniques			
Nozzle chamber insulation and chamber construction materials studies to investigate new substances to withstand the heat and erosive effects of modern solid rockets.....	90,000	280,000	100,000
Manufacturing method studies applicable to future very large motors; evaluation of easy-to-make propellant configurations and the segmented or "building block" rocket concept.....	---	150,000	200,000
Total.....	$90,000	$430,000	$300,000
		Total	$2,800,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

LIQUID ROCKETS

Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
$15,978,589	$30,328,000	$63,000,000

1. OBJECTIVES:

To develop an advanced capability for launching and propelling payloads for space exploration through the use of liquid propellant rocket engines; to improve the performance of space vehicles through the development of improved propellants and equipment; and to work out practical solutions for the technical problems occurring in development and operation of liquid propellant engines.

2. JUSTIFICATION:

The liquid propellant rocket is the mainstay for propulsion of the present and coming generation of space vehicles. To provide capability for launching and propelling payloads for space exploration requires the development of several new high-performance engines of different thrust levels. These include a large booster engine, engines using hydrogen-oxygen propellants in upper stages, and engines using propellants that are storable for prolonged periods of time in the space environment.

For missions aimed at launching large manned vehicles into orbit around the earth or for delivering large instrumented payloads on the surfaces of the planets, booster thrust levels significantly greater than those of ICBM engines are needed. Accordingly, a 1,500,000-pound thrust engine is now under development. Manned vehicular landings on the surface of the moon or planets with return to the earth can be accomplished by clustering 4 to 6 of these engines into a first-stage booster.

The full payload carrying capability of the booster engines can only be realized by the use of upper stages equipped with engines using high energy propellants. The use of hydrogen-oxygen as the propellant for upper stages of space vehicles will increase carrying capability about 50 percent per stage as compared to hydrocarbon-oxygen engines. One large engine using hydrogen-oxygen propellants is now under development. Experimental tests have demonstrated the feasibility of building an engine with a thrust level suitable for use with advanced vehicles on space missions.

3. PROGRAM PHASING:

A contract to develop a single-chamber engine of 1,500,000 pounds thrust was let in 1959. During the fiscal year 1959, thrust chamber hardware was fabricated and preliminary thrust chamber tests were begun. Other components of the engine were designed. Modification of existing test facilities to accommodate this engine and construction of one new test facility necessary for engine testing were undertaken by the Air Force. Fabrication of engine components and extensive testing of all elements of the engine will be started during the fiscal year 1960. Initial assembled engine tests with continued component development are scheduled for the fiscal year 1961.

During the fiscal year 1960, a development effort will be initiated on a large engine using high-energy propellants for application to advanced vehicles.

Applied research and experimentation as well as analytical investigations on advanced engine types will be carried out. Applied research on engine problems in the fiscal year 1959 was devoted to a determination of the feasibility of large thrust single chamber boosters. In the fiscal year 1960 applied research will include analytical and experimental investigations into causes and methods of avoiding combustion oscillations in large rocket engines, and applied research required in further development of the 6,000-pound thrust storable propellant rocket. In the fiscal year 1961 applied research funds will be used to continue the combustion oscillation investigations started in the fiscal year 1960, and to start a project to investigate liquid propellants capable of being stored in a space environment for prolonged time periods.

The fiscal year 1961 advanced engine design investigations will include an investigation to determine methods of simulating operational characteristics of large engines through model tests; and the continuation of injector, thrust chamber, heat transfer, and chamber fabrication investigation pertinent to storable-propellant engines.

4. PROGRAM COSTS:

	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Advanced technical development:			
Advanced engine design investigations.....	$3,558,589	$3,688,000	$3,400,000
Applied research on engine problems.....	420,000	1,470,000	1,800,000
Development of 1,500,000-pound thrust booster rocket engine....	10,000,000	24,200,000	41,000,000
Development of hydrogen-oxygen upper-stage engines.....	---	---	16,000,000
Development of storable propellant engines.....	2,000,000	970,000	800,000
TOTAL.....	$15,978,589	$30,328,000	$63,000,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

LIQUID ROCKETS

Objectives

The liquid propellant rocket is the mainstay for propulsion of the present and coming generations of space vehicles. The purpose of this program is to develop an advanced capability for launching and propelling payloads for space exploration and to improve the performance of space vehicles through the development of improved propellants and equipment.

Advanced Engine Design Investigations and Applied Research on Engine Problems

The objectives of the advanced liquid rocket engine technology investigations are manifold. One objective is to explore the potential improvement in rocket engine performance that can be realized by use of new high energy propellants. A second objective is to increase the performance and reliability of rocket engine systems by development of unique or simplified engine configurations. A third objective is to provide practical solutions for the problems occurring in the development and operation of liquid propellant engines.

It is the nature of projects in the area of advanced engine design investigations to be discontinued after a time for lack of promise or to be supplanted instead by an active development program. Specific examples can be pointed to in the relatively short time span of projects supported by NASA. Support of research on hydrogen-oxygen engines has developed a state-of-art that justifies development of hydrogen fueled engines for practical rocket stages. One such engine, of 15,000 pounds thrust, is currently under development, and requests for proposals have been made for a second engine, of 200,000 pounds thrust. The advanced engine design investigations, along with the applied research on engine problems, lays the ground-work for future advancement of rocket vehicle capability.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Support of hydrogen-oxygen engine research...	$2,065,000	$1,700,000	---
Investigations of hydrogen-fluorine as rocket propellants.....	1,070,000	400,000	---
Investigations of short light weight rocket engine nozzles.....	420,000	700,000	1,200,000
Investigations of pressurized (unpumped) engine systems.....	423,589	1,588,000	2,200,000
Investigations of oscillatory combustion in rocket engines.....	---	200,000	700,000
Studies of engine operating problems after prolonged coasting flight in space...	---	200,000	400,000
Study of propulsion requirements for lunar and planetary missions.....	---	370,000	300,000
Search for new high-impulse high-density propellants.....	---	---	400,000
Total.....	$3,978,589	$5,158,000	$5,200,000

Development of 1,500,000-Pound Thrust Booster Rocket Engine

The 1,500,000-pound thrust engine is the largest single-chamber rocket engine under development by this country. Its thrust level will be nearly ten times the thrust level of any currently available rocket engine. The engine, which will use liquid oxygen and kersosene as propellants, will provide propulsion for the booster stages of manned space vehicles. Manned vehicular landings on the surface of the moon or planets with return to earth can be accomplished with launch stages using a cluster of four to six of these engines. The boost stage of such a lunar vehicle will develop between 6,000,000 and 9,000,000 pounds of thrust. Lunar landings with return of a manned space craft will necessitate the development of launch vehicles of this thrust level.

Because of the high degree of reliability that is required of a propulsion unit that will propel men into space, and because such reliability can be developed only by an intensive and

continued testing program, the 1,500,000 pound thrust engine development was begun early in 1959. The present schedule of development contemplates flight rating tests of the engine by mid-1963. Because of the enormous expense of flight testing such a large vehicle, however, the preliminary flight rating tests will be followed by an intense quality improvement program with the objective of reducing risk of failure of the first flight systems and, ultimately, risk of the lives of men. Such testing will extend to mid-1966. A boost vehicle which will use this engine is scheduled for first flights in 1967.

The engine development involves the fabrication and testing of several major components, and their assembly and testing as an engine. Since the turbopump for this engine requires 60,000 horsepower, the development of the turbopump alone is equivalent to the development of a large turbojet aircraft engine. The thrust chamber and injector are of such size that new fabrication equipment must be prepared and new assembly methods must be developed prior to the actual operational testing of the chamber.

To test the engine and its components three test stands are under construction at Edwards Air Force Base. One of these is an existing missile test stand being modified for testing the 1,500,000 pound thrust engine. The other stands are for testing the thrust chamber and the complete engine. The thrust chamber test stand is now nearly complete and test work will be under way in June 1960. The first engine testing will be done on the converted missile stand and is scheduled to begin early in 1961. In addition to these stands at Edwards Air Force Base, former missile engine test stands at the Field Propulsion Laboratory of Rocketdyne are being modified for development of the turbopump, gas generator, propellant valves, controls, and other components of the engine. Some of these are already in use. One of these facilities has been used for short duration firing tests of a full-scale non-regeneratively cooled thrust chamber.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Preliminary design	$751,000	---	---
Component development	3,791,000	$12,596,000	$16,119,000
Component test	622,000	2,197,000	3,848,000
Engine development	408,000	5,755,000	14,683,000
Engine test	---	---	2,325,000
Fabrication and test equipment	4,428,000	2,452,000	317,000
Propellants	---	1,200,000	3,708,000
Total	$10,000,000	$24,200,000	$41,000,000

Development of 200,000-Pound Thrust Hydrogen-Oxygen Engine

The development of large boosters of thrust levels of 1,500,000 to 9,000,000 pounds for man-carrying missions in space requires the development of highly reliable high-performance engines of suitable thrust levels. Because of the investment, in terms of stage costs, particularly in second and succeeding stages, the use of high-energy propellants to achieve maximum performance per pound of boosted weight is justifiable. The state-of-art of use of hydrogen and oxygen propellants in rocket engines has progressed to a point where we can confidently proceed with the development of a 200,000 pound thrust hydrogen-oxygen engine. A stage using this engine will be capable of carrying nearly twice the payload of a stage of similar weight using oxygen and kerosene.

The 200,000 pound thrust hydrogen-oxygen engine will be used in upper stages to be developed for the Saturn launch vehicle. The same engine and stages will later be used with launch vehicles of even greater thrust.

Saturn flights using the 200,000 pound thrust hydrogen-oxygen engine in an upper stage are planned for 1965. Bids for the development of this engine have been requested and a contract is expected to be negotiated by June 1960. The preliminary flight rating tests of this engine are scheduled for three years from the date of contract with flight qualification tests to be complete in 4 1/2 years.

A significant proportion of the total funds of this project will be used to provide propellants. It is anticipated that a commercial source to produce and supply fuel for the project will be developed.

Proposals for development of the 200,000 pound thrust hydrogen-oxygen engine have been requested by NASA. At this time these proposals have not been received or evaluated. No contractor has yet been selected. Therefore the following budgetary figures are estimates based on the experience of costs incurred in development of other liquid propellant rocket engines.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Preliminary design.....	---	---	$585,000
Component development.....	---	---	4,686,000

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Component test	---	---	$914,000
Engine development	---	---	490,000
Engine test	---	---	---
Fabrication and test equipment	---	---	5,325,000
Propellants	---	---	4,000,000
Total	---	---	$16,000,000

Development of Storable Propellant Engines

Storable propellant engines will be used in small rockets of the type required for space trajectory correction, satellite orbit correction, and attitude control, and in rocket systems which must contain the propellants over prolonged periods in space. Storable propellants will be required for accomplishing planetary orbits or planetary landings, since the least practical travel time to either Mars or Venus is of the order of several months. The Jet Propulsion Laboratory is currently developing a storable propellant rocket of 6,000 pounds thrust. This rocket uses hydrazine and nitrogen tetroxide as propellants. Such propellants have an advantage over liquified gas propellants because of the reduced loss of propellants due to boil-off caused by the sun's radiation in space.

The 6,000 pound thrust engine has already been fired successfully in static test stands. Testing (conducted both at the JPL and at the JPL site at Edwards Air Force Base) is directed toward the objective of developing a reliable ready-to-use unit.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Development of thrust chamber	$930,000	$360,000	$190,000
Development of controls, valves, and gas regulators	290,000	170,000	80,000
Engine development	280,000	240,000	370,000
Fabrication and test equipment	470,000	110,000	80,000
Propellants	30,000	90,000	80,000
Total	$2,000,000	$970,000	$800,000
		Total	$63,000,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

NUCLEAR SYSTEMS TECHNOLOGY

Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
$3,810,496	$6,000,000	$10,000,000

1. OBJECTIVES:

To develop the components and technology required to permit the development of nuclear powered systems to deliver large payloads to interplanetary objectives. The current emphasis in this program is on solution of the many technological problems that now stand in the way of nuclear system development.

2. JUSTIFICATION:

The two principal types of nuclear systems that are considered suitable for the propulsion of high payload rocket systems in space are the nuclear heat transfer rocket system and the electrical propulsion system using a nuclear reactor system to generate electrical power. The Nuclear Systems Technology program supports the work on the nuclear heat transfer rocket system and on the nuclear reactor electric power generating systems.

The nuclear heat transfer rocket is a system in which hydrogen is heated to high temperatures in a nuclear reactor to produce specific impulses in the range of 700 to 1,000 pounds of thrust per pound of hydrogen flowing per second. The high specific impulse potentially available from the nuclear heat transfer rocket permits the delivery of large payloads for various missions requiring high energy. The nuclear rocket can be used in booster rocket systems as well as in the space environment.

Although early emphasis in the nuclear heat transfer rocket program was on research aimed at the development of large thrust or high reactor power first-stage rockets, the current goals of the program are aimed at accumulating the necessary research information required to develop a reactor flight test system that would be launched by chemical rockets. Such a system could eventually be incorporated into a space vehicle stage which would take off for its interplanetary objective after having been launched into an earth orbit by large chemical rockets. In this program, the NASA is working with the Atomic Energy Commission.

Nuclear reactor electrical power generating systems are required to supply the electrical power needed to accelerate charged particles or neutral plasmas to high velocities in order to produce thrust in the electrical propulsion systems which appear to have good capabilities for space missions. (The accelerator or thrust production components of the electrical propulsion systems are discussed under the program entitled Space Power Technology.) Analyses of space mission capabilities of these electrical propulsion systems have indicated that such systems will be competitive with the low thrust nuclear heat transfer rocket system described above. One of the disadvantages of the electrical propulsion system is the long trip time involved as the result of the low ratio of thrust-to-stage weight. One of the advantages of the electrical propulsion system is that the electrical generating equipment may be used for communications when the payload has been propelled to its planetary objective.

It is one of the purposes of the present program to do the research necessary to develop high power, light weight nuclear reactor electric generating systems. It is felt that the development of such high power systems must wait for the accumulation of various fundamental data and research on critical components of the system. In addition to the funds required for applied research leading to advanced high power systems, funds are included in this program to continue the development of a system for converting energy from nuclear heat to electrical power using currently available information. This conversion system will be matched with the SNAP-8 reactor being developed at the request of the NASA by the Atomic Energy Commission. This reactor electric system will produce enough power to supply communications needs for planetary missions as well as to test early versions of electrical propulsion systems.

3. PROGRAM PHASING:

The work under this program is divided into nuclear reactor electric generating systems and nuclear heat transfer rockets. The fiscal year 1959 funds for nuclear reactor electric generating systems were used to design conversion equipment for a nuclear-electric

system (SNAP-8) and to initiate fabrication of the components. In addition, work was started on the acquisition of data that will be required in the design of higher power, higher temperature systems. Funds for the support of the nuclear heat transfer rocket reactor test program were transferred to the Atomic Energy Commission to undertake the development of a pump that will be used in the test program. In addition, funds were used to initiate experiments (such as the effect of radiation on the properties of materials at cryogenic temperatures) that will supply information necessary in the eventual design and operation of nuclear rockets.

In the fiscal year 1960, the components of the nuclear electric system will be fabricated and component testing will be initiated. The work on the fundamental information required to permit the design of higher power, higher temperature systems will be expanded. For instance, work will be undertaken on the corrosion characteristics of high temperature working fluids. The support of the reactor test program will be expanded. The development of a pump for operation under the conditions required for early reactor testing will be completed, and research and development on a pump drive system will be undertaken. Work on the fundamental information that will be required in the design of nuclear rockets will be expanded. For example, work on shielding methods will be undertaken. The test loop for the study of radiation effects at cryogenic temperatures will be designed, fabrication will be started, and preliminary tests will be run.

In the fiscal year 1961 the first conversion system tests will be run as part of the nuclear-electric system (SNAP-8) development program. Much of the fundamental data required for the design of components of a high power, high temperature system should be completed so that early applied research design and experimental studies should be initiated on critical components of such systems. In the nuclear heat transfer rocket program, it is planned to develop the turbopump to full rated performance for use in higher power reactor tests than those considered in the fiscal year 1960 pump development. Work will be expanded on the other non-nuclear components that will be required in the nuclear rocket system.

4. PROGRAM COSTS:	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Advanced technical development:			
Nuclear heat transfer rockets:			
Reactor test (Rover) support.....	$1,910,496	$3,000,000	$4,300,000
Applied research on nuclear rockets....	1,100,000	1,100,000	1,000,000
Bread board engine design.....	---	---	200,000
Total.....	3,010,496	4,100,000	5,500,000

	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Nuclear electric power generating systems:			
SNAP-8 development.....	600,000	1,000,000	2,000,000
Applied research on high power systems.	200,000	900,000	2,500,000
Total.....	800,000	1,900,000	4,500,000
TOTAL.....	$3,810,496	$6,000,000	$10,000,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

NUCLEAR SYSTEMS TECHNOLOGY

Objectives

This program covers the two principal types of nuclear systems that are considered suitable for the propulsion of high payload rocket systems in space - the nuclear heat transfer rocket system and the nuclear electric power generating system. A description of the elements of this program follows:

Nuclear Heat Transfer Rocket System

Reactor test (Rover) support: The NASA has the responsibility for supplying and developing certain non-nuclear hardware for the AEC nuclear rocket reactor program. In general, this non-nuclear hardware is equipment that is required in nuclear rocket flight systems. In addition, the NASA is responsible for supplying all nuclear rocket test facilities with the liquid hydrogen and other propellants that are required. The reactor test support items are listed below:

Pump development: A liquid hydrogen pump is being developed for use in the reactor test program to pump hydrogen from the storage tank into the reactor during the test program. Such a pump is also required in rocket flight systems.

Turbopump system development: The liquid hydrogen pump mentioned above will be developed to its full rated flow and pressure capability. A turbine and a gas generator will be developed to drive this pump. This system will be installed in the AEC reactor test facility for evaluation of reactor performance when combined with the characteristics of a turbopump hydrogen propellant feed system.

Liquid hydorgen cooled jet nozzle: A liquid hydrogen cooled jet nozzle is required for the AEC reactor test program to evaluate the effect of regenerative cooling on reactor operation. In addition, the heat load on a nuclear reactor rocket jet nozzle is so great at the conditions that will be run that hydrogen cooling is necessary if reactor testing is to be possible. This item covers the cost of developing a suitable hydrogen cooled nozzle and of conducting the necessary advanced work at higher temperatures than those that will be encountered in the early tests.

Liquid hydrogen and propellant supply: As mentioned above, the NASA is responsible for supplying the propellants that are required for the nuclear rocket program. At the present time, the necessary hydrogen is being supplied from Air Force facilities and the NASA has agreed to reimburse the Air Force for all of the propellant used. Hydrogen is used in the reactor tests, and in the development of all of the non-nuclear components mentioned above. In addition, nitrogen and helium are used in the various test facilities to purge the system and to pre-cool or chill the system down so that excessive evaporation of the costly hydorgen will be avoided.

Applied research on nuclear rockets: The work covered by this line item in the NASA fiscal year 1961 budget is aimed at developing the technology that is necessary before nuclear rocket systems can be designed, built and operated. This technology involves problems that result when the reactor and other components in the nuclear rocket are packaged closely together as they would have to be in a flight system. It includes analysis and experiments to determine and solve the problems associated with the use of hydrogen in a reactor radiation field. The items included in this applied research phase of the program follow:

Rocket-system dynamics: The successful operation of a nuclear rocket system requires the analysis and development of a system to automatically control both the hydrogen flow system and the nuclear reactor. The interaction of all of the flow system and reactor components using data obtained during steady static tests of all of the components will be analyzed so that adequate control systems may be designed. These control system studies will include the analysis and design of systems for automatically starting up the rocket system, shutting it down so that the reactor does not burn up, and then restarting the reactor system so that the system may accomplish useful space missions.

Radiation effects at cryogenic temperatures: The packaging of the non-nuclear components around the reactor in a nuclear rocket results in the operation of certain components in a radiation field at liquid hydrogen temperatures as low as 430° below zero. Although a considerable amount of work on the effects of radiation on the engineering properties of materials has been and is being done as part of the various nuclear powerplant programs that are in process, no work is being done at the low temperatures that will be encountered in the nuclear rocket. It is, therefore, necessary that these effects be experimentally evaluated as part of our nuclear rocket applied research program. These effects may be much more important at the temperatures in the nuclear rocket than they are in other nuclear systems.

Shielding: The application of nuclear power to rocket propulsion will require shielding of the payload and, very likely, of the hydrogen propellant tank. For high power systems or for long trip times, this shielding may become so heavy that the payload capabilities of the system are seriously reduced. Although shielding work has been in process for some time with relation to the nuclear powered airplane, the shielding requirements and shielding configurations for space propulsion systems are sufficiently different that new shield concepts must be devised and new methods of calculating shields and using the experimental data must be devised. This program is therefore broken down into two areas: analysis and experiments on new shield concepts, and development of methods of calculating space shields.

Liquid-hydrogen properties and instruments: It has been determined that many of the properties of hydrogen that are required in system design and operation are unknown at this time. In addition, it is necessary to develop instrumentation that will be used to measure hydrogen conditions throughout the nuclear rocket so that these data may be sensed and fed into the automatic control system of the nuclear rocket. Because of the background of experience of the National Bureau of Standards Cryogenics Laboratory in this area, the funds included in this item will be transferred to NBS to determine the data that are necessary and to determine suitable means of measuring such quantities as hydrogen mass flow, pressures, and temperatures.

Opposite Page 180-4:

Turbo pump system:	FY 1960 money $200K Lewis - $200K Rocketdyne - all thru AEC.
Nozzle:	Bids due 25 March. One year contract - delivery 1 April 1961. Heat conductivity of H_2 higher than combination of H_2 and O_2.
Propellant supply:	May go as high as $2,500K. $2.50 lb. now. From Linde 50¢ lb.

Hydrogen flow in nozzles: At high temperatures and low pressures, hydrogen dissociates from its two-atom molecule to the single atom. In passing through a jet nozzle, this dissociated hydrogen has a tendency to recombine and release the energy that was required to dissociate it. If all of the dissociated hydrogen is recombined, then the specific impulse is increased considerably. It has, however, never been determined how much of the dissociated hydrogen does recombine. It has also not been determined how heat is transferred to the walls of the nozzle in such a recombining system. Work is, therefore, required to determine the characteristics of the flow of hydrogen through jet nozzles so as to determine the effects on specific impulse.

Breadboard engine design: As part of the nuclear rocket program, it is recognized that flight testing will be required to evaluate the peculiar effects of the space environment on the system operation. It is, therefore, necessary to design a system which will lend itself to extensive flight test work. A system which contains all of the important components of the flight test system but not necessarily packaged or positioned as they would be in the flight test system is required to ground test the performance interaction prior to installation in a flight configuration. Such a system is called a "breadboard" engine. The design of the flight test system and of the breadboard engine will be very closely related. This item, therefore, covers design work on both the flight test system and the ground breadboard engine.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Reactor test (Rover) support:			
Pump development.....	$1,910,496	$1,500,000	$1,200,000
Turbopump system development.....	---	400,000	1,500,000
Liquid hydrogen cooled jet nozzle.....	---	200,000	800,000
Liquid hydrogen and propellant supply...	---	900,000	800,000
	1,910,496	3,000,000	4,300,000

Opposite Page 180-5:

Rocket System Dynamics:	Aerojet. Total about $2,500K.
Radiation Effects:	Lockheed.
LH_2 Properties:	Continuing program at about same level.
H_2 Flow in Nozzles:	Connell.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Applied research on nuclear rockets:			
Rocket system dynamics.....	$100,000	$150,000	300,000
Radiation effects at cryogenic temperatures.....	1,000,000	300,000	100,000
Shielding:			
Analysis and experiments on new concept	---	50,000	100,000
Development of method of calculating space shield.....	---	100,000	100,000
Liquid hydrogen properties and instruments	---	150,000	300,000
Hydrogen flow in nozzles.....	---	250,000	---
Flight system design studies.....	---	100,000	100,000
	---	1,100,000	1,000,000
Breadboard engine design.....	---	---	200,000
Total.....	$3,010,496	$4,100,000	$5,500,000

Nuclear Electric Power Generating Systems

SNAP-8 development: Large amounts of power are required to permit transmission of detailed information from interplanetary distances that will be encountered in our space exploration missions. In addition, large amounts of power are required for large communication systems and also for accomplishing early missions using electrical propulsion. The SNAP-8 system is intended to satisfy the many requirements for power in the range from 30 to 60 electrical kilowatts. The development of this SNAP-8 nuclear reactor electric power generating system is being conducted jointly with the Atomic Energy Commission. The AEC is developing the reactor, reactor controls, and the shielding required in the system. The funds covered by this line item in the NASA budget cover the work to be supported under the NASA responsibility to develop the system to convert from the reactor power to the electrical power output and to integrate the reactor and the conversion equipment into an operational, reliable system.

Applied research on high power systems: Nuclear electric generating systems such as SNAP-8, which are based upon current operating temperatures and existing components, are limited to electrical outputs of a few kilowatts, sufficient to meet auxiliary power requirements and also provide power for a low thrust electric rocket. Systems of higher electrical output could be built, but they would be too heavy for space applications. Development of nuclear electric generating systems of high electrical output for use with high-performance electric rockets will require extension of our current knowledge of working fluid properties to higher operating temperatures. Also required is the development of high performance, light weight components, capable of operating continuously and unattended for many months, perhaps years. The applied research program on high power systems is aimed at developing the technology of nuclear electric generating systems to meet these future requirements. The following items are included in this program:

Effect of space environment on materials:

Emissivity studies: The waste heat from a nuclear electric system will be rejected to space by a radiator, the efficiency of which depends upon the emissivity, a property of the radiating surface. Under the low vacuum of space, the surface condition and therefore the emissivity of a given material will be different from that in the atmosphere. For example, coatings on the surface may boil off under the low vacuum conditions in space. The emissivity of radiator materials is being measured under vacuum conditions like those in space to provide necessary radiator design data.

Meteoroid damage experiments: Since the radiator is the largest exposed component of a space power system, it is vulnerable to damage by meteoroids. Also because of its large size the radiator is the greatest single contributor to overall weight and therefore must be designed for minimum possible weight. To arrive at as precise a design as possible, the concentration and the penetrability of meteoroids must be established. This is to be accomplished by means of instrumented satellites which will detect and transmit data on encounters with meteoroids in space. The funding in this item is for design of such satellites and experiments on the instrumentation to be used.

Liquid metal and vaporized metal technology:

Property data: Design of high power, light weight, nuclear systems requires knowledge of many properties of the working fluid not now available. An example of one such property is the amount of heat required to vaporize a given quantity of the liquid. Fluid properties are to be measured for useful working fluids at the high temperatures required in high power systems.

Boiling metal heat transfer: Another property of the working fluid required for design is the rate at which heat must be supplied for boiling the working fluid as it enters the boiler. Similarly the rate of heat rejection in the condenser must be known. These heat transfer properties are to be measured at high temperatures in the working fluids that will be used in space power systems.

Corrosion tests: The working fluids to be used in nuclear electric systems are highly corrosive at the required temperatures. Tests must be performed to determine their compatibility with the various materials which they will encounter. Much is known today about corrosion properties, but very little at the high operating temperatures of advanced nuclear electric systems. Experiments of the type which have been run at low temperatures will now be extended to higher temperatures. Various working fluids and containment materials will be studied.

System design studies: As design information becomes available from the applied research program, it must be applied to system design studies. These design studies are necessary to evaluate the performance of various systems and to pinpoint problem areas or components requiring further work. It is expected that this will be a continuing effort, constantly advancing to higher levels of system performance.

Liquid metal component tests:

High temperature generators: Applied research on this component will be aimed at achieving efficient, reliable operation at the high operating temperatures that the generator will be subjected to in the advanced nuclear electric systems. In addition, this item will cover the work necessary to insure sucessful generator operation in the presence of high-temperature metal vapors.

High-temperature metal vapor turbines: The turbine is driven by a vaporized working fluid and, for high power systems, a vaporized liquid metal will probably be used. The turbine drives the fluid pumps and the electric generator. In developing turbines of higher power that are capable of operating at higher temperatures than in current systems, several areas of research must be explored. A typical one is the erosive action of liquid droplets mixed with the vapor entering the turbine. The attainment of high efficiency is a necessary requirement. This item covers applied research on such advanced turbines.

Condensor-heat rejection systems: These systems reject the waste heat of the electric generating working cycle. The vaporized metal working fluid is converted into liquid and, in general, is subcooled. Because of the need for light weight systems, these units must be characterized by a highly efficient structural design combining large radiation surfaces, minimum weight, and low vulnerability to meteoroid damage. In high power systems these large heat rejection radiators will have to be stored in the vehicle nose cone and erected or extended to the operating configuration in space. Operation in the weightless environment of space is another requirement to be developed and studied in condensor-heat rejection systems. This development and applied research work is covered by the funds indicated.

Liquid metal bearing and seal tests: Some of the most difficult design problems in a liquid metal system are in the bearing and seals of the rotating units comprising the turbine, electric generator, and pumps. These units must operate unattended for many months and even years at high rotational speeds, high temperatures, in contact with corrosive fluids. Methods of insuring adequate bearing lubrication and cooling using the metal working fluids must be experimentally studied. Development of fluid seals must proceed concurrently with the bearing studies.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
SNAP-8 development.....	$600,000	$1,000,000	$2,000,000
Applied research on high power systems:			
Effect of space environment on materials:			
Emissivity studies.....	100,000	100,000	---
Meteoroid damage experiments.....	100,000	100,000	300,000
Liquid metal and vaporized metal technology:			
Property data.....	---	200,000	300,000
Boiling metal heat transfer.....	---	200,000	300,000
Corrosion tests.....	---	300,000	500,000
System design studies.....	---	---	100,000
Liquid metal component tests:			
High temperature generators.....	---	---	300,000
High temperature metal vapor turbines.	---	---	300,000
Condensor-heat rejection systems.....	---	---	100,000
Liquid metal bearing and seal tests...	---	---	300,000
	200,000	900,000	2,500,000
Total.....	$800,000	$1,900,000	$4,500,000
		Total	$10,000,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

SPACE POWER TECHNOLOGY

Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
---	$4,814,000	$8,000,000

1. OBJECTIVES:

To develop electrical thrust devices and electrical power supplies based on energy sources other than nuclear reactors for application in space vehicles.

2. JUSTIFICATION:

Nearly all space vehicles require an electrical power supply (auxiliary power unit) to provide electricity for operating instruments, communications and other equipment. Solar cells and batteries are usually used, but for power requirements of 0.5 to 30 electrical kilowatts, other systems should be developed which will have a lower weight, higher reliability, or lower cost. Solar-heated systems using mechanical or static power conversion equipment appear promising for long duration missions in space. Chemical auxiliary power systems are desirable for certain missions. Improved storage batteries or regenerative fuel cells are desirable for energy storage in conjunction with solar auxiliary power unit systems. By placing reliance on the progress to be made in various programs sponsored by the Department of Defense, it is possible for NASA to limit its program on auxiliary power units in the fiscal years 1960 and 1961 to the development of a 3-kilowatt solar auxiliary power unit, with limited support of applied research and development on advanced solar and chemical systems.

Electrical propulsion systems are desirable because of their low propellant consumption for certain space missions. Applications include attitude control, orbit correction, main propulsion, and vernier control of velocity for spacecraft which have initially been boosted outside the earth's atmosphere. Research and development is needed on propulsion

by means of arc plasma jets, ion rockets, and plasma acceleration systems, for potential use with nuclear-electric and possibly solar-electric power supplies.

3. PROGRAM PHASING:

Funds for the fiscal year 1960 will be used to initiate the development of a 3-kilowatt solar auxiliary power unit, and to conduct applied research and component development on advanced solar and chemical power systems and on arc plasma jet and ion propulsion.

Funds for the fiscal year 1961 will provide for the continuation of applied research and component development projects and for initiating the development of plasma jet and ion propulsion systems. The scheduling of the development of electrical propulsion systems will be phased to match the availability of electrical power supplies, such as the SNAP-8 nuclear-electric power system.

4. PROGRAM COSTS:

	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Advanced technical development:			
Applied research and development.....	---	$1,914,000	$4,400,000
Solar auxiliary power unit development.....	---	1,600,000	2,100,000
Plasma jet rocket engine applied research and development.....	---	700,000	800,000
Ion rocket engine applied research and development.....	---	600,000	700,000
TOTAL.....	---	$4,814,000	$8,000,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

SPACE POWER TECHNOLOGY

Objectives

This program covers two areas of advanced technical developments: space propulsion and auxiliary power units. The objective of the space propulsion program is to develop the technology of electrical thrust devices which may ultimately be applied with nuclear-electric power supplies for propulsion of spacecraft on lunar or planetary missions. The use of electrical propulsion systems is potentially superior to chemical or nuclear heated rockets, particularly for round-trip planetary missions.

The relative advantages of electrical propulsion can only be assessed after further research and development. A primary goal is to conduct experimental flight testing of one or more types of electrical rockets with the 30 kw SNAP-8 nuclear-electric power supply in the 1965 time period. The results of these feasibility demonstration tests will provide crucial data for planning propulsion developments in the 1965-70 time period leading to later planetary exploration missions.

The objective of the auxiliary power units program is to develop the technology of generating electrical power from solar and chemical energy sources to permit the development of lightweight, reliable space power supplies which will be critically important systems in all payloads of spacecraft.

Applied Research and Development

Propellant feed system components for plasma rocket engines: The objective of this project is to develop optimum designs and techniques for storing, pressurizing, and controlling the flow of propellants to an arc plasmajet engine at low flow rates for mission durations of several weeks. The funds requested in the fiscal year 1961 will initiate research, design and development on tankage, insulation, pressurization systems, flow controls and valves which are applicable for use with a 30 kw (0.5 pound thrust) arc plasmajet engine.

Ion engine system components: The objective of this project is to develop engine and propellant feed system components for a 30 kw ion rocket engine which will generate 0.1 pound thrust. The fiscal year 1961 funds will initiate component development for an engine system which would undergo ground testing in the fiscal years 1962 to 1964 and flight testing in about 1965 with the Snap-8 nuclear-electric power supply.

Plasma acceleration engine: Since there is an optimum value of jet velocity which should be used by an electric rocket for each category of space missions in order to maximize payload, it will be desirable to have a flexible electrical thrust device which can vary its jet velocity (specific impulse) to suit the mission requirements. The use of electromagnetic fields to accelerate an electrically conducting gas shows promise of being comparable in efficiency to ion propulsion and to have the advantage of being able to operate with specific impulse as low as 1,000 seconds and as high as 10,000 seconds or more. The lower values are actually optimum for lunar missions whereas the higher values will be needed for planetary missions.

The objective of this project is to obtain research data and to establish the feasibility of plasma acceleration devices for potential application in nuclear-electric propulsion systems. The fiscal year 1961 funds will initiate applied research and component development of plasma acceleration devices capable of operating at a specific impulse of 1,500 to 3,000 seconds which is optimum for propulsion and orbit control in the vicinity of the Earth-Moon system.

Thermal energy storage: The purpose of this project is to obtain basic thermal and physical data on lithium hydride as a material for storing thermal energy for use in solar-mechanical or solar-thermoelectric space power systems. Lithium hydride has a high heat of fusion and appears to be very desirable for providing heat storage for solar-power unit operation while in the shadow of the Earth or Moon. The fiscal year 1960 funds have been programmed for transfer to the AEC to measure basic properties and to test experimental components. No funds are needed for this project in the fiscal year 1961.

Solar collector: Funds in the amount of $30,000 were assigned to the Langley Research Center in the fiscal year 1960 to provide equipment for testing 10-foot diameter solar collectors of the aluminized plastic umbrella type, which are particularly promising for very lightweight construction to be used with heat-power conversion systems. No funds are needed for this project in the fiscal year 1961.

Solar-thermionic power systems: The objective of this project is to advance the technology of solar-thermionic power systems which is already receiving substantial support from the Air Force. The emphasis is on proving the feasibility of very accurate and lightweight reflecting solar concentrators which are capable of generating the temperatures of 2000°F or higher needed for use with thermionic power converters. The fiscal year 1961 funds will continue component developments initiated in the fiscal year 1960 and will provide for simulated space environmental testing of solar concentrators and satellite testing of reflector material samples.

Silicon cell (solar battery) arrays: The purpose of this project is to conduct research on the effects of the space environment (radiation and meteoroids) on the performance of solar batteries and to develop advanced techniques for structural mounting, protecting against the space environment, and attaining proper temperature control. These problems demand continuing efforts in order to improve the life and reliability and to reduce the weight of photovoltaic power systems. The fiscal year 1961 funds will continue applied research and component development being initiated with fiscal year 1960 funds.

Electrolytically regenerated fuel cells: It is desired to develop a regenerative fuel cell which can replace nickel-cadmium batteries as an electrical energy storage system for use with solar cell or solar-thermionic systems. The advantage will be a much lighter weight system which can be recycled for many thousand orbits, storing electrical energy from a solar power supply while in the sun and providing power while in the shade of the Earth or Moon. The fiscal year 1961 funds will provide for environmental and life testing of fuel cell and electrolyzer components and for the continuation of research and development started with fiscal year 1960 funds. A prototype system is planned for 1963-1964.

Hydrogen-oxygen fuel cell: The purpose of this project is to develop a modular type hydrogen-oxygen fuel cell system to produce from 1 to 5 kw for application in unmanned or manned lunar circumnavigation vehicles or in short duration (1 to 2 weeks) manned orbital laboratories in the 1964 time period.

Solar power conversion and sun-orientation systems: The objective of this project is to conduct exploratory studies and research, and to perform tests to determine the relative merits of various types of power conversion systems and of sun orientation systems adaptable to solar auxiliary power units. The program will concentrate on supporting research for solar-heated auxiliary power units.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961	
Projects on space propulsion:				
Development of propellant feed system components for plasma rocket engines....	---	---	$300,000	
Development of ion engine system components.....	---	---	900,000	
Plasma acceleration engine research and development.....	---	---	600,000	1.8
Projects on auxiliary power units:				
Research and development on thermal energy storage.....	---	$170,000 AEC	---	
Solar collector research.....	---	30,000 LANGLEY	---	
Solar-thermionic power systems research and development.....	---	300,000 IND.	900,000	
Research and development on silicon cell (solar battery) arrays.....	---	300,000 JPL GSD	300,000	
Research and development on electrolytically regenerated fuel cells.....	---	200,000	500,000	2.6
Hydrogen-oxygen fuel cell development.....	---	---	500,000	
Studies, research and development of solar power conversion and sun-orientation systems.....	---	914,000 JPL	400,000	
Total.....	---	$1,914,000	$4,400,000	

Solar Auxiliary Power Unit Development

3 kw solar auxiliary power unit(Sunflower-I): The objective of this project is to develop a reliable electrical power supply based on solar energy for general purpose usage in satellites and space probes of the Centaur and Saturn class for missions in the time period 1963-1968. This

power system will be capable of continuously generating 3 kw of electrical power, which will be adequate for advanced meteorological satellites, active communication satellites, manned or unmanned orbital laboratories, and for wide bandwidth communication from space probes.

The project will include the flight testing of an experimental prototype in a test vehicle in 1963 and the ground demonstration of one-year life capability in 1964. Firm plans for operational prototypes will be dependent on further studies of payload requirements for specific missions. The solar power system development is being initiated in the fiscal year 1960 based on competitive evaluation of several types of solar energy collection and power conversion equipment.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
3 kw solar auxiliary power unit development..	---	$1,600,000	$2,100,000

Plasma Jet Rocket Engine Applied Research and Development

1 kilowatt arc plasma jet engine: The objective of this project is to establish the feasibility of using one or more small electric arcs to heat a fluid and to expand it controllably at high jet velocity through jet nozzles to provide the necessary torque to control the angular orientation of a spacecraft. If feasible, this system would replace gas bottles which are presently used for attitude control and would permit long durations of operation with a minimum weight of fluid. The fiscal year 1961 funds will support continuation of research and development initiated with the fiscal year 1960 funding and will provide for ground testing of a feasibility demonstration model of a plasma jet attitude control system.

30 kilowatt arc plasma jet engine: The objective of this project is to develop the first electrical thrust device for experimental flight testing with the Snap-8 nuclear-electric power supply in the 1965 time period. This electric propulsion system may permit an increase by a factor of two or more in the payload which the Centaur can place in a 24-hour orbit (e.g., an active communication satellite) and will provide test data needed to choose the optimum propulsion systems for later lunar and planetary missions. The fiscal year 1961 funding will initiate development of a 30 kw prototype engine which would undergo preliminary flight rating tests in fiscal years 1963 and 1964.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
1 kw arc plasma jet engine research and development.....	---	$200,000	$200,000
30 kw arc plasma jet engine research and development.....	---	500,000	600,000
Total.....	---	$700,000	$800,000

Ion Rocket Engine Applied Research and Development

Alkali metal ion engine: Solutions are needed to the several critical applied research problems which at present delay the development of alkali metal ion engines. These key problems are related to cesium-ion sources, sputtering erosion of electrodes by ion beams, and ion beam neutralization. The funds requested for the fiscal year 1961 will provide for a continuation of applied research initiated in the fiscal year 1960 and will provide additional research results to support the development of a 30 kw ion engine.

Bombardment-type ion engine: The objective of this project is to establish the feasibility of an ion rocket engine based on an electron bombardment type ion source. Considerable experience has been obtained with this type of ion source in other technical fields, but it is not clear whether such an ion source can be made comparable in efficiency to a contact-type source which must use alkali metals such as relatively expensive cesium. The bombardment-type source is particularly desirable because it would permit the use of more available and less expensive propellants. The fiscal year 1961 funds will provide for a continuation of research initiated with the fiscal year 1960 funding and will provide additional research results to support the development of a 30 kw ion engine.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Alkali metal ion engine.....	---	$450,000	$500,000
Bombardment-type ion engine.....	---	150,000	200,000
Total.....	---	$600,000	$700,000
		Total	$1,000,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

SCOUT

Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
$6,048,000	$2,800,000	---

1. OBJECTIVES:

To develop a highly reliable, versatile, and inexpensive vehicle to extend capabilities for aerodynamic and space research.

2. JUSTIFICATION:

A review of the various scientific experiments to be performed over the next several years has indicated the need for highly versatile, reliable, and inexpensive vehicles which can be launched with minimum facilities and which can be used to conduct a wide range of scientific experiments. These experiments include placing a variety of scientific payloads into 300-500 mile orbits, high-altitude probes, high-velocity reentry tests, advanced heating and ablation studies, and many similar types of experiments. A study of the existing available vehicles indicates they are all complex and costly, and not fully optimized for the kind of mission and use described above.

The Scout vehicle is a natural extension and evolution of the multistaged solid propellant rocket systems that have been developed over the last ten years for high-velocity aerodynamic and reentry research studies. The solid propellant rocket systems have demonstrated a very high degree of reliability in operation. The systems also combine simplified logistics and handling inherent in solids so that a reliable and inexpensive vehicle can be achieved.

The Scout vehicle consists of four solid rocket stages whose performance is representative of advanced state-of-the-art solid propellants. The guidance system incorporates three-axis stabilization with a digital pitch programmer and complete servo system. Aerodynamic controls consist of jet vanes and aerodynamic surfaces for the first stage, peroxide reaction jets for the second and third stages, and spin stabilization for the fourth stage. It will have capabilities for launching payloads of 150-200 pound in circular orbits at 300 miles; for placing 100-pound payloads at about 5,000 mile altitudes; for achieving very high-velocity reentry; and for use in space target identification and guidance system evaluation.

The use of solid propellant motors, the simplicity of components, and the simplicity of launching and handling techniques will allow launching of the vehicle from a variety of sites including the NASA's Wallops Station. A minimum of handling and launching costs are involved.

3. PROGRAM COSTS:

There are four major areas of development in the Scout program: the propulsion system, the guidance system, the airframe and the launcher. Contracts for the development and procurement of components in all four areas were initiated in the fiscal year 1959. The procurement includes eight sets of propulsion units, four guidance systems and air frames, and one launcher. The development and qualification of all the basic components for the Scout vehicle will be completed in the fiscal year 1960. Four additional guidance systems and airframes to complete the procurement for a total of eight vehicles will also be accomplished in the fiscal year 1960. Four vehicle flights will be conducted in the period January-July 1960. While the primary purpose of these flights will be vehicle evaluation, useful payloads will be incorporated on all flights except the first one. The balance of the eight vehicles will be fired during the fiscal year 1961 at approximately two month intervals and will incorporate specific payloads to carry out useful research programs. Additional data will be obtained on vehicle performance. Since it is anticipated that the development flight tests will be completed during the fiscal year 1961, no additional funds have been budgeted under this program for the fiscal year 1961.

4. PROGRAM COSTS:

	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Flight research program:			
Development and delivery of eight complete vehicles including launcher and ground test equipment.....	$6,048,000	$2,800,000	---
TOTAL.....	$6,048,000	$2,800,000	---

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

SCOUT

Objectives

The purpose of this program is to develop a highly reliable, versatile, and inexpensive vehicle to extend capabilities for aerodynamic and space research. The Scout is the smallest of the basic NASA family of orbital vehicles and will be a "workhorse" for smaller size payloads.

Scout development is essentially complete, and the first flight date is scheduled for the fourth quarter of fiscal year 1960. Flights are planned every two months thereafter for the initial series of eight vehicles. A breakdown of program elements and related costs follows:

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Rocket motors (4 stages):			
First stage: "Algol" developed by Aerojet, rocket weight 23,000 lbs., thrust 115,000 lbs., diameter 40"; an improved propellant adaptation of the Aerojet Jupiter motor; development is complete.....	$1,300,000	$374,000	---
Second stage: "Castor", developed by Thiokol, rocket weight 8,900 lbs., thrust 56,000 lbs., diameter 31"; an improved propellant version of the Sergeant booster; development is complete.....	726,000	375,000	---

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Rocket motors (4 stages) (continued):			
Third stage: "Antares" developed by the Allegany Ballistics Laboratory, total weight 2,220 lbs., thrust 13,600 lbs., a new rocket based on a scale-up of the fourth stage; four more firings will complete development.....	$1,123,000	330,000	---
Fourth stage: "Altair" developed by ABL, total weight 505 lbs., thrust level 3,060 lbs.; adaptation of the Vanguard top stage; no development required.....	160,000	---	---
Guidance and control units: Minneapolis-Honeywell has the guidance development and W. Kidde Co. the subcontract for the peroxide jet reaction systems which attitude control the second and third stages; the guidance system has 3 axis stabilization and a pitch programmer; it controls the two reaction jet systems to maintain proper vehicle attitude during flight.....	921,000	976,000	---
Airframe and launcher: Chance Vought Aircraft has contracted to build the Scout launcher at Wallops Island and to build the airframe which consists of the structure between the rockets, the payload heat shield, and fourth stage spin table.	1,070,000	484,000	---

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Instrumentation and Preliminary Development: The Langley Research Center is fabricating and installing all interstage wiring, telemetering equipment and data-taking instrumentation; Funding shown here covers costs of supplies, equipment, materials, and instruments.....	748,000	261,000	---
Total.....	$6,048,000	$2,800,000	---

need $2,605 K to complete
$1,750 K for new 3rd & 4th stage

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

DELTA

Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
$12,927,417	$13,300,000	$12,500,000

1. OBJECTIVES:

To provide a reliable space flight vehicle for medium payload satellites and small payload space probes, replacing the present Thor-Able, Juno II, Jupiter C, and Vanguard vehicles.

2. JUSTIFICATION:

Space projects to date have utilized vehicles that have been adapted from military ballistic missile boosters. While providing valuable interim service, most of these vehicles suffer from technical limitations that restrict their desirability for long-term application as space vehicles.

The Delta space flight vehicle will replace the small-payload vehicles currently in use. It will be similar to the Thor-Able, but will have a coast-phase attitude control system, permitting higher injection altitudes. Delta will be a three-stage vehicle in which the first stage will consist of a production Thor missile with the nose cone and guidance unit removed. The second stage will consist essentially of the second stage used in Vanguard and Thor-Able with an improved radio-inertial guidance system of higher accuracy. The third stage will be a solid propellant rocket motor developed for Vanguard.

The Delta vehicle will be applied to a number of satellites and space probe projects. It will have a payload capacity of 300 to 500 pounds for satellite applications and up to 65 pounds for probe shots to the vicinity of the moon. Delta will be useful for both inclined and polar orbits and will be launched from both the Atlantic and the Pacific Missile Ranges. Requirements for greater lunar payload capability and for increased accuracy in achieving close tolerances for orbital circularity, and special demands for obtaining attitude stabilization of certain payloads, have all combined to dictate more stringent design limits on the vehicle. In the fiscal year 1961, funds will be expended to develop hardware intended to yield more precise and controllable flight paths and velocities while at the same time increasing payload weight capacity and attitude orientation.

3. PROGRAM PHASING:

The Delta program is divided into five parts: the fabrication and test of the modified Vanguard/Thor-Able second stage; the procurement and test of the guidance system; the modification of the Thor boosters; the integration of the complete Delta; and the preparation and launch.

Incremental funding for this program, including the procurement of twelve vehicles, was initiated during the fiscal year 1959. All phases of the vehicle engineering program have proceeded on schedule.

Funding for the fiscal year 1960 and beyond is required for the planned continuation of the initial contract. Specific sums proposed for obligation in a given fiscal year are not associated with particular vehicles. However, the fiscal year 1960 funding essentially supports hardware fabrication and flight operation costs for East Coast launchings; and the fiscal year 1961 funding will support similar operations from the West Coast and will also initiate the vehicle improvement program to increase reliability, accuracy, and performance.

4. PROGRAM COSTS:	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Flight research program:			
Vehicle engineering and manufacturing, ground service equipment, and trajectory computations	$12,927,417	$11,645,000	$9,000,000

Range and launching services, shipping costs.....	---	$1,655,000	$2,300,000
Vehicle reliability improvements and modifications.....	---	---	1,200,000
TOTAL.....	$12,927,417	$13,300,000	$12,500,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

DELTA

Objectives

The Delta program was instituted to inject payloads weighing several hundreds of pounds into specified orbits or on Earth escape trajectories. The Delta vehicle was based on pre-existing vehicle stages in the interest of early payload yields as well as favorable reliability.

The Delta vehicle constitutes three rocket stages each of which has a considerable flight experience background as a result of previous programs. Therefore, no test vehicles as such are planned. Delta number one will fly the Echo project payload (100-foot sphere) and the launch of this vehicle is scheduled for the last half of April, 1960. Of the twelve Delta vehicles, eight are scheduled for launch in the fiscal year 1961, with the remaining four to be launched in the fiscal year 1962. Missions will include communications, geodetic, meteorological, radiation, and other scientific satellite payloads and a deep-space probe. The Delta program spans the period April 1959 to May 1962.

The paragraphs below briefly discuss the major elements of the Delta task for the fiscal year 1961, with reference to the cost breakdown which follows:

Vehicles and Support Equipment

The task of integrating the three propulsive stages used in Delta is an extensive one. In addition to basic modifications to these stages to afford compatability, as well as improvements (the second-stage thrust-chamber material has been changed from aluminum to steel in the interest of reliability), many new devices must be designed and built. An example is the gas-jet system for coasting phase-attitude control. The prime contractor is charged with this modification and integration work as well as all checkout operations and analysis of test data up to and including the launch phase. In some instances he must make significant allowances, both operationally and hardware-wise, for special NASA payload requirements.

The Delta vehicle will employ precision ground-based guidance (Bell Telephone Laboratory System). In this system lightweight, highly reliable equipment is flown in the vehicle; a

complex radar-computer-command aggregate located at the launch base controls the flight. In order for the ground radar to transmit adequate vehicle steering signals, an associated computer must generate orders for the radar. Delta funds purchase the computation services necessary to convert final trajectory data into the computer orders. In order to maximize the payload weight and the probability of success for each Delta flight, a comprehensive study of trajectories and error analyses is being performed by the prime contractor. This work is necessarily expensive because of the variety of the Delta missions, and the many variations of each which must be studied.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Vehicle engineering and manufacturing: Covers cost of over-all vehicle design, procurement of subsystems, system integration and checkout, and ground servicing equipment; includes procurement of second-stage propulsion systems 3rd-stage hardware (minus rocket motors) and launch services.....	$7,039,000	$10,200,000	$8,000,000
Boosters: Procurement of basic Thor boost vehicle.....	5,751,667 (11 THORS)	---	---
Third-stage rocket motors: Procurement of motors, with modifications, for Delta vehicle.....	136,750	---	---
Guidance system services: To obtain use of the Bell Telephone Laboratory's ground-based guidance system for in-flight vehicle control; includes preparation of the ground-based computer program.....	---	625,000	1,000,000

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Special trajectory and error analysis: A large number of electronic computer studies, including critical flight parameters, are required as missions are changed or as new safety limitations arise.....	---	$234,516	---
Total.....	$12,927,417	$11,059,516	$9,000,000

Range and Launching Services

Items in this category include vehicle and equipment shipment, basic range costs, and the expense of shifting the entire Delta operation from the east coast to the west coast. The Thor boosters, the second stage units and the third-stage rocket motors originate at different points and are therefore shipped separately to AMR or PMR. The support activity of the firing range is, of course, extensive. Services purchased vary from the operation of numerous launch site and downrange telemetry ground stations to pad safety operation. Propellants for the two liquid-rocket stages will also be provided by the range. A diversity of work-orders must be performed by range personnel. These include special facility modifications or additions as required.

As mentioned above, the entire Delta operation is to be transferred from AMR to PMR approximately half-way through the program. The expense of transferring support equipment, as well as modifications and additions required at PMR, is covered under this category.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Shipping costs: Shipment of vehicles from contractor's plant to launch site.....	---	$125,000	$300,000

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Basic range costs: Covers propellants, logistics, personnel overtime, and range work orders.....	---	$825,000	$1,000,000
Transfer from AMR to PMR: Permits transfer of necessary test and ground-service equipment for operations to shift from AMR to PMR midway in the launching program.....	---	---	1st launch May 62 1,000,000 (6 at PMR)
Total.....	---	$950,000	$2,300,000

Vehicle Modification Program

Experience has indicated the necessity of incorporating minor redesign and modifications to a launching vehicle during the launching program. This is to take advantage of experience gained in meeting problems as they arise. For example, it may be found necessary to provide special moisture shields in the vehicle electrical system to ward off the effects of high humidity while the vehicle is on the launch stand. Modifications are often required because of a change in external requirements. Special vehicle and payload accommodations at the launch site are frequently necessary. These usually require special equipment and procedures such as payload cooling system.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Reliability improvement and normal modifications: Cost of vehicle modifications as they are indicated throughout the firing program; efforts to improve reliability and simplify testing as applicable experience becomes available.....	---	$770,484	$1,200,000

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Special vehicle and payload accommodations at launch site:	---	$520,000	---
Total.....	---	$1,290,484	$1,200,000

12,500,000

Total 38,500,000

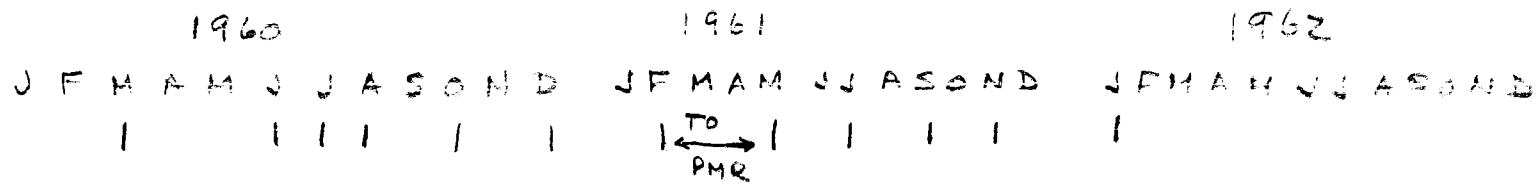
Launch Schedule

Nov Dec Jan Feb Aug Sept - Oct Dec Feb 61 — May 61 Jul Sept Nov

2 months to begin

Jan 62

LAUNCH SCHEDULE:



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

VEGA

Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
$14,291,494	$4,000,000	---

1. OBJECTIVES:

The objective was to provide the first general purpose space vehicles in the National Space Vehicle Program. The Vega project was terminated on December 11, 1959, to reduce the number of rocket vehicles used in the United States space program. Other rocket vehicles in the national inventory will be used to accomplish the satellite and space probe projects for which the Vega had been planned.

2. JUSTIFICATION:

The Vega project included a two-stage and a three-stage vehicle system. In both, the first stage used the Convair Atlas and the second stage, a General Electric engine. The GE engine, originally used as the primary booster of the Vanguard, was being modified to include altitude start and re-start capability. The third stage used the 6,000 pound-thrust storable fuel engine currently under development by NASA's Jet Propulsion Laboratory. This particular engine will be continued as an advanced development for use in large spacecraft of the future. It is also expected that some of the material and components developed by Convair will be usable in the Centaur program.

3. PROGRAM PHASING:

During the fiscal year 1959, incrementally funded contracts were let for the design, development, fabrication and testing, and launching of eight Vega vehicles, including the requisite modification to the Atlas first-stage and the development of the Vega second-stage powerplant.

During the fiscal year 1960 the preliminary design of the second stage, the construction of a captive test article and the development of the second-stage engine were continued. The construction of flight engines and vehicles was also initiated.

The Vega project was terminated on December 11, 1959.

4. PROGRAM COSTS:	Fiscal Year 1959	Fiscal Year 1960 (Including termination costs)	Fiscal Year 1961
Flight research program:			
Second stage development, fabrication, and testing.....	$11,290,000	$1,580,000	---
Third stage development, fabrication, and testing.....	3,001,494	2,420,000	---
TOTAL.....	$14,291,494	$4,000,000	---

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

VEGA

Objectives

The Vega vehicle program was undertaken in March, 1959, to provide a medium payload-carrying capability within the NASA family of space vehicles. The Centaur, which will be a more efficient vehicle based upon higher energy propellants, is expected to be available for operational use (following a development period) in the fall of the calendar year 1962. Vega was to have been an interim vehicle to allow relatively heavy payloads to be placed in earth orbits and on the moon pending the availability of Centaur. By this means, NASA could carry on a vigorous space program without waiting for Centaur to become operationally available.

Following initiation of the Vega project, the Air Force Ballistic Missile Division undertook a vigorous development program to provide an Agena-B second-stage vehicle for use in certain highly classified Department of Defense missions. The Agena-B is expected to have payload-carrying capabilities of the same order as originally planned for Vega. Some of these vehicles could be made available to NASA to perform the Vega missions. Because the work on Centaur was progressing very well, and because NASA could save government funds by participating in the Air Force Agena-B program, thereby providing the required interim vehicle, it was decided to terminate Vega on December 11, 1959.

Without Vega as an interim, substantially "off the shelf", vehicle or its equivalent, NASA would have been forced to delay its heavy satellite and lunar exploration program until Centaur was available in the fall of the calendar year 1962. The urgency of the space program did not permit this delay. The substitution of Agena for the terminated Vega will fill this gap effectively.

Final termination costs have not yet been determined, but it is expected that the final Vega costs will total some $18.3 million, summarized as follows:

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Second-stage development, fabrication and testing:			
Second-stage engine:			
Development	2,120,000	340,000	---
Fabrication	900,000	240,000	---
Testing	1,400,000	300,000	
Second-stage structure:			
Development	3,100,000	200,000	---
Fabrication	2,340,000	300,000	---
Testing	1,430,000	200,000	---
Total	$11,290,000	$1,580,000	---
Third-stage development, fabrication and testing:			
6,000 pounds thrust engine	1,100,000	900,000	---
Third-stage structure	551,494	140,000	---
Lunar payload	1,350,000	1,380,000	---
Total	$3,001,494	$2,420,000	---
	14,291,494	4,000,000	
		14,291,494	
		$18,291,494	

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

CENTAUR

Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
$4,000,000	$37,000,000	$47,000,000

1. OBJECTIVES:

To develop a general purpose space flight vehicle employing a high-energy fuel in an upper stage.

2. JUSTIFICATION:

Centaur is a two-stage vehicle whose first stage is a modified Atlas "D" missile. The modification consists of replacing the cone frustum part of the forward liquid oxygen tank with a cylindrical section having the same diameter as the rest of the Atlas. Between the lower and upper stages is a structural adapter that is attached permanently to the lower stage. The upper stage is mounted on top of the adapter which is jettisoned with the modified Atlas booster. Sets of hydrogen peroxide rockets are utilized for upper-stage attitude control during the coast period. The significant feature of Centaur is the use of liquid hydrogen as a fuel, thus providing a launch vehicle of much greater capability than previously available.

The Centaur project was transferred from ARPA to NASA on July 1, 1959. Technical direction is by an Air Force team located at the Air Force Ballistic Missile Division and reporting directly to NASA Headquarters.

3. PROGRAM PHASING:

The Centaur missions will involve placing communications satellites in a stationary 24-hour orbit, and lunar and planetary probes. The first six developmental vehicles will be used for both vehicle systems tests and for payload missions.

During the fiscal year 1959 the Air Force let incrementally funded contracts for the development of the Centaur engines, for the development and fabrication of the Centaur second stages, and for the modification to the Atlas boosters.

The existing contracts will be continued under NASA funding during the fiscal year 1960 and 1961. During the fiscal year 1960 static tests of the complete Centaur powerplant will be run and preliminary design will be completed on the second stage. Tests will be initiated to simulate zero-g conditions on the liquid gas tank during coasting flight.

The final design of the Centaur powerplant and second stage will be completed and the flight test program will be started during the fiscal year 1961.

4. PROGRAM COSTS:

	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Flight research program:			
Procurement of booster vehicles....	$4,000,000	---	$6,500,000
Development and procurement of second-stage and engine.....	---	$37,000,000	39,500,000
Launching operations.....	---	---	1,000,000
TOTAL.....	$4,000,000	$37,000,000	$47,000,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

CENTAUR

Objectives

The Centaur is a two-stage general purpose space flight vehicle employing a high-energy fuel in the upper stage. The Centaur is being developed to provide an intermediate size (between Scout and Saturn) vehicle which will allow early launches carrying medium size payloads into earth orbits.

An immediate requirement exists for a vehicle of the capability and performance characteristics of the Centaur. This program, on which incrementally funded contracts were let by the Air Force in the fiscal year 1959, is being prosecuted by NASA on as rapid a basis as possible within the funds available. Static tests of the complete Centaur power plant will be started during the fiscal year 1960 and the development flight tests will be started in the fiscal year 1961.

The development flight test program will utilize at least the first six vehicles which are currently on order and are being incrementally funded. While these first six launchings will carry some payload, the flights will be primarily directed to de-bugging the vehicle system itself. The operational phase is expected to begin with the seventh Centaur.

Procurement of Booster Vehicles

The Air Force Ballistic Missile Division is responsible for providing six Atlas boosters for the Centaur program, modified to adapt the Atlas to carry the Centaur upper stage. One Atlas will be delivered approximately three months prior to each Centaur launch at AMR.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Procurement of six (6) Atlas boosters modified for use with Centaur.....	$4,000,000	---	$6,500,000

Development and Procurement of Second Stage and Engine

The Pratt and Whitney Division of United Aircraft Corporation has been awarded the contract for the design, development, testing and manufacture of nine complete Centaur second-stage high-energy propulsion units. Each of these units comprises two combustion chambers, each with its own turbopump propellant feed system. In addition, 6 single-chamber units will be provided for ground testing: three will be used by Convair and three will go to NASA's Lewis Research Center for testing at simulated altitude conditions, prior to commencement of the Centaur flight program at AMR. In addition, Pratt and Whitney will provide field personnel services to assist Convair in its static tests of the second stage at Sycamore Canyon.

The Convair-Astronautics Division, General Dynamics Corporation, is under contract for the design, development testing, and manufacture of six Centaur second stages, utilizing the Pratt and Whitney propulsion unit as Government-furnished equipment.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Development and procurement of second stage:			
Development guidance, controls and stabilization system... (9 units).....	---	$8,600,000	$4,400,000
Fabrication of six (6) guidance sets.....	---	600,000	2,400,000
Development of second-stage tankage.....	---	9,200,000	6,100,000
Fabrication of six (6) second-stage tanks..	---	1,600,000	3,200,000
Point Loma structural and propellant handling.....	---	---	4,300,000
Sycamore Canyon static firings.....	---	---	5,100,000
Development and procurement of second-stage engines:			
Development of turbopump assembly.....	---	6,500,000	2,200,000
Fabrication of 24 turbopumps.....	---	1,400,000	5,200,000
Development of thrust chambers.....	---	7,300,000	1,800,000
Fabrication of 24 thrust chambers.....	---	1,800,000	2,600,000
Field services at Sycamore Canyon.....	---	---	800,000
Field services at AMR.....	---	---	1,400,000
Total.....	21,000,000	$37,000,000	$39,500,000

Launching Operations

Services to launch the Centaur vehicle will be provided by contract with Convair, as follows:

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Checkout, booster.....	---	---	$100,000
Checkout, second stages.....	---	---	100,000
Launch, complete vehicles.....	---	---	800,000
Total.....	---	---	$1,000,000
		Total	*47,000,000

Launch Schedule
1961
June - Sept - Dec

1962
Feb - April - June
Aug - Dec
Mars & Venus

19

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

SATURN

Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
($19,325,020)1/	($55,182,980)1/	$134,308,000

1. OBJECTIVES:

To develop a multi-stage launching vehicle for various advanced space-flight missions.

2. JUSTIFICATION:

The Saturn program comprises a series of multi-stage launching vehicles of increasing payload capability for performing various space-flight missions. Minimum requirements for three important missions are: (1) to send large payloads to the moon and near planets; (2) to place several tons of payload in a 24-hour equatorial orbit; and (3) to place a manned spacecraft (such as Dynasoar) in an earth orbit. The first version of Saturn is designed to meet these requirements. Succeeding Saturn vehicles will have greatly increased capabilities for all three of the missions previously mentioned. The increased capability is to be obtained by using upper stages from the early versions as building blocks in the final vehicle, thus, minimizing the number of new stages that have to be developed. The Saturn's first stage is propelled by a cluster of eight ICBM-type engines which deliver a total thrust of one and one-half million pounds. The final version of Saturn will use up-rated engines giving a thrust of at least two million pounds. The first Saturn vehicle will be a three-stage rocket; the final version may have five stages. Launching of the first Saturn booster with dummy upper stages is scheduled for the latter half of 1961.

The Saturn project was initiated on August 15, 1958, by an order from the Advanced Research Project Agency to the Army Ordnance Missile Command. The project was funded in the

1/ Funded by the Department of Defense.

Saturn

fiscal years 1959 and 1960 by ARPA. The President of the United Stated, on November 2, 1959, announced his intention to transfer the Saturn project to NASA. In anticipation of the transfer, NASA and the Department of Defense have established an interim working agreement that provides for immediate assumption by NASA of the responsibilities for the technical management of the Saturn vehicle development.

3. **PROGRAM PHASING:**

During the fiscal year 1959 the design of the first-stage booster and the design of tooling for the first-stage clustered tanks were initiated.

During the fiscal year 1960 the design and development of the first-stage booster was undertaken. Construction of prototype tankage proceeded, and individual engines were delivered for test. A captive firing of the eight engine cluster is scheduled for the latter half of fiscal year 1960. Contracts for upper stage engines and vehicles will have been let before the end of fiscal year 1960.

The fiscal year 1961 funds will provide for the continued development, construction, and testing of the first-stage booster tanks and engines. In addition, design and development of upper stages, initiated in the fiscal year 1960, will be continued. Part of the fiscal year 1961 funds will provide for the development of vehicle-borne guidance, controls and instrumentation, and the development of ground-service equipment.

4. **PROGRAM COSTS:**

	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Flight research program:			
Development and fabrication of first-stage boosters	---	---	$57,500,000
Development and fabrication of upper stages	---	---	42,300,000
Guidance, controls, and instrumentation	---	---	12,800,000
Ground-service equipment	---	---	9,708,000
Direct material	---	---	12,000,000
Total	($19,325,020)1/	($55,182,980)1/	$134,308,000

1/ Funded by the Department of Defense.

SUMMARY OF FY 1961 SATURN BUDGET
(in millions)

	ORIGINAL		ADDITION	REVISED
S & E	$ 34.316		$ 3.200	$ 37.516
C&E	13.000		33.500	46.500
R&D (support of plant)	11.676		--	11.676
R&D (contracts)	81.008		53.300	134.308
TOTALS	$ 140.000		$ 90.000	$ 230.000
		F-1	15.000	
		200K	8.000	
			$ 113.000	

4 Saturn vehicles FY 61

(3 completed - 1 started)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

SATURN

Objectives

This program, which has been assigned the highest national priority, is designed to provide a multi-stage vehicle of high payload carrying capability coupled with a substantial growth potential. The mission objectives of the early version Saturn are as follows:

1. To send large payloads to the moon and near planets.

2. To place several tons of payload in a 24-hour equatorial orbit.

3. To place a manned spacecraft in an earth orbit.

The requirement for developing a vehicle of the magnitude of Saturn is based upon the objective of flying much larger payload missions than can be handled by presently available vehicles.

Development of the Saturn vehicle is proceeding through an orderly schedule of ground and flight tests. Captive ground tests are scheduled in the fiscal year 1960; a development flight test program consisting of at least ten vehicles will start in the fiscal year 1961; and the first operational flight is planned for the first quarter of the fiscal year 1964. Technical direction of this program is at the NASA Huntsville Facility.

Development and Fabrication of First-Stage Boosters

By the beginning of the fiscal year 1961, the final assembly of the first Saturn flight test vehicle (SA-1) will have been started. The initial nonflyable booster (SA-T) will have completed its first firing test at Huntsville.

During the fiscal year 1961, delivery of SA-1 to the Atlantic Missile Range for flight testing is scheduled. Final assembly operations on vehicles SA-2 and SA-3 are also planned to commence in the fiscal year 1961. Fabrication of basic structural components for SA-4, the first Saturn vehicle to carry a live upper stage, is to be started.

As evidenced in the cost breakdowns, emphasis is to be heavily placed on extensive development engineering tests, on both the H-1 rocket engine by the contractor and on the vehicle itself at Huntsville. A stepped-up program of reliability testing on Saturn components, systems, and ground equipment is considered mandatory. Cost breakdowns are shown for estimated 1961 requirements only; fiscal year 1959 and 1960 requirements were funded by the Department of Defense.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Booster tankage and structure: Provides propellant supply and structural integrity to support upper stages during boost phase through the atmosphere; items listed are for use in the structural fabrication and assembly of Saturn booster stages and for qualification tests of components for four vehicles:			
Bulkheads, rings, stiffeners, skins	---	---	$825,000
Lower shrouding	---	---	458,000
Upper shrouding	---	---	687,000
Propellant feed, vent, and pressurization systems	---	---	3,446,000
Electrical components	---	---	527,000
High-pressure spheres	---	---	298,000
Switches and valve systems	---	---	458,000
Recovery equipment	---	---	435,000
Miscellaneous items	---	---	166,000
	---	---	7,300,000

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Development engineering: Analysis, design, redesign, prototype fabrication, and developmental testing of stage I components and systems. This effort is to assure that the Saturn vehicle will demonstrate high reliability in its accelerated flight program; procurement of contractor engineering, development, and testing services includes:			
Recovery system for booster.....	---	---	$400,000
Flow system, valving and pressurization.....	---	---	4,600,000
Structural design and analysis.....	---	---	2,700,000
Testing of Saturn components.....	---	---	4,500,000
Aeroballistic studies and trajectory work...	---	---	1,600,000
Fabrication processes.....	---	---	800,000
Development of prototype hardware.....	---	---	3,300,000
	---	---	17,900,000
H-1 rocket engine procurement: For procurement of flight engines, test and spare engines, spare components, modification kits, field service by Rocketdyne for four (4) vehicles; includes long lead time items on later vehicle engines:			
Forty (40) rocket engines at $175,000 each..	---	---	7,000,000
Four (4) spare engines.....	---	---	700,000
Eight (8) test engines.....	---	---	1,400,000
Support parts.....	---	---	3,600,000
Engineering change orders.....	---	---	900,000
Handbooks.....	---	---	150,000
Field service activity.....	---	---	250,000
	---	---	14,000,000

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
H-1 rocket engine development: Engine and component test program to improve reliability and performance:			
Engineering and testing.....	---	---	$5,075,000
Research and development hardware.....	---	---	2,700,000
Materials.....	---	---	600,000
Contractor travel and subsistance.....	---	---	250,000
Test equipment.....	---	---	175,000
	---	---	8,800,000
Propellants: Hydrocarbon fuel and liquid oxygen for all firing tests at Huntsville and at Rocketdyne.....	---	---	LOX 1¢ 2¢ 2,000,000
Reliability: Extensive component and systems testing including life and environmental tests with the aim of increasing booster reliability; to procure flight-type components in large enough samples to obtain a substantial degree of validity in the statistical analysis of the results of these tests:			
Engine systems components.....	---	---	1,000,000
Valves, switches, connectors, etc.....	---	---	1,500,000
Control equipment.....	---	---	1,000,000
Measuring equipment.....	---	---	250,000
Electrical equipment.....	---	---	750,000
Ground-service equipment.....	---	---	500,000
	---	---	5,000,000

Advanced Area R&D for Booster Tankage and Structure - - $2,500,000

Four specific studies considered mandatory are:

1. Experimental shock, accoustical, and vibration environment effect on vehicle.

   Side-note: Nothing is known of the accoustical power level in the proximity of eight large rocket engines, and its effect on vehicle components.

2. Development of **reliable** fire detection and sector extinguishing equipment.

   Side-note: The one-engine-out capability hangs very much on work in this area. Mention of the effect of inadvertent engine shut-down because of unreliable sensors should suffice.

3. Investigation of base-heating in the complex aerodynamic turbulent region at the rear of the booster.

   Side-note: Polaris (four **nozzles**) has suffered from this problem. An early Jupiter was lost because of base-heating.

4. Investigation of the effect of von Karman alternate vortex shedding on the vehicles; development of suppression means if necessary.

   Side-note: von Karman forces can destroy the unsupported vehicle on the stand if aerodynamic and structural resonance occurs. Vanguard required rubber-strip spoilers on the second stage to suppress vortex effects; the Saturn susceptability is unknown.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Advanced area research and development: For work on special problems associated with booster development; examples of such areas include: effects and possible suppression of sloshing; dynamics of elastic missiles; joining techniques for large tanks; special stress and buckling problems; and behavior of material and components at low temperatures.....	---	---	$2,500,000
Total.....	---	---	$57,500,000

Development and Fabrication of Upper Stages

Under a contract to be let prior to the close of the fiscal year 1960, the development of the new hydrogen-fueled upper stage (designated S-IV) will be undertaken. It is planned to use this stage, which will incorporate four up-rated Centaur rocket engines, in the two-stage Saturn test vehicles SA-4, 5, and 6.

A comprehensive engineering modification program is to be conducted in the fiscal year 1961 for the purpose of adapting the Centaur vehicle as third and top stage of the Saturn. This stage is designated S-V and is scheduled for incorporation into vehicle SA-7 and later vehicles.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
S-IV stage: 220 inch diameter; four uprated Centaur engines; to be the second stage of Saturn:			
Engine research and development for uprating from 15,000 to 20,000 pounds thrust.....	---	---	$8,100,000
Engines delivered to stage contractor (16 each at $250,000).....	---	---	4,000,000
Engines for test (5 each at $250,000).....	---	---	1,250,000
Propellants (liquid hydrogen and liquid oxygen) for testing.....	---	---	1,000,000
Stage research and development (less engines).....	---	---	17,650,000
Delivered stage for Saturn vehicle SA-4 ($2,500,000) and partial payment for stage for SA-5 ($1,250,000).....	---	---	3,750,000
Special stage ground-servicing equipment...	---	---	700,000
	---	---	36,450,000
S-V stage: An adaptation of the present Centaur vehicle; to be the third stage of the Saturn.....	---	---	5,850,000
Total.....	---	---	$42,300,000

Guidance, Control, and Instrumentation

Systems development and the procurement of components for the guidance and control systems, vehicle measuring instruments, and telemetry and radio tracking equipment has been scheduled to keep pace with the vehicle fabrication and test program. Requirements are summarized as follows:

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Guidance and control hardware: Procurement from various manufacturers, four sets of control, radio tracking and command, measuring, and telemetry systems:			
Guidance and control equipment.....	---	---	$2,400,000
Telemetry system.....	---	---	620,000
Tracking and range safety.....	---	---	428,000
Measuring system.....	---	---	2,332,000
Spare units and tests.....	---	---	1,120,000
	---	---	6,900,000
Systems development: Including design, prototype fabrication, and testing:			
Guidance and control equipment.....	---	---	2,400,000
Telemetry system.....	---	---	750,000
End organs.....	---	---	400,000
Radio tracking system.....	---	---	450,000
	---	---	4,000,000
Special instrumentation: Instrumentation for development and qualifications testing of components and subsystems, recorders, transducers, and automatic data reduction systems.	---	---	1,900,000
Total.....	---	---	$12,800,000

Ground-Service Equipment

The size of the Saturn booster has dictated that new approaches be adapted in transportation and handling techniques. Many new items will be required for the propellant loading systems which must accurately deliver several times the propellants required for current missile boosters. A large number of booster pneumatic, hydraulic, and electrical check-out panels are required. The combined vehicle systems check out must be completely thorough and yield accurate records. The magnitude and complexity of the engineering task in these areas are enormous. For example, up to 530 separate telemetry channels are being provided in the Saturn booster. The work load involved in checking out and calibrating such a large number of information channels is such as to dictate the use of fully automatic equipment.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Development engineering: To improve equipment compatibility and reliability.....	---	---	$2,500,000
Procurement: To implement contractual procurement of equipment to support initial build-up of Saturn launch facility and to support subsequent firings; to support handling and transportation of stages 1 and 2:			
Liquid oxygen vacuum jacketed tanks.....	---	---	440,000
Launching hold-down and support arms.....	---	---	400,000
Umbilical tower.....	---	---	300,000
Two sets of firing accessories.....	---	---	700,000
Two transport barges.....	---	---	760,000
Installation of ground-service equipment at AMR.....	---	---	800,000
Miscellaneous handling and alignment equipment.....	---	---	400,000

Advanced Area R&D for Ground Support Equipment - - - $1,108,000

Two specific studies considered mandatory are:

1. Development of automatic propellant loading systems.

   Side-note: The simultaneous loading and topping of cryogenic propellants, and particularly hydrogen into a vehicle of up to four stages will be very difficult. Automatic equipment is a must. Improper loading severely diminishes stage effective mass-ratio.

2. Rapid vehicle systems digital check-out equipment development.

   Side-note: The vehicle check-out method must be performed rapidly for all sub-systems, systems, and finally the integrated vehicle itself to limit check-out time to a reasonable duration.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Vehicle systems check-out equipment, recorders, pneumatic panels, data processing system.....	---	---	$1,700,000
Vehicle transport assembly fixtures (3 at $200,000 each).....	---	---	600,000
	---	---	6,100,000
Advanced area research and development: For work on special problems associated with ground-service equipment development in such areas as quick data handling systems for check-out procedures, propellant transfer and loading systems, ground control systems, etc.....	---	---	1,108,000
Total.....	---	---	$9,708,000

Direct Materials

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
To obtain materials to fabricate tooling, integrate ground-support equipment, and produce boosters; included are such items as sheet metal, rivets, bolts, couplings, hand tools and transducers.....	---	---	$12,000,000
		Total	$134,309,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

TRACKING AND DATA ACQUISITION

Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
$3,095,674	$16,266,000	$32,550,000

1. OBJECTIVES:

To operate tracking and data acquisition facilities necessary to support the overall NASA space flight program; to provide tracking and data acquisition support for space flight operations upon request by other government agencies; and to provide for research and development on improved tracking and data acquisition systems and equipment. Major technical objectives included in fiscal year 1961 program are:

(a) Improvement of the overall accuracy and efficiency of existing NASA tracking stations.

(b) Development of a prototype electronic tracking system of inherently greater precision than any present system.

(c) Development of communications techniques for spacecraft at planetary distances.

(d) Speed-up of data handling to reduce time lag between the experiment and the conclusions.

(e) Development of special trajectory measuring techniques and systems for complex payloads.

2. JUSTIFICATION:

In all cases of space flight operations, whether a scientific satellite, a space probe, a sounding rocket, or a manned vehicle, there is a need for tracking units capable of delivering orbital data or position time histories, and a need for telemeter receivers for data acquisition. These devices must be properly coordinated by communications links to permit the data to be transmitted to a suitable computing center, where it may be rapidly reduced to a form in which it can be studied and analyzed by the scientists. The data represents the raw material from which the scientific experimenters will gain their new knowledge of space. The quantity and quality of this raw material will determine the progress made in space research.

While the NASA network of stations is designed to afford the maximum amount of operational flexibility, there are special conditions associated with each test which may require equipment modifications, or in certain cases, the temporary installation of new items of equipment at new tracking locations.

In order to minimize the requirements for new stations, or to compensate for temporary deficiencies, the NASA proposes to provide support to cooperating non-NASA stations which are suitably equipped to perform a useful function for the purposes of a particular experiment.

ADVANCED TECHNICAL DEVELOPMENT

Tracking and data acquisition systems development: A continuing effort must be maintained to advance the state of the art in tracking systems and methods, in data reduction and analysis techniques, and in methods of telemetry and data transmission. Specific areas of basic research include theoretical studies and experimental verifications of the effects of propagation delays on various transmissions of time signals since accurate time measurement to within a fraction of a second is necessary in refined calculations of orbits; theoretical and applied research in low noise pre-amplifiers to improve reception of faint radio signals; theoretical studies and analysis of improved orbital computation methods; and studies into techniques for communicating with space vehicles at planetary distances.

In addition, development of refinements in the measuring capabilities of present minitrack systems is contemplated to meet more exacting requirements. Included are the development

of such items as a rubidium-vapor, frequency-standard equipment to improve calibration accuracy; precision propagation delay measurement equipment; on-site data reduction systems; and prototype calibration equipment to calibrate tracking systems.

The development of new types of tracking and data acquisition equipment is proposed which will have more accuracy than present systems. This work will include new antenna systems and receivers to operate at higher frequencies (2000 mc); transmitters for range determination; self-tracking systems for directional antennas; and payload beacons for use in conjunction with the ground systems.

Computer support programs: Studies will be undertaken to determine the best modulation technique for data acquisition and for the adaptability of the data received to computer programs for reducing the data. Consultative services will be used in this research effort.

Data systems development: Work will be continued in this area to foster the development of automatic data reduction techniques as well as to improve the data reduction on data now being received from telemetry systems operating in satellites in orbit.

Optical systems development: It is proposed to improve the present capability in this basic method of tracking especially for geodetic programs. Improvements are necessary in the timing system and in the methods of reducing data from photographic film accurately and rapidly. Electronic-optical techniques will be investigated to marry the advantages of electronics and optics into an improved system for tracking optically. Other work will include star cataloging, application of optical tracking to lunar or deep space vehicles, exploration of possible uses of optical telemetry, improvements in image converters and photo-detectors, and the use of light reflectors on payloads.

Mercury tracking net techniques: The Mercury tracking net will undergo continuing refinement and improvement to insure maximum effectiveness and reliability. Work will continue on data error analysis, telemetry systems, tracking techniques, and communications as applied to manned space flight. The use of contract consultants are relied on heavily in this work.

Development of high gain antennas: Many long range problems are involved in developing equipment to meet the requirements of communicating with vehicles at distances of millions of miles. While payload power is expected to increase, it will still be necessary to improve the antennas and receivers on the ground. In this connection it will be necessary to do considerable

research and development to design and develop techniques and systems to economically improve upon present large antenna systems to receive relatively faint signals.

Trajectory measurement and command equipment: Special types of equipment are needed for vehicles whose controlled trajectory go well beyond the range of established launching ranges. The type of equipment required will depend on the characteristics of the payload, and what command control functions are involved. Certain vehicles will have capability for stopping and starting powered flight in last engine stages. To control the operation of such stages at remote locations will require development of special trajectory measurement and command control equipment.

FLIGHT RESEARCH PROGRAM

Operation of satellite ("Minitrack") stations: During the fiscal year 1961 there will be fourteen Minitrack operating stations, including four new ones being installed during the fiscal year 1960. These stations employ radio interferometers and are used primarily for tracking satellites which send out radio signals, where precise real-time data is not required. They have all weather capability. They cannot track passive satellites (ones which do not emit signals) nor can they provide the precise orbit data available from optical systems. They have the advantage of being able to detect the angular direction of a satellite with respect to the station without prior information as to precisely where to look. These stations must be located in areas free of extraneous electrical disturbances. From a number of observations from different stations, a reasonable orbital determination can be made.

Each Minitrack station receives and records telemetry data on magnetic tape. Data from these stations are fed to a central control, communications, and computing center at the Goddard Center. Automatic data read-out equipment is being provided to speed up data collection and to permit tracking a greater number of satellites.

The operational cost of three Microlock stations is included in the 1961 estimates. These stations will be managed by the technical personnel that manage the Minitrack stations. The Microlock stations may eventually be integrated into the Minitrack net at common locations with the Minitrack stations.

Operation of optical tracking stations: The existing twelve Baker-Nunn optical stations will continue in operation during the fiscal years 1960 and 1961 under the technical and administrative direction of the Smithsonian Astrophysical Observatory.

The optical stations can photograph relatively faint space objects (satellites) against star backgrounds to provide a precise determination of the angular position of the object. Observations can only be made when the visibility is good and by virtue of sunlight reflected from the object. Therefore, observations can only be made in periods of clear twilight. Moreover, the camera can only see a small segment of the sky at a time, and it must have a prior knowledge of where to look or the satellite will pass out of range before the camera can search any appreciable segment of the sky. Information on where to look is usually obtained from Minitrack or similar electronic systems which do not have the acquisition limitations of optical systems.

It is theoretically possible from three or more optical observations to obtain the most precise orbital data of any technique known. For certain geophysical experiments, such as in geodetic and air drag experiments, the maximum precision of optical techniques is necessary. The optical stations must be located at sites where the weather conditions are such that good visibility generally prevails. This site limitation is not necessarily compatible with the site locations of electronic systems, which have other criteria governing their best location.

Included in the cost of operating the optical stations is the cost of data transmission, data reduction, and data interpretation which is performed by the Smithsonian Astrophysical Observatory at Cambridge, Massachusetts. Funds are included for the cost of the Moonwatch teams which are volunteer groups assisting the Smithsonian Astrophysical Observatory in securing observations of satellites at different places in the world, using simple telescope equipment. The compensation to the Moonwatch teams merely defrays expenses for materials and for certain items of equipment. There is no compensation for the volunteer services as such.

Operation of the deep space network: During the fiscal year 1961 it is expected that three stations will be operational. The JPL station at Goldstone, California is currently operational; the Woomera, Australia station will be added during the fiscal year 1960; and the South Africa station will be completed during the fiscal year 1961.

The deep space stations are used primarily for tracking and data acquisition from vehicles penetrating deep into space, such as lunar probes. They may also be adapted for gathering larger amounts of data, such as may be involved in the transmission of TV pictures from space vehicles. They are not suitable for satellites in low orbits because of the low tracking rates of the antennas. They have great sensitivity, however, to very faint signals which cannot be detected by ordinary electronic systems. They also are being equipped to be capable of trans-

mitting signals to space vehicles at great distances for the purpose of issuing commands to the vehicle. The transmitters will also be able to be used for communications satellite experiments.

Funds are included under this heading for the contractual services required in the operation of auxiliary portable trajectory tracking and command station equipment in the fiscal year 1961 to meet operational requirements involved in trajectory measurement and guidance functions on deep space probes.

Operation of Mercury net stations: A total of about 18 stations are included in the Mercury network of stations, including the control center and the communications and computing center. The operation of these stations and the recovery operations will be a joint effort involving the Department of Defense, foreign countries, and NASA. The communications system will primarily utilize leased commercial lines and military circuits.

Operation of non-NASA stations: The NASA will make use on a part-time basis of a number of cooperating non-NASA stations which provide tracking capability. Examples are the facilities at Jodrell Bank, England, and at Fort Churchill, Canada. The extent of the NASA use of these facilities is arrived at by mutual agreements based on the duration and complexity of the particular experiments. In certain cases the NASA may provide funds for special items of equipment needed to accomplish particular experiments.

Operations at AMR and PMR stations: All NASA sounding rockets, satellites, or space probes will be launched during the fiscal years 1960 and 1961 from either the NASA Wallops Station, the Canadian station at Fort Churchill, or the Department of Defense AMR or PMR stations. The majority of the launchings will take place at the AMR station. Reimbursable items of cost for use of the AMR and PMR stations will include utilities for NASA offices and operations and special items of equipment related specifically to NASA experiments in specific missions.

Other operational costs: A portion of the funds requested under this program will be used to procure services involved in the transmission of the data acquired at Wallops to the appropriate communications center and for data reduction services under contract. As the computer capabilities of the Goddard Center increase, the contract costs for data reduction services will decrease.

The NASA will have over 40 tracking stations in operation, including the Mercury stations, in the fiscal year 1961. An estimate of approximately ten percent of the overall operating costs of the stations has been added to provide adequate funds for maintenance and repair, provisioning of spares and logistic materials such as tapes, and various paper materials.

3. PROGRAM COSTS:	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Advanced technical development:			
Tracking and data acquisition systems development	---	$850,000	$2,670,000
Computer support programs	---	160,000	200,000
Data systems development	---	330,000	900,000
Optical systems development	---	50,000	900,000
Mercury tracking net techniques	$507,674	500,000	500,000
Development of high gain antennas	348,000	175,000	1,000,000
Trajectory measurement and command equipment	---	1,275,000	1,050,000
Total	855,674	3,340,000	7,220,000
Flight research program:			
Operation of satellite stations:			
Operation of Minitrack and Microlock stations	1,250,000	3,000,000	4,750,000
Data transmission	200,000	500,000	850,000
Total	1,450,000	3,500,000	5,600,000
Operation of optical tracking stations:			
Operation of Baker-Nunn stations	410,000	1,450,000	1,950,000
Moonwatch teams	50,000	250,000	250,000
Data transmission and reduction	150,000	800,000	1,300,000
Total	610,000	2,500,000	3,500,000

	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Operation of deep space stations:			
Operation of Goldstone station.....	---	$1,400,000	$1,250,000
Operation of Woomera station.....	---	---	850,000
Operation of South Africa station.....	---	---	600,000
Trajectory equipment operation.....	---	---	400,000
Data transmission.....	---	---	400,000
Total.....	---	1,400,000	3,500,000
Operation of Mercury net stations:			
Operation of Mercury stations.....	---	1/	1/
Data transmission.....	---	1,000,000	5,450,000
Total.....	---	1,000,000	5,450,000
Operation of non-NASA stations:			
Jodrell Bank, England.....	$180,000	200,000	300,000
Fort Churchill, Canada.....	---	650,000	700,000
All other.....	---	50,000	400,000
Total.....	180,000	900,000	1,400,000
Operations at AMR and PMR stations:			
AMR operations.....	---	426,000	1,500,000
PMR operations.....	---	200,000	600,000
Total.....	---	626,000	2,100,000
Other operational costs:			
Wallops Station data transmission.....	---	200,000	350,000
Data reduction services.....	---	2,250,000	800,000

1/ Funding included under "Manned space flight" program.

	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Network Maintenance and repairs.....	---	$250,000	$1,800,000
Network spares and materials.....	---	300,000	830,000
Total.....	---	3,000,000	3,780,000
TOTAL.....	$3,095,674	$16,266,000	$32,550,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1961 ESTIMATES

TRACKING AND DATA ACQUISITION

Tracking and Data Acquisition Systems Development

The development of space tracking and communications systems progresses only as the state-of-the-art is extended. The ground facilities and systems which were developed during the IGY specifically for relatively low altitude and simple satellites, are still in use during the fiscal years 1959 and 1960. Plans are presently crystalizing for more complex satellites and for deep-space exploration vehicles which will be required to communicate back to an earth base over extreme distances. The increased level of effort in the advanced technical development area reflected in the fiscal year 1961 budget will insure that certain basic studies are made and that the development of advanced systems and equipments will meet the requirements of these vehicles.

Tracking systems, basic research, and development: Work started during the fiscal year 1960 will continue at an accelerated pace in the fiscal year 1961. The calibration system studies are directed towards developing more precise and simpler calibration methods for the radio interferometer "Minitrack" system. These studies have a two-fold purpose: first, to provide a greater understanding of the various factors which can distort the field of an interferometer system; and second, to do the basic work necessary to develop procedures for the application of machine methods to a major portion of the calibration process. For example, NASA has supported the punching of star catalogs on IBM cards, making them available in more useable form for research programs and for calibrating tracking systems. The development of low noise receiver pre-amplifiers will be carried on in the fiscal year 1961 at an accelerated rate. Reduction of the noise level in this portion of the receiving circuit will materially increase the range and data handling capacity of existing communications systems. In order to improve the time tie-in between the tracking stations scattered around the globe, a basic research effort will be initiated in the fiscal year 1961 aimed at more precise determination of the various elements involved in propagation delays and to point the way towards possible improvements in timing accuracy. Theoretical analyses

of orbit computation methods will be undertaken to determine the ultimate precision of the various tracking systems.

Tracking and data acquisition systems development: The major portion of these funds in the fiscal year 1960 provide for the design, prototype construction, and testing of components for converting the radio tracking systems to the newly assigned 136-137 mc. band. Items covered here include the development of tracking antennas and receivers, telemetry antennas and receivers, as well as over-all telemetry system studies. Timing system development in the fiscal year 1960 consisted primarily of the redesign of the basic time standards for use with the new 136 mc system and the development of a system for furnishing time signals in a form compatible with computer operation. In the fiscal year 1961, efforts will continue on the program started in the fiscal year 1960. In addition, contracts will support the development of rubidium vapor frequency standards or equivalent for timing use at selected field stations. Although VLF (very low frequency) transmissions may be the eventual answer as far as consistency of propagation delays is concerned, the actual time delay itself must be measured. The cost of station calibration and of calibration equipment development will increase somewhat due to the addition of new Minitrack stations and the addition of greater coverage of the existing stations. Data system development in the fiscal year 1960 represents the necessary redesign of the measurement portion of the Minitrack system required by the new frequency assignment and the development of a completely automatized data readout system. Prototypes of the data readout systems have been produced and are undergoing field evaluation at the station at Blossom Point, Maryland. The major area of data systems development in the fiscal year 1961 will be a readout system for the precision interferometer tracker.

Precision interferometer development: A major effort during the fiscal year 1961 will be the development of a precision interferometer Minitrack system to be operated in the 2000 mc range. The shorter wavelengths of a higher frequency are equivalent to a more finely divided scale, and make possible more precise radio tracking. In addition to the improved angular tracking accuracy, the system will be capable of relatively wide bandwidth operation which can be utilized to give higher data acquisition rates. A medium-sized parobolic antenna for ambiguity

resolution and data acquisition is funded separately as a construction item. For some satellite tracking requirements the measurement of range is almost mandatory. Prototype development of a compatible ranging system and the required airborne beacon is contemplated. The system will be developed so that ranging can be omitted by the experimenters if not required or if payload weight is at a premium.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Tracking systems, basic research and development:			
Calibration and system studies.....	---	$50,000	$250,000
Antenna studies.....	---	25,000	---
Low-noise pre-amplifiers.....	---	25,000	100,000
Ionosphere studies.....	---	50,000	50,000
Propagation studies related to timing..	---	---	100,000
Theoretical analysis, orbit computation methods.....	---	---	150,000
	---	150,000	650,000
Tracking and data acquisition systems development:			
Timing systems development.....	---	75,000	200,000
Calibration systems development.....	---	100,000	150,000
Data system improvement development....	---	75,000	190,000
136 mc Minitrack antenna development...	---	100,000	---
136 mc receiver development.....	---	70,000	---
Telemetry systems studies.....	---	100,000	---
Telemetry antenna development.....	---	75,000	---
Telemetry receiver development.....	---	105,000	---
	---	700,000	540,000

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Precision interferometer development:			
Interferometer antenna development.....	---	---	$510,000
Receiver development, prototype construction.....	---	---	250,000
Antenna feeds, self-tracking equipment...	---	---	200,000
Ranging system, prototype development....	---	---	220,000
Airborne beacon, prototype development...	---	---	100,000
Special test systems development.....	---	---	200,000
	---	---	1,480,000
Total.....	---	$850,000	$2,670,000

Computer Support Programs

Funds are required to undertake studies directed toward determining modulation and data recording formats most adaptable to computer operations in data reduction.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Computer operations studies.....	---	$160,000	$200,000

Telemetry Data Systems Development

Work will be continued and expanded in this area, fostering the development of automatic techniques for data recording and reduction and the development of improved, more nearly standardized telemetry systems. The telemetry studies will be expanded in the fiscal year 1961 and aimed at obtaining basic design information for the development of one or more optimized telemetry systems. A prime requirement of these systems will be compatibility with automatic data reduction

processes and high data handling capacity. Component development will be accelerated during the fiscal year 1961, extending the state-of-the-art to provide more reliable and efficient "hardware".

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Studies of telemetry and data reduction techniques	---	$130,000	$300,000
Component development and improvement	---	150,000	300,000
Prototype systems development	---	50,000	300,000
Total	---	$330,000	$900,000

Optical Systems Development

The development of optical systems will be carried out primarily under the direction of the Goddard Center. The program will include basic and applied research in optical systems and the development of prototype optical tracking systems. A basic research program will be initiated with particular emphasis on means for electronic detection of optical images. The use of optical principles in telemetry will be studied; this will include monitoring efforts sponsored by DOD activities. The prototype portable optical tracking station required by the flashing light geodetic satellite will be designed.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Studies of optical techniques	---	$15,000	$300,000
Development of optical components	---	15,000	300,000
Prototype systems development	---	20,000	300,000
Total	---	$50,000	$900,000

Mercury Tracking Net Techniques

Work in this area is accomplished by means of a task-type contract with the Lincoln Laboratory of MIT supporting the research and development aspects of the project Mercury tracking, communications, and data acquisition network. The Lincoln Laboratory works in conjunction with the ground facilities group of the Langley Research Center, providing consulting services and investigations of technical problems affecting the over-all performance and success of project Mercury. Specific items covered include:

Evaluation and consulting on the design of communications systems.
Formulation of a detailed ground communications plan.
Studies of high-frequency radio propagation as related to reliability of communication with the capsule.
Study of computer capabilities and requirements.
Evaluation of telemetry systems.
Evaluation of radar skin tracking.
Design and evaluation of radar acquisition devices.
Consultive services on simulation techniques.

This work is extremely valuable in providing highly qualified technical services to study specific problems in greater detail than time would otherwise allow. It has resulted in considerable cost savings by pinpointing, in advance of equipment construction, probable weak points of communications and other systems.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Technical monitoring and the development of ground station equipment and techniques....	$507,674	$500,000	$500,000

Development of High Gain Antennas

The ability of a lunar or planetary probe to communicate information back to the Earth is directly related to the over-all gain or effective area of the ground based receiving antenna. The existing 85-foot diameter automatic tracking antennas, such as the two installed at the NASA Goldstone facility are adequate for many purposes. However, even a cursory study of the problems in-

volved in transmitting large amounts of data from distances of millions of miles indicates that many component advancements are necessary, including an increase in effective antenna area. The fiscal year 1959 funds were used by the JPL at the Goldstone site to develop special antenna feeds, improved receiving equipment, and a special coordinate converter to remove parallax caused by the required separation of the 85-foot transmitting and receiving antennas. In the fiscal year 1960, research is being initiated to create antenna gains much greater than those currently available at an economical price. These fundamental studies will be continued at about the same pace during the fiscal year 1961. However, enough information will be on hand by that time to make it practical to undertake systems studies, model antenna construction, and test of the more promising systems. It is anticipated that this work will progress far enough to make it practical to let a contract for preliminary design work on a full scale large aperture antenna. At about the same time, preliminary design studies will be initiated on the multiple or wide-band feed systems for this antenna. Siting studies will be conducted during this period.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Feed systems design and development.....	$70,000	---	---
Coordinate converter.....	200,000	---	---
Receiver improvements.....	78,000	---	---
Fundamental antenna research.....	---	$175,000	$175,000
System studies of large aperture antenna.....	---	---	125,000
Model antenna construction.....	---	---	200,000
Preliminary design of large aperture antenna.	---	---	300,000
Preliminary feed system design.....	---	---	150,000
Preliminary siting studies.....	---	---	50,000
Total.....	$348,000	$175,000	$1,000,000

Trajectory Measurement and Command Equipment Development

Special types of tracking, telemetry recording, and command equipment are required for vehicles whose controlled trajectories go well beyond the range of established launch facility instrumentation. The type of equipment required depends, to a great extent, on the characteristics of the payload and what command and control functions are involved. Certain vehicles will be capable of

stopping and restarting powered flight with the last engine stages. To monitor and control the operation of such stages at remote locations will require the development of special transportable trajectory measurement and command control equipment. The fiscal year 1960 funds under this item were allocated to the Jet Propulsion Laboratory to determine the requirements and initiate prototype development and construction. The equipment developed with the fiscal year 1960 funding will be used for operations with the Agena B, and will also provide initial vehicle acquisition data for the deep space stations. As the design and operational concepts for the Centaur, Saturn and other advanced vehicles become better defined, the requirements for such ground facilities will have to be re-evaluated. The fiscal year 1961 funding will finance such continued studies and also the design and prototype construction of the equipment specifically aimed at the Centaur requirements.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Requirement studies and theoretical analysis.	---	$200,000	$200,000
Antenna and servo development.....	---	230,000	200,000
Ranging system, prototype development.....	---	300,000	180,000
Command transmitter and feeds.....	---	180,000	200,000
Test calibration systems development.....	---	90,000	20,000
System checkout and modification.....	---	120,000	120,000
Preliminary site requirements studies.....	---	55,000	30,000
Telemetry receiving equipment.....	---	100,000	100,000
Total.....	---	$1,275,000	$1,050,000

Operation of Satellite Stations

Operation of Minitrack and Microlock stations: The Minitrack stations were originally set up during the IGY to track the Vanguard satellites. These contractor operated stations employ radio interferometers and are used primarily for tracking satellites which send out radio signals. By the fiscal year 1961, there will be 14 Minitrack stations in operation, including four new ones being installed during the fiscal year 1960. The three Microlock stations use a doppler technique to measure radial velocity of launch vehicles. To date, they have primarily

been used for measuring the operation of the final stage of the launching vehicle. By using triangulation techniques, actual trajectory can be obtained to give "quick look" injection data. During the fiscal year 1959 and most of the fiscal year 1960 these stations were operated by the Army Signal Corps and the Army Ballistic Missile Agency. Direction of the operation of the three portable Microlock stations will be taken over by the Goddard Space Flight Center during the fiscal year 1960. Full year operating costs are included in the fiscal year 1961 estimates.

The majority of the cost during the three years indicated is for the operation of the Minitrack network. It will be noted that the operating costs in the fiscal year 1960 are greater than they were in the fiscal year 1959 when approximately the same number of stations were existent. This is due to having added logistic support in the fiscal year 1960, and also to the fact that for a good portion of the fiscal year 1959 our stations were still being operated by Army personnel under a separate funding arrangement as part of Project Vanguard. The fiscal year 1960 estimates include delivery of the equipment associated with the change-over to the new 136-megacycle tracking frequency. The operating cost increase in the fiscal year 1961 is due to the larger number of stations, including new Minitrack stations and the three portable Microlock stations. The complexity of station equipment will also be greater. The fiscal year 1961 estimates include the first full year of contract operation of calibration aircraft for station calibration. A plane is tracked by the electronic system; the angular position readings are simultaneously checked by optical angular measurements to prove the accuracy of the electronic equipment. In addition, certain scientific experiments require special tracking and data acquisition support to meet unusual requirements of payloads. For instance, transportable telemetry receivers and recorders are required depending on the design of certain payloads. Similarly special command transmitters are also dependent on payload designs.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Operation of Minitrack stations.....	$250,000	$2,575,000	$3,500,000
Operation of Microlock stations.....	---	25,000	300,000
Station calibration services.....	---	150,000	700,000
Special tracking and data acquisition support	---	250,000	250,000
Total.....	$250,000	$3,000,000	$4,750,000

Data transmission: Data transmission costs increase during the three years indicated. During the fiscal year 1959, a portion of the data transmission was accomplished by using military circuits. In the fiscal year 1960, all Minitrack data transmission is being handled by leased teletype circuits which have operational capabilities of 60 to 100 words per minute. The network links the Minitrack stations (there will be 14 in the fiscal year 1961) to the NASA control center at Goddard and to the U. S. Missile Launching Ranges and other DOD facilities.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Minitrack and Microlock leased communication lines.....	$200,000	$500,000	$850,000

Operation of Optical Tracking Stations

Operation of Baker-Nunn stations: The existing twelve Baker-Nunn optical stations will continue in operation during the fiscal year 1961 under the technical direction of the Smithsonian Astrophysical Observatory at Cambridge, Massachusetts. These optical stations can photograph a satellite against a star background to provide a precise determination of its angular position. Observations can only be made when the visibility is good and while sunlight is being reflected from the object. Therefore, observations can only be made in periods of clear twilight. Since the cameras can only see a small segment of the sky at a time, information on where to look is usually obtained from Minitrack or similar electronic systems which do not have the acquisitional limitations of optical systems.

The cost of operating the optical stations is included in an annual grant to the Smithsonian Institution. During the fiscal year 1960, there were five observers instead of the former three at each station to allow a more normal work week and to place the station operation on a more permanent basis. With increasing satellite activity, an increase to six observers at each station is planned for the fiscal year 1961. A substantial increase in equipment costs

during the fiscal year 1961 will be required for the replacement or improvement of precision clocks at the optical stations.

Moonwatch teams: Moonwatch teams are volunteer groups that assist the Smithsonian Astrophysical Observatory in securing observations of satellites at different places in the world, using simple telescope equipment. The project was started as a part of the IGY program, and has been continued under the Smithsonian grant. Support covers only expenses for materials and items of equipment. Several new "apogee" sites are planned for initial operation in the fiscal years 1960 and 1961, and improved optical instruments will be provided to obtain better data on faint satellites.

Data transmission and reduction: The network data transmission and reduction costs cover the central operations at Cambridge, including the communications center for the optical stations and the Moonwatch teams, computations on a real-time basis for prediction information, photo-reduction, and advanced analysis. Computing services to make the data available in the proper form for scientific purposes are a major item in the cost. There is at present a significant backlog of film data which has not yet been analyzed. Reduction of this data requires additional personnel to extract from the large volume of individual satellite photographs the pertinent information on a satellite's position at a given time.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Operation of Baker-Nunn stations.....	$150,000	$1,450,000	$1,950,000
Moonwatch teams.....	50,000	250,000	250,000
Data transmission and reduction.....	410,000	800,000	1,300,000
Total.....	$610,000	$2,500,000	$3,500,000

Operation of Deep Space Stations

In the fiscal year 1959, operations at the Jet Propulsion Laboratory's Goldstone station were funded by the U. S. Army as part of their contract with the JPL. In the fiscal year 1960,

however, NASA is funding operation of the Goldstone station. The station is composed of a transmitting site and a receiving site seven miles apart. Major operations during the fiscal year 1960 concern the coming Echo (communication satellite) experiment, the deep space Thor-Able-4 and Pioneer launches, the Soviet probes, and the Explorer VI eccentric satellite. In addition, work is being done at Goldstone involving research on deep space communications such as parametric amplifiers, dish surface measurement, optical collimation, star tracking, radiometer sky measurements, and electrical isolation tests. Fiscal year 1960 operational costs for this station are high due to its isolation and lack of permanent technical and support facilities.

The NASA missions to be covered during the fiscal year 1961 include one deep space launch, two lunar orbiters, and an advanced lunar probe vehicle. Despite an accelerated research and development program during the fiscal year 1961, there will be a reduction in the operating costs of the Goldstone site if funds for the construction of permanent technical and support facilities being requested under the Construction and Equipment appropriation are approved.

Operational stations during the fiscal year 1961 will also include the Woomera, Australia site (tentatively operational in October 1960), the South Africa site (tentatively operational in January 1961), and a transportable initial trajectory tracking and data acquisition station. It is planned to let contracts for the operation of the Woomera, South Africa, and initial trajectory stations as construction is completed. Virtually all of the station personnel will be indigenous.

Data transmission lines will connect all the deep space stations to a centralized data and control center at the Jet Propulsion Laboratory.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Goldstone operation	---	$1,400,000	$1,250,000
Woomera operation	---	---	850,000
South Africa operation	---	---	600,000
Trajectory equipment operation	---	---	400,000
Data transmission	---	---	400,000
Total	---	$1,400,000	$3,500,000

Operation of Mercury Net Stations

The costs of operating the Mercury net station are detailed in the Manned Space Flight program writeup. However, the cost for all data transmission links and communications are carried under this project to permit better integration of over-all NASA tracking stations communications.

A total of about 18 stations are included in the Mercury network, including the control center at AMR and the communications and computing center at Goddard. The communications system for network data transmissions will primarily utilize commercial lines and military circuits. Mercury network data transmission costs include full-period leased facilities from the American Telephone and Telegraph Company as well as various commercial and communications agencies in foreign countries. A letter of intent has been issued from NASA to AT&T to provide early implementation of the necessary data links. The actual circuit tariff rates (subject to minor changes) given in the breakdown are indicative of costs that will be incurred and also serve as a basis for the estimate of the total net costs. A major portion of the uncompleted segment of the network, as shown in the breakdown, is still being studied and negotiated at this time. Engineering estimates of their cost, including fair share installation cost, terminal equipment, and tariff rates to be incurred, are in the order of $4,000,000 for the fiscal year 1961. Since the Mercury network operations will not begin until the latter part of the fiscal year 1960 and will be on a limited basis as compared to the fiscal year 1961, the over-all cost for the fiscal year 1960 is estimated to be about 20 percent of that for the fiscal year 1961.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Operation of Mercury stations.....	---	1/	1/

1/ Funding included under "Manned Space Flight" program.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Data transmission links:			
GSFC to Hawaii (1 voice cable).....			$281,000
GSFC to Hawaii (2 teletypes).....			288,000
GSFC to Pt. Arguello (PMR) (teletype).....			38,000
GSFC to Vancouver, B. C. (teletype).....			38,073
GSFC to Mexico (teletype).....			33,000
GSFC to White Sands (teletype).....			30,000
GSFC to Corpus Christi (teletype).....			25,500
GSFC to Eglin AFB (teletype).....			18,000
GSFC to Patrick AFB (7 voice).....			114,000
GSFC to Patrick AFB (6 teletypes).....			85,000
GSFC to London (1 voice).....			240,000
GSFC to New York (AT&T) (6 teletypes).....			24,000
New York to London (cable).....			96,000
GSFC to Bermuda (radio or cable, voice)....	---	$1,000,000	126,000
Terminal equipment on above.....			100,000
London to Canary Island (2 radio teletypes)			
London to Nigeria (2 radio teletypes).....			
Kauo to Zanzibar (2 radio teletypes).....			
Zanzibar to Indian Ocean ship (2 radio teletypes).....			
I.O. ship to Perth, Australia (2 radio teletypes).....			3,913,427
Perth to Woomera (2 cable teletypes).....			
Woomera to Sydney (1 cable teletype).....			
Woomera to West Australia (2 cable teletypes).....			
Sydney to Hawaii (1 radio teletype).....			
Sydney to Vancouver (1 cable teletype).....			
Hawaii to Canton Is. (1 radio teletype)....			
Total.....	---	$1,000,000	$5,450,000

Operation of Non-NASA Stations

A number of non-NASA stations which provide special capabilities are used by the NASA on a part-time basis. Examples are the facilities at Jodrell Bank, England, and Fort Churchill, Canada. The extent of the NASA use of these facilities is arrived at by mutual agreements or contracts based on the duration and the complexity of the particular experiment. In certain cases the NASA may provide funds for special items of equipment needed to accomplish particular NASA experiments.

Jodrell Bank, England: An agreement was reached with the University of Manchester, England, for the cooperative use of the Jodrell Bank 250-foot radio telescope station for NASA projects. The cost in the fiscal year 1959 is based on six satellites or space probes which will require about 160 8-hour days for use of the telescope, at a cost of $1,200 per day. The estimates for the fiscal year 1960 assume the use of this facility for a similar number of space probes and satellites. A nominal increase is estimated for the fiscal year 1961 to allow for increased activity.

Fort Churchill, Canada: By mutual agreement between the Department of Defense and the NASA, it was decided that the NASA and the Army would share equally the operating costs of Fort Churchill. On the basis of a yearly cost of $1,300,000 for the fiscal year 1960, the NASA portion is $650,000. The NASA share of the operating cost for Fort Churchill in the fiscal year 1961 allows for a nominal increase in operating cost. The use of Fort Churchill is required in the NASA sounding rocket program; approximately sixty sounding rockets will be launched from Fort Churchill during the fiscal year 1961.

Other non-NASA stations: Support of other non-NASA stations for the fiscal year 1960 is based on reimbursing other activities for the occasional use of their facilities. For example, funds have been supplied to PMR for the use of an Hawaiian station for the Explorer VII satellite, as well as to Japan and the University of Heidelburg. An increase in this activity is anticipated in the fiscal year 1961 and is based on the possible use of certain non-NASA stations for meteorological work, since NASA may not have adequate facilities in time for the meteorological satellites without outside help. As space activities of foreign governments increase, it is expected that the NASA may find it necessary to contract for tracking and data acquisition facilities for short periods of time, either due to work load at NASA facilities or for technical reasons which make it advantageous to use facilities at unusual geographic locations.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Jodrell Bank, England.....	$180,000	$200,000	$300,000
Fort Churchill, Canada.....	---	650,000	700,000
Other non-NASA stations or facilities.....	---	50,000	400,000
Total.....	$180,000	$900,000	$1,400,000

Operations at Atlantic Missile Range and Pacific Missile Range Stations

Operations at the Atlantic Missile Range: By mutual agreement between the NASA and the AMR, certain items of operating cost are reimbursable to the Air Force. This agreement stems from a basic military range policy which requires all range users to provide facilities and equipment, including modifications thereto, that are unique to the user's purpose, and consumables and other expenses required directly in support of the user's project. Typical reimbursable items are: propellants, telephone toll charges, overtime pay, travel by range personnel, special equipment modifications, and miscellaneous contract services. The major reasons for the increased cost of these items in the fiscal year 1961 are the increase in Project Mercury activity, and the heavy schedule of launchings planned for the Delta vehicle.

Operations at the Pacific Missile Range: During the fiscal year 1960, reimbursable costs will be incurred in connection with the design, construction, and operation of the launch and support facilities required for the Nerv and Delta programs. Nerv is a special sounding rocket project for radiation research. Four Nerv vehicles will be fired from PMR during the fiscal year 1960. The Delta launch complex must also be made ready during this period, and logistic support for Mercury stations in the Pacific will be initiated. In the fiscal year 1961, the Delta launchings will begin, and polar Scout launchings are also expected to get under way. Support operations for the Mercury stations will increase with the acceleration of the Mercury program.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
AMR operations.....	---	$426,000	$1,500,000
PMR operations.....	---	200,000	600,000
Total.....	---	$626,000	$2,100,000

Other Operational Costs

Wallops Station data transmission: Activity at the Wallops Station relating to the launching of satellites, atmospheric probes, air-space probes, and related space experiments requires extensive data transmission between the Wallops Station, the Goddard Space Flight Center, and the Atlantic Missile Range. The communication links will be used to transmit vehicle performance data, payload data, and control data between the stations in near real time. In addition to the lease of transmission facilities, suitable translating terminal equipment will be necessary to encode and decode data sent and received over the links. The increase in funds requested for the fiscal year 1961 reflects the increased activity planned for the Wallops Station.

Data reduction services: This item represents the estimated requirements for contractual computation services. The services are required both for the data systems division and for the theoretical division of the Goddard Space Flight Center. The data systems division work is primarily in the field of orbital computation and research on orbital computation methods, while the work of the theoretical division is in support of basic mathematical data analysis. The lower fiscal year 1961 estimate is made possible by the completion and installation of the computation facilities at the Goddard Space Flight Center; these facilities are expected to take over some of the work which is now performed under contract.

Maintenance, repairs, spares, and materials: The cost of operating the NASA tracking networks (excluding research and data reduction services) is approximately $10,000,000 in the fiscal year 1960. Based on experience with this complex electronic equipment, about 5% was programmed for maintenance and spares during the fiscal year 1960. By the fiscal year 1961 four new Minitrack stations, two more deep space stations, and a number of complex Mercury network stations will have

become fully operational. Moreover, a number of the existing stations will have been improved with new and more complex equipment. The overall increase in facilities will represent approximately a four- or five-fold increase in complexity of network equipment to support space flight operations. In addition, contract specialists and special equipment will have to be sent to the various field stations in connection with the maintenance and up-dating of equipment. Spare parts in greater quantity and of a more costly nature will have to be provided. The cost to maintain the NASA networks at normal proficiency is estimated at about 10% of the operational cost (approximately $23,000,000) for the fiscal year 1961.

Item	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
Wallops Station data transmission:			
Wallops to Goddard	---	$50,000	$100,000
Wallops to AMR	---	50,000	190,000
Terminal equipment for Wallops	---	100,000	30,000
Terminal equipment to Goddard	---	---	15,000
Terminal equipment for AMR	---	---	15,000
Data reduction services	---	2,250,000	800,000
Maintenance and repairs	---	250,000	1,800,000
Spares and materials	---	300,000	830,000
Total	---	$3,000,000	$3,780,000