National Aeronautics and Space Administration

BUDGET ESTIMATES

FISCAL YEAR 1966

Volume VII

ADVANCED RESEARCH AND TECHNOLOGY PROGRAMS

TRACKING AND DATA ACQUISITION PROGRAMS

RESEARCH AND DEVELOPMENT
CONSTRUCTION OF FACILITIES
ADMINISTRATIVE OPERATIONS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1966 ESTIMATES

ADVANCED RESEARCH AND TECHNOLOGY PROGRAMS

TRACKING AND DATA ACQUISITION PROGRAMS

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT

GENERAL STATEMENT

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

MANNED SPACE FLIGHT: Extended duration and rendezvous flights in earth orbit, and lunar landing and return.

SPACE SCIENCE AND APPLICATIONS: A broad program of scientific study of the Earth, Moon, Sun, planets, stars and interplanetary space, and the development of technology pertinent to applied uses such as meteorological and communication satellites.

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

TRACKING AND DATA ACQUISITION: A function pertinent to the support of the extensive NASA space flight program.

MANNED SPACE FLIGHT

A major part of the amount requested for FY 1966 will be applied to the manned space flight program. The broad objectives of this program which remain unchanged are: to increase and broaden our capability to support men in space and provide them with a space operation's capability for scientific and technological purposes. Toward this end there are projects Gemini and Apollo, as well as studies and supporting development needed for advanced manned flight missions. Gemini will furnish information on the operation of two men in space for periods of up to two weeks; and will provide for the development of space navigation, guidance, rendezvous and docking techniques. The objectives of Apollo are developing hardware, operational, and support systems to provide a broad national capability for a program of space exploration. This program has as a specific goal, in this decade, of achieving manned flight to the moon, lunar landing, limited lunar exploration and the safe return of the men to Earth. The advanced flight mission activity provides information and supporting developments pertinent to the extension of the current manned flight programs.

In FY 1966 the Gemini program will move into its long duration manned flight phase and the initial rendezvous flight will be undertaken. This activity will be of direct significance to Apollo. The Apollo program will be involved in extensive ground test activity in preparation for the first flight tests of the command and service modules with the Saturn IB launch

vehicle, which will take place in FY 1966, and in preparations for later flight tests of the Saturn V launch vehicle. In the area of advanced flight missions particular attention will be given to design studies and advanced component development to extend the usefulness of the Apollo spacecraft.

SPACE SCIENCE AND APPLICATIONS

A significant part of the budget requested for FY 1966 will support the space science and applications program. The objectives of the science part of the program are scientific studies of the Earth, space about the Earth, the Moon, the planets and interplanetary space. This program encompasses the following types of flight projects: Geophysical satellites, earth orbiting solar and astronomical observatories, soft landing lunar probes, lunar orbiting satellites, probes to the planet Mars and probes into interplanetary space. The biosatellite program, directed toward the study of the effects of space environment on biological systems, will be continued. In the area of applications, projects TIROS and Nimbus continue to reflect NASA support for the on-going operational weather satellite development for the Weather Bureau; in addition, the program provides for the technology required for future operational systems. Effort will also continue in the development of the Applications Technology Satellite, which will provide information required for the design and development of future communications, meteorological and scientific satellite systems.

ADVANCED RESEARCH AND TECHNOLOGY

The advanced research and technology effort constitutes a continuing overall program to support the current aeronautics and space programs and to assure the scientific and engineering bases for undertaking future programs. The major portion of this work, which looks beyond the present programs, is to develop new knowledge and technological advancements applicable to missions of the future. This program includes effort in the fields of spacecraft and launch vehicle technology, human factors, electronics, chemical and nuclear propulsion, space power systems and aeronautics including supersonic transport research.

TRACKING AND DATA ACQUISITION

A world-wide network of tracking and data acquisition stations is essential to support the broad space flight program of the agency. The tracking and data acquisition effort during FY 1966, as in prior years, will be directed to support the planned flight programs and provide, where necessary, increased tracking and data acquisition capability. Particular attention will be given to the support of the Apollo manned space flight program and to the large observatory class of unmanned satellites in the space science program.

TECHNOLOGY UTILIZATION

The technology utilization program provides for the identification, evaluation and dissemination to the industrial community, technical information gained from the various programs for which there are potential industrial and commercial applications. Included in the program are efforts to develop better methods for management of large-scale research and development programs, to improve our understanding of matters related to the growth of science and technology programs, and to the transfer of technological advances and innovations developed in the NASA program to industry at large.

FINANCING

The FY 1966 budget to support the research and development program, discussed in detail in this volume, is $4,575,900,000. This compares to a program totaling $4,268,632,000 for FY 1965.

The program amounts shown for FY 1964 and FY 1965 in this budget reflect two significant adjustments in comparison to the amounts appropriated for these two fiscal years. These are: 1 - Certain support services (principally housekeeping) are now included in the budget for the "Administrative Operations" appropriation; and 2 - Of the FY 1965 appropriation, $72,494,000 has been applied to the FY 1964 Apollo program.

Expenditures for the current fiscal year are estimated at $3,782,000,000 and $4,120,000,000 for FY 1966.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

GENERAL STATEMENT

This appropriation provides for the design, construction, purchase of equipment, modernization of facilities, and for advanced design of facilities planned for future authorization. The major program elements may be summarized as follows:

MANNED SPACE FLIGHT: These projects will support the Apollo spacecraft and Saturn launch vehicle development and test efforts. Specific items included will provide for needed astronaut training facilities, engineering work areas and augmentation of support facilities.

SCIENTIFIC INVESTIGATIONS IN SPACE: Projects in this category will support activities in space science. They will provide for needed improvements in the testing of spacecraft and experiments carried as spacecraft payloads for the unmanned lunar and planetary exploration program, for improvements in other facilities for unmanned spacecraft missions and for necessary improvements to launch area facilities for the medium class and small launch vehicles.

ADVANCED RESEARCH AND TECHNOLOGY: These estimates cover projects for research, laboratory and supporting facilities for the Electronics Research Center, and for contractor technical facilities used in research pertinent to large advanced liquid-fueled engine systems.

AIRCRAFT TECHNOLOGY AND SUPPORTING OPERATIONS: Estimates for these projects include facilities to support the V/STOL and advanced aircraft programs and facilities for tracking and data acquisition.

The appropriation for FY 1965 was $262,880,500. The same amount was authorized for 1965. $74,700,000 is requested for FY 1966; a decrease of $188,180,500 from the 1965 appropriation. Total expenditures for construction of facilities are estimated to be $406,000,000 in FY 1966, a decrease of $118,000,000 from the $524,000,000 estimated for FY 1965.

The budget request contains $78,000 to provide fall-out shelters for selected new facilities. The amount has been determined in consultation with the Department of Defense based on DOD policy and criteria.

The format for reflecting fall-out shelters in each of the projects in the budget request varies. The reason is to distinguish among those facilities in which provision for fall-out protection is either inherent in the structure, provision is required, or, because of prohibitive costs and

hazardous areas provision for fall-out protection would not be desirable.

This volume contains material in support of the requested authorization and appropriation for FY 1966.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ADMINISTRATIVE OPERATIONS

GENERAL STATEMENT

The Administrative Operations appropriation provides for personnel, travel, and other supporting expenses of NASA installations including Headquarters engaged in the conduct of Research and Development programs. These installations are institutionally administered by the Associate Administrator who has prime responsibility for the R&D programs conducted at each installation. The Associate Administrator for Manned Space Flight is responsible for the Kennedy Space Center, Manned Spacecraft Center, and the Marshall Space Flight Center. Goddard Space Flight Center, the Pacific Launch Operations Office, and Wallops Station are under the institutional cognizance of the Associate Administrator for Space Science and Applications. The Associate Administrator for Advanced Research and Technology is institutionally responsible for the Ames Research Center, the Electronics Research Center, the Flight Research Center, Langley Research Center, the Lewis Research Center, and the Space Nuclear Propulsion Office. Headquarters reports directly to the Associate Administrator, and the Western Operations Office reports to the Deputy Associate Administrator for Industry Affairs. Installation descriptions and funding requirements are grouped in this volume in accordance with the prime missions of the installations.

Manpower

With the exception of an increase of 300 positions for the Electronics Research Center, there is no planned increase in manpower at other NASA installations during FY 1966. The following tabulations indicate the distribution of NASA personnel by program and the numbers of personnel by center:

Personnel Distribution

	1964	1965	1966
Direct Personnel by Program			
Manned Space Flight			
Gemini	1,141	1,402	1,385
Apollo	8,266	8,835	8,857
Advanced missions	343	343	343
	9,750	10,580	10,585
Space Science and Applications			
Physics and astronomy	1,234	1,292	1,297
Lunar and planetary exploration	296	388	382
Sustaining university program	68	73	73

	1964	1965	1966
Space Science and Applications (cont'd)			
Launch vehicle development.....	340	317	314
Launch vehicle procurement.....	324	346	334
Bioscience.....	240	236	239
Meteorological satellites.....	297	312	306
Communication satellites.....	127	76	65
Applications technology satellites...	56	103	113
	2,982	3,143	3,123
Advanced Research and Technology			
Basic research.....	1,268	1,259	1,266
Space vehicle systems	1,389	1,366	1,324
Electronics systems.....	906	1,040	1,325
Human factor systems.....	214	211	219
Nuclear-electric systems.....	529	490	489
Nuclear rockets.....	530	524	524
Chemical propulsion.....	425	409	309
Solar and chemical power.....	275	318	319
Aeronautics.....	1,394	1,467	1,600
	6,930	7,084	7,375
Tracking and Data Acquisition	851	802	800
Technology Utilization.....	50	50	50
Sub-total, direct positions.....	20,563	21,659	21,933
Support Personnel			
Director and staff.....	472	537	540
Administration.....	4,411	4,432	4,439
Research and development support.....	5,499	5,521	5,533
NASA-wide support.....	1,039	1,051	1,055
Sub-total, support positions.....	11,421	11,541	11,567
Total, permanent positions.....	31,984	33,200	33,500
Sub-total, other positions.....	515	600	600
Total, all positions.....	32,499	33,800	34,100

Personnel Requirements

	1964	1965	1966
Manned Space Flight			
Kennedy Space Center.....	1,592	2,045	2,045
Manned Spacecraft Center.....	4,171	4,686	4,686
Marshall Space Flight Center....	7,502	7,489	7,489
	13,265	14,220	14,220
Space Science and Applications			
Goddard Space Flight Center.....	3,610	3,677	3,677
Pacific Launch Operations Office	22	19	19
Wallops Station.....	516	518	518
	4,148	4,214	4,214
Advanced Research and Technology			
Ames Research Center.....	2,201	2,185	2,185
Electronics Research Center.....	25	250	550
Flight Research Center.....	605	605	605
Langley Research Center.....	4,279	4,238	4,238
Lewis Research Center.....	4,851	4,815	4,815
Space Nuclear Propulsion Office.	112	116	116
	12,073	12,209	12,509
Supporting Activities			
Headquarters, NASA.....	2,091	2,156	2,156
North Eastern Operations Office.	32	- 0 -	- 0 -
Western Operations Office.....	375	401	401
	2,498	2,557	2,557
Permanent positions.....	31,984	33,200	33,500
Positions, other than permanent.....	515	600	600
TOTAL.....	32,499	33,800	34,100

Funding

The FY 1966 funding request for Administrative Operations is $36.3 million less than the FY 1965 estimate. This decrease is primarily due to the initial procurement of major automatic data processing equipment in FY 1965, where the procurement of such equipment was more economical than continued rental. The estimate in FY 1966 for the procurement of additional equipment is sharply reduced from FY 1965. The object classification description of resources requested is tabulated below:

ANALYSIS OF RESOURCES REQUIREMENTS BY OBJECT CLASSIFICATION

(Thousands of Dollars)

		1964	1965	1966
11.	Personnel compensation.....	288,081	336,696	345,207
12.	Personnel benefits.....	20,241	23,490	24,193
21.	Travel and transportation of persons	18,536	21,000	21,000
22.	Transportation of things.....	5,400	5,675	5,049
23.	Rents, communications and utilities.	47,230	53,191	49,556
24.	Printing and reproduction.....	4,387	4,683	4,869
25.	Other services.....	70,952	93,037	108,023
26.	Supplies and materials.....	24,203	22,968	23,140
31.	Equipment.....	22,236	79,152	23,109
32.	Lands and structures.....	10,339	5,811	5,235
40.	Insurance claims and indemnities...	5	18	19
Total.....		511,610	645,721	609,400

Of the $645.7 million shown for FY 1965, $22.5 million is included as the comparative cost of items formerly provided from the Research and Development appropriation and which are being budgeted as part of the Administrative Operations request for the first time in FY 1966. In FY 1966, $24.8 million is requested for these items which are: housekeeping support of the Merritt Island Launch Area at the Kennedy Space Center, NASA, and at the White Sands Missile Range; the cost at the Jet Propulsion Laboratory of the lease of administrative aircraft and certain contract administration costs.

Personnel Compensation and Benefits

The cost of providing for personnel compensation and benefits is estimated to be $9.2 million more in FY 1966 than in FY 1965. This increased cost is directly related to the increase of 704 manyears of employment, in FY 1966 over FY 1965. Of this increase, 544 manyears are due to the cost of the full year for the 1,300 increase in NASA's strength in FY 1965. The

balance, or 160 manyears, is the manyears derived from the 300 additional positions planned for the Electronics Research Center in FY 1966.

Other Costs

The FY 1966 request for travel and other supporting expenses shows a net reduction of $45.5 million from the FY 1965 estimate. This net reduction includes a decrease of approximately $56 million in the procurement of ADP equipment, which is only partially offset by increases in utilities, other services, and supplies and materials. In general, these increases are the result of additional facilities being completed and becoming operational, a higher level of average employment, and the partial restoration in FY 1966 of items which were deferred in FY 1965 when NASA absorbed the cost of the "Government Employees Salary Reform Act of 1964", approved in August 1964 (PL 88-426). The specific increases as they relate to each installation are explained in the installation presentations contained in this volume.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1966 ESTIMATES

SUMMARY OF RESEARCH AND DEVELOPMENT BUDGET PLAN
AS RECONCILED TO FINANCING SCHEDULE

	Fiscal Year 1964	Fiscal Year 1965	Fiscal Year 1966
Budget Activity:			
1. Manned Space Flight:			
(a) Gemini.....	$418,900,000	$308,400,000	$242,100,000
(b) Apollo.....	2,272,952,000	2,606,778,000	2,997,385,000
(c) Advanced mission studies.....	21,200,000	26,000,000	10,000,000
2. Scientific Investigations in Space:			
(a) Physics and astronomy.....	189,118,000	182,546,000	224,300,000
(b) Lunar and planetary exploration.....	267,445,000	281,803,000	294,515,000
(c) Bioscience.....	21,479,000	37,700,000	40,600,000
(d) Launch vehicle development.....	125,100,000	107,900,000	97,500,000
3. Space Applications.....	100,451,000	73,165,000	94,600,000
4. Space Technology.....	298,692,000	283,600,000	235,500,000
5. Aircraft Technology.....	21,795,000	35,240,000	42,200,000
6. Supporting Activities:			
(a) Tracking and data acquisition.....	194,347,000	274,750,000	246,200,000
(b) Sustaining university program.....	40,000,000	46,000,000	46,000,000
(c) Technology utilization.....	3,500,000	4,750,000	5,000,000
Total Budget Plan.....	$3,974,979,000	$4,268,632,000	$4,575,900,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1966 ESTIMATES

SUMMARY OF RESEARCH AND DEVELOPMENT BUDGET PLAN AS RECONCILED TO FINANCING SCHEDULE

	Fiscal Year 1964	Fiscal Year 1965	Fiscal Year 1966
Financing:			
Appropriation.....	$3,926,000,000	$4,363,594,000	$4,575,900,000
Transferred to-			
"Construction of facilities" (77 Stat. 439).....	-20,046,300	---	---
"Administrative Operations" (77 Stat. 439).....	-15,685,000	---	---
Appropriation (adjusted).....	3,890,268,700	4,363,594,000	4,575,900,000
Transferred to "Construction of facilities" in FY 1965	-1,411,000	---	---
Prior year funding applied - available from adjustments to FY 1963 budget plan....	2,785,300	---	---
Transfers from prior years "Construction of facilities" funds.....	17,293,000	---	---
Reprograming to prior year budget plan.....	72,494,000	-72,494,000	---
Comparative transfer to "Administrative Operations"	-6,451,000	-22,468,000	---
Total financing of budget plan.....	$3,974,979,000	$4,268,632,000	$4,575,900,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1966 ESTIMATES

RESEARCH AND DEVELOPMENT

BUDGET PLAN BY PROGRAM BY COGNIZANT OFFICE

BUDGET ACTIVITY		FY 1964	FY 1965	FY 1966
	MANNED SPACE FLIGHT.....	$2,713,052,000	$2,941,178,000	$3,249,485,000
1a	Gemini.....	418,900,000	308,400,000	242,100,000
1b	Apollo.....	2,272,952,000	2,606,778,000	2,997,385,000
1c	Advanced mission studies.....	21,200,000	26,000,000	10,000,000
	SPACE SCIENCE AND APPLICATIONS.....	$746,879,000	$731,486,000	$797,515,000
2a	Physics and astronomy.	148,623,000	136,814,000	172,100,000
2b	Lunar and planetary exploration.....	205,762,000	206,150,000	215,615,000
6b	Sustaining university program.....	40,000,000	46,000,000	46,000,000
2d	Launch vehicle development.....	111,900,000	96,500,000	63,600,000
*	Launch vehicle procurement.....	129,986,000	154,672,000	194,500,000
2c	Bioscience.....	21,479,000	28,700,000	31,500,000
3	Meteorological satellites.....	63,177,000	31,200,000	42,700,000
3	Communications satellites.....	8,413,000	8,055,000	2,800,000
3	Applications technology satellites.....	17,539,000	23,395,000	28,700,000
	ADVANCED RESEARCH AND TECHNOLOGY.....	$317,201,000	$316,468,000	$277,700,000
4	Basic research.....	22,653,000	21,231,000	22,000,000
4	Space vehicle systems.	45,714,000	44,495,000	35,000,000
4	Electronic systems....	28,700,000	25,422,000	34,400,000
4	Human factor systems..	13,200,000	13,320,000	14,900,000
4	Nuclear-electric systems.....	45,963,000	42,492,000	27,000,000
4	Nuclear-rockets.....	79,176,000	56,731,000	58,000,000
4	Chemical propulsion...	46,000,000	63,792,000	30,000,000

BUDGET ACTIVITY		FY 1964	FY 1965	FY 1966
	ADVANCED RESEARCH AND TECHNOLOGY (Cont'd)..			
4	Solar and chemical power.....	$14,000,000	$13,745,000	$14,200,000
5	Aeronautics.....	21,795,000	35,240,000	42,200,000
6a	TRACKING AND DATA ACQUISITION.....	$194,347,000	$274,750,000	$246,200,000
6c	TECHNOLOGY UTILIZATION.	$3,500,000	$4,750,000	$5,000,000
	TOTAL PLAN	$3,974,979,000	$4,268,632,000	$4,575,900,000

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

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1966 ESTIMATES

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

(In thousands of dollars)

PROGRAM OFFICE	TOTAL	J. F. KENNEDY SPACE CENTER, NASA	MANNED SPACECRAFT CENTER	MARSHALL SPACE FLIGHT CENTER	GODDARD SPACE FLIGHT CENTER	PACIFIC LAUNCH OPERATIONS OFFICE	WALLOPS STATION	AMES RESEARCH CENTER	ELECTRONICS RESEARCH CENTER	FLIGHT RESEARCH CENTER	LANGLEY RESEARCH CENTER	LEWIS RESEARCH CENTER	SPACE NUCLEAR PROPULSION OFFICE	HEADQUARTERS	WESTERN OPERATIONS OFFICE
Office of Manned Space Flight															
1964	2,713,052	49,881	1,356,036	1,266,424	206	-	-	75	-	-	2,017	2,975	-	35,091	347
1965	2,941,178	48,622	1,397,050	1,437,356	275	-	-	75	-	-	2,900	600	-	54,100	200
1966	3,249,485	69,345	1,465,040	1,656,600	500	-	-	200	-	-	3,700	300	-	53,550	250
Office of Space Science and Applications															
1964	746,879	1,819	3,256	780	235,148	-	-	25,843	-	44	35,168	197,522	-	87,202	160,097
1965	731,486	4,808	7,254	675	183,408	90	1,390	35,085	-	85	59,806	197,323	-	108,994	132,568
1966	797,515	4,225	17,800	13,440	227,712	-	4,500	28,305	-	100	51,860	196,730	-	105,375	147,468
Office of Advanced Research and Technology															
1964	317,201	-	3,702	31,821	8,252	-	-	14,404	-	8,447	38,741	99,759	60,355	25,026	26,694
1965	316,468	-	1,750	28,511	8,127	-	-	17,724	1,873	9,190	32,548	115,825	44,995	34,322	21,603
1966	277,700	-	3,235	18,035	9,300	-	-	16,945	5,200	16,530	42,776	61,595	48,900	33,638	21,546
Office of Tracking and Data Acquisition															
1964	194,347	-	-	2,900	132,817	-	5,100	-	-	1,800	2,450	-	-	7,210	42,070
1965	274,750	-	-	2,000	195,201	-	5,450	-	-	2,200	2,200	-	-	7,900	59,799
1966	246,200	-	-	1,500	173,400	-	5,900	-	-	2,000	2,500	-	-	7,900	53,000
Office of Technology Utilization and Policy Planning															
1964	3,500	-	-	-	-	-	-	-	-	-	-	-	-	3,500	-
1965	4,750	-	-	-	-	-	-	-	-	-	-	-	-	4,750	-
1966	5,000	-	-	-	-	-	-	-	-	-	-	-	-	5,000	-
Total Budget Plan															
1964	3,974,979	51,700	1,362,994	1,301,925	376,423	-	5,100	40,322	-	10,291	78,376	300,256	60,355	158,029	229,208
1965	4,268,632	53,430	1,406,054	1,468,542	387,011	90	6,840	52,884	1,873	11,475	97,454	313,748	44,995	210,066	214,170
1966	4,575,900	73,570	1,486,075	1,689,575	410,912	-	10,400	45,450	5,200	18,630	100,836	258,625	48,900	205,463	222,264

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1966 ESTIMATES

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

(In thousands of dollars)

PROGRAM		TOTAL	J. F. KENNEDY SPACE CENTER, NASA	MANNED SPACECRAFT CENTER	MARSHALL SPACE FLIGHT CENTER	GODDARD SPACE FLIGHT CENTER	PACIFIC LAUNCH OPERATIONS OFFICE	WALLOPS STATION	AMES RESEARCH CENTER	ELECTRONICS RESEARCH CENTER	FLIGHT RESEARCH CENTER	LANGLEY RESEARCH CENTER	LEWIS RESEARCH CENTER	SPACE NUCLEAR PROPULSION OFFICE	HEADQUARTERS	WESTERN OPERATIONS OFFICE 1/
OFFICE OF MANNED SPACE FLIGHT, TOTAL	1964	2,713,052	49,881	1,356,036	1,266,424	206	-	-	75		-	2,017	2,975	-	35,091	347
	1965	2,941,178	48,622	1,397,050	1,437,356	275	-	-	75	-	-	2,900	600	-	54,100	200
	1966	3,249,485	69,345	1,465,040	1,656,600	500	-	-	200	-		3,700	300	-	53,550	250
Gemini	1964	418,900	-	418,900	-	-	-	-	-	-	-	-	-	-	-	-
	1965	308,400	-	308,050	-	-	-	-	-	-	-	-	-	-	350	-
	1966	242,100	-	241,700	-	-	-	-	-	-	-	-	-	-	400	-
Apollo	1964	2,272,952	49,481	933,486	1,257,179	206	-	-	75	-	-	-	2,975	-	29,293	257
	1965	2,606,778	48,172	1,080,800	1,429,406	275	-	-	75	-	-	1,200	600	-	46,050	200
	1966	2,997,385	68,945	1,221,940	1,651,300	500	-	-	200	-	-	2,000	300	-	51,950	250
Advanced mission studies	1964	21,200	400	3,650	9,245	-	-	-	-	-	-	2,017	-	-	5,798	90
	1965	26,000	450	8,200	7,950	-	-	-	-	-	-	1,700	-	-	7,700	-
	1966	10,000	400	1,400	5,300	-	-	-	-	-	-	1,700	-	-	1,200	-
OFFICE OF SPACE SCIENCE AND APPLICATIONS, TOTAL	1964	746,879	1,819	3,256	780	235,148	-	-	25,843	-	44	35,168	197,522	-	87,202	160,097
	1965	731,486	4,808	7,254	675	183,408	90	1,390	35,085	-	85	59,806	197,323	-	108,994	132,568
	1966	797,515	4,225	17,800	13,440	227,712	-	4,500	28,305	-	100	51,860	196,730	-	105,375	147,468
Physics and astronomy	1964	148,623	-	1,020	195	123,753	-	-	605	-	44	2,333	150	-	20,047	476
	1965	136,814	-	2,300	20	107,473	-	1,390	1,764	-	85	2,280	-	-	21,168	334
	1966	172,100	-	2,600	20	133,585	-	4,500	2,255	-	100	1,730	-	-	26,660	650
Lunar and planetary exploration	1964	205,762	-	1,867	505	1,084	-	-	15,382	-	-	20,146	-	-	9,521	157,257
	1965	206,150	-	4,429	535	1,111	-	-	16,054	-	-	43,050	-	-	10,667	130,304
	1966	215,615	-	14,000	300	900	-	-	8,600	-	-	37,300	-	-	9,500	145,015
Sustaining university program	1964	40,000	-	-	-	-	-	-	-	-	-	-	-	-	39,940	60
	1965	46,000	-	-	-	-	-	-	-	-	-	-	-	-	45,965	35
	1966	46,000	-	-	-	-	-	-	-	-	-	-	-	-	45,965	35
Launch vehicle development	1964	111,900	983	-	-	250	-	-	-	-	-	115	109,497	-	1,055	-
	1965	96,500	1,783	-	-	925	-	-	-	-	-	650	91,317	-	1,825	-
	1966	63,600	1,050	-	13,000	550	-	-	-	-	-	300	47,600	-	1,100	-
Launch vehicle procurement	1964	129,986	836	-	-	23,326	-	-	-	-	-	11,930	87,875	-	6,019	-
	1965	154,672	3,025	-	-	19,960	90	-	-	-	-	13,106	106,006	-	12,485	-
	1966	194,500	3,175	-	-	23,025	-	-	-	-	-	11,700	149,130	-	7,470	-
Bioscience	1964	21,479	-	234	-	250	-	-	9,856	-	-	-	-	-	9,896	1,243
	1965	28,700	-	475	-	250	-	-	17,267	-	-	-	-	-	9,209	1,499
	1966	31,500	-	1,000	-	250	-	-	17,450	-	-	-	-	-	11,550	1,250
Meteorological satellites	1964	63,177	-	135	80	62,346	-	-	-	-	-	444	-	-	172	-
	1965	31,200	-	50	120	29,575	-	-	-	-	-	420	-	-	1,035	-
	1966	42,700	-	200	120	39,720	-	-		-	-	530	-	-	2,130	-
Communication satellites	1964	8,413	-	-	-	7,661	-	-	-	-	-	200	-	-	552	-
	1965	8,055	-	-	-	1,415	-	-	-	-	-	300	-	-	6,340	-
	1966	2,800	-	-	-	1,500	-	-	-	-	-	300	-	-	1,000	-
Applications technology satellites	1964	17,539	-	-	-	16,478	-	-	-	-	-	-	-	-	-	1,061
	1965	23,395	-	-	-	22,699	-	-	-	-	-	-	-	-	300	396
	1966	28,700	-	-	-	28,182	-	-	-	-	-	-	-	-	-	518

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1966 ESTIMATES

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

(In thousands of dollars)

PROGRAM		TOTAL	J. F. KENNEDY SPACE CENTER, NASA	MANNED SPACECRAFT CENTER	MARSHALL SPACE FLIGHT CENTER	GODDARD SPACE FLIGHT CENTER	PACIFIC LAUNCH OPERATIONS OFFICE	WALLOPS STATION	AMES RESEARCH CENTER	ELECTRONICS RESEARCH CENTER	FLIGHT RESEARCH CENTER	LANGLEY RESEARCH CENTER	LEWIS RESEARCH CENTER	SPACE NUCLEAR PROPULSION OFFICE	HEADQUARTERS	WESTERN OPERATIONS OFFICE 1/
OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY, TOTAL	1964	317,201	-	3,702	31,821	8,252	-	-	14,404	-	8,447	38,741	99,759	60,355	25,026	26,694
	1965	316,468	-	1,750	28,511	8,127	-	-	17,724	1,873	9,190	32,548	115,825	44,995	34,322	21,603
	1966	277,700	-	3,235	18,035	9,300	-	-	16,945	5,200	16,530	42,776	61,595	48,900	33,638	21,546
Basic Research	1964	22,653	-	-	986	235	-	-	1,692	-	-	1,466	3,464	-	7,831	6,979
	1965	21,231	-	-	916	257	-	-	1,881	-	30	1,861	2,234	-	8,260	5,792
	1966	22,000	-	-	920	260	-	-	1,900	200	30	1,920	2,750	-	8,220	5,800
Space vehicle systems	1964	45,714	-	629	13,569	878	-	-	1,942	-	1,403	15,257	3,186	-	3,282	5,568
	1965	44,495	-	730	16,744	956	-	-	2,922	-	2,020	9,659	2,326	-	5,700	3,438
	1966	35,000	-	855	4,490	930	-	-	2,655	-	1,180	13,461	1,770	-	6,519	3,140
Electronic systems	1964	28,700	-	1,079	4,644	3,274	-	-	2,399	-	1,072	8,848	463	-	4,087	2,834
	1965	25,422	-	475	3,469	2,797	-	-	3,650	1,873	1,103	6,390	445	-	2,493	2,727
	1966	34,400	-	880	4,525	3,035	-	-	3,390	5,000	1,400	9,120	580	-	3,270	3,200
Human factor systems	1964	13,200	-	1,900	235	-	-	-	3,820	-	1,342	1,835	137	-	3,931	-
	1965	13,320	-	445	220	-	-	-	4,113	-	2,000	3,204	230	-	3,108	-
	1966	14,900	-	900	300	-	-	-	4,680	-	1,500	4,450	200	-	2,870	-
Nuclear-electric systems	1964	45,963	-	94	263	1,320	-	-	-	-	-	-	41,719	-	685	1,882
	1965	42,492	-	100	290	1,142	-	-	-	-	-	400	37,038	-	1,186	2,336
	1966	27,000	-	100	400	1,200	-	-	-	-	-	-	22,700	-	1,000	1,600
Nuclear rockets	1964	79,176	-	-	7,153	-	-	-	-	-	-	-	11,330	60,355	-	338
	1965	56,731	-	-	1,280	-	-	-	-	-	-	-	10,450	44,995	-	6
	1966	58,000	-	-	1,300	-	-	-	-	-	-	-	7,800	48,900	-	-
Chemical propulsion	1964	46,000	-	-	3,542	375	-	-	-	-	-	1,144	31,205	-	3,194	6,540
	1965	63,792	-	-	3,592	550	-	-	-	-	-	1,480	45,227	-	8,760	4,183
	1966	30,000	-	500	5,100	800	-	-	-	-	-	1,980	8,095	-	8,825	4,700
Solar and chemical power	1964	14,000	-	-	1,429	2,170	-	-	105	-	-	710	6,403	-	630	2,553
	1965	13,745	-	-	2,000	2,425	-	-	191	-	-	690	4,309	-	1,009	3,121
	1966	14,200	-	-	1,000	3,075	-	-	170	-	-	740	5,000	-	1,109	3,106
Aeronautics	1964	21,795	-	-	-	-	-	-	4,446	-	4,630	9,481	1,852	-	1,386	-
	1965	35,240	-	-	-	-	-	-	4,967	-	4,037	8,864	13,566	-	3,806	-
	1966	42,200	-	-	-	-	-	-	4,150	-	12,420	11,105	12,700	-	1,825	-
OFFICE OF TRACKING AND DATA ACQUISITION	1964	194,347	-	-	2,900	132,817	-	5,100	-	-	1,800	2,450	-	-	7,210	42,070
	1965	274,750	-	-	2,000	195,201	-	5,450	-	-	2,200	2,200	-	-	7,900	59,799
	1966	246,200	-	-	1,500	173,400	-	5,900	-	-	2,000	2,500	-	-	7,900	53,000
Tracking and data acquisition	1964	194,347	-	-	2,900	132,817	-	5,100	-	-	1,800	2,450	-	-	7,210	42,070
	1965	274,750	-	-	2,000	195,201	-	5,450	-	-	2,200	2,200	-	-	7,900	59,799
	1966	246,200	-	-	1,500	173,400	-	5,900	-	-	2,000	2,500	-	-	7,900	53,000
OFFICE OF TECHNOLOGY UTILIZATION AND POLICY PLANNING	1964	3,500	-	-	-	-	-	-	-	-	-	-	-	-	3,500	-
	1965	4,750	-	-	-	-	-	-	-	-	-	-	-	-	4,750	-
	1966	5,000	-	-	-	-	-	-	-	-	-	-	-	-	5,000	-
Technology utilization	1964	3,500	-	-	-	-	-	-	-	-	-	-	-	-	3,500	-
	1965	4,750	-	-	-	-	-	-	-	-	-	-	-	-	4,750	-
	1966	5,000	-	-	-	-	-	-	-	-	-	-	-	-	5,000	-
TOTAL BUDGET PLAN	1964	3,974,979	51,700	1,362,994	1,301,925	376,423	-	5,100	40,322	-	10,291	78,376	300,256	60,355	158,029	229,208
	1965	4,268,632	53,430	1,406,054	1,468,542	387,011	90	6,840	52,884	1,873	11,475	97,454	313,748	44,995	210,066	214,170
	1966	4,575,900	73,570	1,486,075	1,689,575	410,912	-	10,400	45,450	5,200	18,630	100,836	258,625	48,900	205,463	222,264

1/Amount for Western Operations Office includes funds for the Jet Propulsion Laboratory as shown in the Research and Development program justification (Vol. II)

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1966 ESTIMATES

SUMMARY OF CONSTRUCTION OF FACILITIES BUDGET PLAN AS RECONCILED TO FINANCING SCHEDULE

	Fiscal Year 1964	Fiscal Year 1965	Fiscal Year 1966
Budget Activity			
1. Manned Space Flight.....	$496,841,600	$213,481,500	$27,825,000
2. Scientific Investigations in Space.....	16,698,700	5,765,000	8,377,000
3. Space Applications.....	3,933,000	---	---
4. Space Technology.....	60,949,700	23,812,000	20,435,000
5. Aircraft Technology.....	2,585,000	4,452,000	762,000
6. Supporting Activities.....	134,442,300	15,370,000	17,301,000
Total Budget Plan.....	$715,450,300	$262,880,500	$74,700,000
Financing:			
Appropriation.....	$680,000,000	$262,880,500	$74,700,000
Transferred from:			
"Research, development, and operation" (77 Stat. 439).....	20,046,300	---	---
"Administrative operations" (77 Stat. 439).....	13,300,000	---	---
Appropriation (adjusted).....	713,346,300	262,880,500	74,700,000
Transfer from "Research, development, and operation" in FY 1964 (76 Stat. 731, 75 Stat. 355, and 77 Stat. 439).	2,104,000	---	---
Total financing of budget plan.....	$715,450,300	$262,880,500	$74,700,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1966 ESTIMATES

SUMMARY OF CONSTRUCTION OF FACILITIES BUDGET PLAN
BY BUDGET ACTIVITY SHOWING LOCATION TOTALS INCLUDED IN EACH ACTIVITY

	Fiscal Year 1964	Fiscal Year 1965	Fiscal Year 1966
1. MANNED SPACE FLIGHT.....	$496,841,600	$213,481,500	$27,825,000
John F. Kennedy Space Center, NASA.....	280,520,300	85,377,200	7,295,000
Manned Spacecraft Center	36,142,000	24,443,000	4,400,000
Marshall Space Flight Center.....	30,081,000	14,999,700	4,776,000
Michoud Plant.....	9,058,000	6,313,500	300,000
Mississippi Test Facility.....	96,163,300	54,182,000	2,121,000
Various Locations.....	44,877,000	28,166,100	6,133,000
Facility Planning and Design.....	---	---	2,800,000
2. SCIENTIFIC INVESTIGATIONS IN SPACE.....	$16,698,700	$5,765,000	$8,377,000
Ames Research Center....	96,000	---	2,749,000
Goddard Space Flight Center.....	13,164,500	500,000	2,400,000
Jet Propulsion Laboratory	3,243,200	2,895,000	---
John F. Kennedy Space Center, NASA.....	170,000	1,741,000	1,300,000
Various Locations.....	5,000	---	---
Wallops Station.....	20,000	629,000	1,048,000
Facility Planning and Design.....	---	---	880,000
3. SPACE APPLICATIONS.....	$3,933,000	$ ---	$ ---
Goddard Space Flight Center.....	3,933,000	---	---

	Fiscal Year 1964	Fiscal Year 1965	Fiscal Year 1966
4. SPACE TECHNOLOGY.....	$60,949,700	$23,812,000	$20,435,000
Ames Research Center.....	11,464,000	3,100,000	---
Electronics Research Center.....	4,820,000	10,050,000	10,000,000
Langley Research Center....	9,872,700	3,253,000	7,568,000
Lewis Research Center.....	20,468,000	1,555,000	867,000
Nuclear Rocket Development Station.....	4,190,000	---	---
Various Locations.....	10,135,000	5,854,000	---
Facility Planning and Design.....	---	---	2,000,000
5. AIRCRAFT TECHNOLOGY.....	$2,585,000	$4,452,000	$762,000
Ames Research Center.....	20,000	2,630,000	---
Flight Research Center.....	2,495,000	---	---
Langley Research Center....	70,000	1,322,000	682,000
Lewis Research Center.....	---	500,000	---
Facility Planning and Design.....	---	---	80,000
6. SUPPORTING ACTIVITIES.....	$134,442,300	$15,370,000	$17,301,000
Goddard Space Flight Center	84,000	1,291,000	---
Jet Propulsion Laboratory..	---	725,000	---
John F. Kennedy Space Center, NASA.....	4,000,000	1,955,000	---
Various Locations.....	129,803,300	10,279,000	15,561,000
Wallops Station.....	555,000	1,120,000	---
Facility Planning and Design.....	---	---	1,740,000
TOTAL PLAN.....	$715,450,300	$262,880,500	$74,700,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1966 ESTIMATES

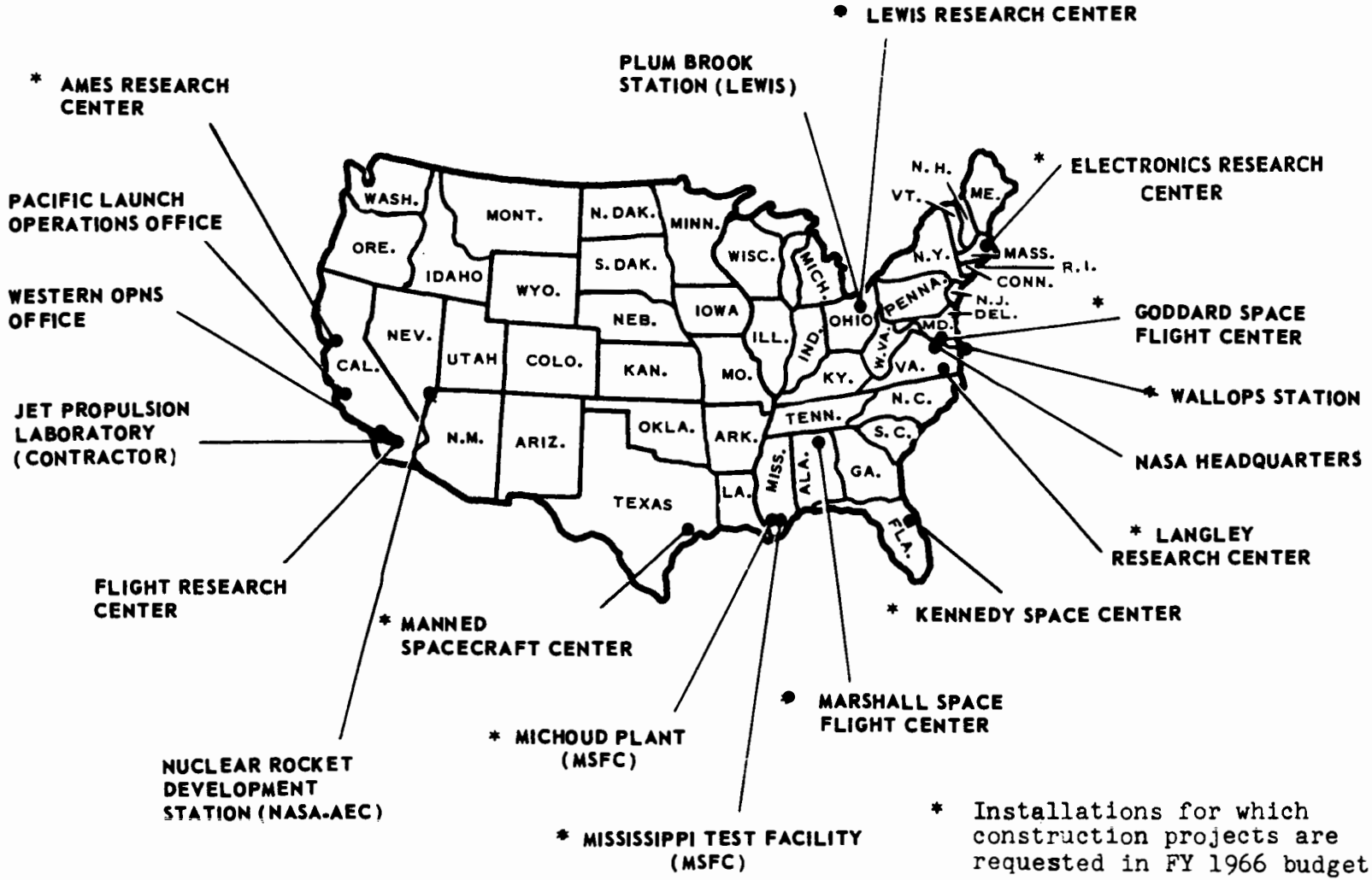
SUMMARY OF CONSTRUCTION OF FACILITIES BUDGET PLAN BY LOCATION

Location	Fiscal Year 1964	Fiscal Year 1965	Fiscal Year 1966
Ames Research Center.....	$11,580,000	$5,730,000	$2,749,000
Electronics Research Center.....	4,820,000	10,050,000	10,000,000
Flight Research Center.....	2,495,000	---	---
Goddard Space Flight Center.....	17,181,500	1,791,000	2,400,000
Jet Propulsion Laboratory.....	3,243,200	3,620,000	---
John F. Kennedy Space Center, NASA.....	284,690,300	89,073,200	8,595,000
Langley Research Center.....	9,942,700	4,575,000	8,250,000
Lewis Research Center.....	20,468,000	2,055,000	867,000
Manned Spacecraft Center.....	36,142,000	24,443,000	4,400,000
Marshall Space Flight Center....	30,081,000	14,999,700	4,776,000
Michoud Plant.....	9,058,000	6,313,500	300,000
Mississippi Test Facility.....	96,163,300	54,182,000	2,121,000
Nuclear Rocket Development Station.....	4,190,000	---	---
Various Locations.....	184,820,300	44,299,100	21,694,000
Wallops Station.....	575,000	1,749,000	1,048,000
Facility Planning and Design1/..	---	---	7,500,000
Total Plan.....	$715,450,300	$262,880,500	$74,700,000

1/Amounts appropriated in fiscal year 1964 and 1965 are reflected by location.

A geographic location of NASA installations is shown on the following page. Installations for which construction projects are requested in the fiscal year 1966 budget are identified.

NASA INSTALLATIONS



* Installations for which construction projects are requested in FY 1966 budget.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1966 ESTIMATES

ADMINISTRATIVE OPERATIONS

SUMMARY OF OBLIGATIONS BY INSTALLATION

	Fiscal Year 1964	Fiscal Year 1965	Fiscal Year 1966
MANNED SPACE FLIGHT			
John F. Kennedy Space Center, NASA	$34,959,000	$61,616,000	$62,697,000
Manned Spacecraft Center	68,634,000	91,201,000	89,658,000
Marshall Space Flight Center	124,443,000	140,458,000	137,387,000
SPACE SCIENCE AND APPLICATIONS			
Goddard Space Flight Center	62,466,000	85,923,000	69,591,000
Pacific Launch Operations Office	1,037,000	835,000	804,000
Wallops Station	9,715,000	11,442,000	9,800,000
ADVANCED RESEARCH AND TECHNOLOGY			
Ames Research Center	29,886,000	31,698,000	32,300,000
Electronics Research Center	730,000	3,600,000	7,622,000
Flight Research Center	9,514,000	9,750,000	9,600,000
Langley Research Center	52,642,000	57,258,000	61,783,000
Lewis Research Center	61,694,000	70,971,000	63,880,000
Space Nuclear Propulsion Office	1,472,000	1,725,000	1,838,000
SUPPORTING ACTIVITIES			
Northeastern Office	379,000	---	---
Western Operations Office	4,924,000	5,989,000	6,337,000
NASA Headquarters	49,115,000	73,255,000	56,103,000
TOTAL	$511,610,000	$645,721,000	$609,400,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ADMINISTRATIVE OPERATIONS

NUMBER OF POSITIONS BY LOCATION

	Fiscal Year 1964	Fiscal Year 1965	Fiscal Year 1966
MANNED SPACE FLIGHT			
John F. Kennedy Space Center, NASA	1,625	2,082	2,082
Manned Spacecraft Center	4,277	4,811	4,811
Marshall Space Flight Center	7,679	7,658	7,658
SPACE SCIENCE AND APPLICATIONS			
Goddard Space Flight Center	3,675	3,725	3,725
Pacific Launch Operations Office	22	22	22
Wallops Station	530	530	530
ADVANCED RESEARCH AND TECHNOLOGY			
Ames Research Center	2,204	2,205	2,205
Electronics Research Center	25	250	550
Flight Research Center	619	619	619
Langley Research Center	4,330	4,308	4,308
Lewis Research Center	4,859	4,847	4,847
Space Nuclear Propulsion Office	112	116	116
SUPPORTING OPERATIONS			
North Eastern Office	33	---	---
Western Operations Office	376	406	406
NASA Headquarters	2,133	2,221	2,221
TOTAL	32,499	33,800	34,100

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1966 ESTIMATES

ADMINISTRATIVE OPERATIONS

DISTRIBUTION OF BUDGET PLAN BY OBJECT CLASSIFICATION BY INSTALLATION

(In dollars)

Object Classification	Total	J.F. Kennedy Space Center, NASA	Manned Spacecraft Center	Marshall Space Flight Center	Goddard Space Flight Center	Pacific Launch Operations Office	Wallops Station	Ames Research Center	Electronics Research Center	Flight Research Center	Langley Research Center	Lewis Research Center	Space Nuclear Propulsion Office	North-eastern Office	Western Operations Office	Headquarters
FISCAL YEAR 1964																
Personnel compensation	288,081,000	13,365,000	34,497,000	72,921,000	32,481,000	193,000	3,806,000	19,042,000	137,000	5,659,000	35,926,000	42,969,000	1,125,000	280,000	3,378,000	22,302,000
Personnel benefits	20,241,000	868,000	2,294,000	4,026,000	2,207,000	12,000	268,000	1,389,000	10,000	410,000	2,654,000	3,112,000	32,000	20,000	231,000	1,678,000
Travel & transp of pers	18,536,000	2,181,000	3,874,000	3,337,000	2,409,000	36,000	140,000	508,000	18,000	234,000	1,288,000	1,461,000	171,000	27,000	243,000	2,607,000
Transportation of things	5,400,000	350,000	1,289,000	583,000	1,458,000	7,000	65,000	59,000	---	31,000	450,000	627,000	11,000	1,000	13,000	456,000
Rents, communications, and utilities	47,230,000	2,575,000	5,114,000	11,780,000	10,790,000	111,000	485,000	4,605,000	---	369,000	4,718,000	4,278,000	---	28,000	315,000	1,969,000
Printing and reproduction	4,387,000	818,000	366,000	1,033,000	622,000	6,000	---	37,000	---	6,000	191,000	58,000	---	4,000	13,000	1,233,000
Other services	54,345,000	4,672,000	9,523,000	13,999,000	5,802,000	70,000	915,000	1,644,000	486,000	1,029,000	2,540,000	2,300,000	---	3,000	456,000	10,906,000
Services of other agencies	16,607,000	4,303,000	1,080,000	2,808,000	438,000	94,000	17,000	112,000	37,000	78,000	533,000	7,000	83,000	3,000	173,000	6,841,000
Supplies and materials	24,203,000	3,284,000	3,427,000	5,911,000	2,228,000	141,000	1,344,000	1,045,000	13,000	600,000	2,718,000	2,865,000	---	10,000	51,000	566,000
Equipment	22,236,000	1,753,000	6,442,000	3,814,000	3,356,000	55,000	1,017,000	614,000	29,000	1,007,000	998,000	2,542,000	---	3,000	51,000	555,000
Lands and structures	10,339,000	790,000	727,000	3,330,000	595,000	310,000	1,658,000	831,000	---	98,000	626,000	1,373,000	---	---	---	1,000
Insurance claims and indemnities	5,000	---	1,000	1,000	---	---	---	---	---	---	---	2,000	---	---	---	1,000
Totals	511,610,000	34,959,000	68,634,000	124,443,000	62,466,000	1,037,000	9,715,000	29,886,000	730,000	9,514,000	52,642,000	61,694,000	1,472,000	379,000	4,924,000	49,115,000
FISCAL YEAR 1965																
Personnel compensation	336,696,000	20,417,000	47,685,000	81,344,000	38,391,000	231,000	4,361,000	20,700,000	1,470,000	6,218,000	38,826,000	45,610,000	1,391,000	---	4,155,000	25,897,000
Personnel benefits	23,490,000	1,364,000	3,164,000	5,475,000	2,707,000	16,000	313,000	1,500,000	110,000	432,000	2,861,000	3,314,000	109,000	---	291,000	1,834,000
Travel & transp of pers	21,000,000	2,113,000	4,908,000	3,759,000	2,730,000	50,000	160,000	610,000	240,000	260,000	1,380,000	1,660,000	200,000	---	296,000	2,634,000
Transportation of things	5,675,000	872,000	1,160,000	550,000	1,195,000	12,000	83,000	58,000	121,000	40,000	440,000	650,000	10,000	---	24,000	460,000
Rents, communications, and utilities	53,191,000	3,973,000	7,967,000	13,231,000	9,936,000	90,000	626,000	4,725,000	389,000	337,000	5,424,000	3,987,000	---	---	448,000	2,058,000
Printing and reproduction	4,683,000	851,000	390,000	1,100,000	317,000	8,000	15,000	35,000	35,000	10,000	200,000	65,000	---	---	17,000	1,640,000
Other Services	80,807,000	19,912,000	12,072,000	20,052,000	4,850,000	166,000	1,233,000	1,355,000	394,000	985,000	2,517,000	2,563,000	15,000	---	567,000	14,126,000
Services of other agencies	12,230,000	5,148,000	665,000	2,918,000	334,000	74,000	50,000	105,000	110,000	---	90,000	45,000	---	---	50,000	2,641,000
Supplies and materials	22,968,000	1,700,000	3,889,000	6,100,000	1,796,000	85,000	1,234,000	1,234,000	154,000	540,000	2,600,000	3,150,000	---	---	65,000	421,000
Equipment	79,152,000	4,333,000	8,453,000	4,928,000	23,201,000	46,000	2,546,000	1,076,000	453,000	762,000	2,419,000	9,325,000	---	---	76,000	21,534,000
Lands and structures	5,811,000	932,000	847,000	1,000,000	466,000	57,000	820,000	300,000	124,000	165,000	500,000	600,000	---	---	---	---
Insurance claims and indemnities	18,000	1,000	1,000	1,000	-	---	1,000	---	---	1,000	1,000	2,000	---	---	---	10,000
Totals	645,721,000	61,616,000	91,201,000	140,458,000	85,923,000	835,000	11,442,000	21,698,000	3,606,000	9,730,000	57,258,000	70,971,000	1,725,000	---	5,989,000	73,255,000
FISCAL YEAR 1966																
Personnel compensation	345,207,000	21,879,000	49,997,000	81,675,000	38,544,000	234,000	4,361,000	20,729,000	4,568,000	6,205,000	38,896,000	45,645,000	1,424,000	---	4,378,000	26,822,000
Personnel benefits	24,193,000	1,465,000	3,328,000	5,531,000	2,716,000	16,000	313,000	1,503,000	332,000	435,000	2,889,000	3,338,000	111,000	---	304,000	1,912,000
Travel & transp of pers	21,000,000	1,538,000	5,417,000	3,825,000	2,760,000	40,000	160,000	600,000	270,000	260,000	1,370,000	1,650,000	200,000	---	303,000	2,627,000
Transportation of things	5,049,000	722,000	944,000	550,000	1,157,000	10,000	83,000	58,000	141,000	40,000	440,000	650,000	3,000	---	26,000	221,000
Rents, communications, and utilities	49,556,000	4,385,000	7,143,000	11,786,000	9,745,000	90,000	465,000	5,205,000	784,000	331,000	4,110,000	2,825,000	---	---	469,000	2,218,000
Printing and reproduction	4,869,000	871,000	390,000	1,150,000	342,000	8,000	15,000	35,000	65,000	10,000	200,000	65,000	---	---	17,000	1,701,000
Other services	96,054,000	23,937,000	15,034,000	21,435,000	6,923,000	160,000	1,633,000	1,488,000	762,000	1,644,000	2,866,000	2,849,000	100,000	---	672,000	17,151,000
Services of other agencies	11,969,000	4,620,000	665,000	2,944,000	443,000	80,000	50,000	112,000	153,000	---	90,000	50,000	---	---	38,000	2,724,000
Supplies and materials	23,140,000	1,579,000	3,889,000	6,100,000	1,974,000	85,000	1,234,000	1,234,000	376,000	540,000	2,600,000	3,050,000	---	---	65,000	414,000
Equipment	23,109,000	1,000,000	2,110,000	1,390,000	4,532,000	46,000	760,000	1,036,000	261,000	524,000	7,821,000	3,315,000	---	---	71,000	243,000
Lands and structures	5,235,000	700,000	740,000	1,000,000	525,000	35,000	725,000	300,000	110,000	150,000	500,000	450,000	---	---	---	---
Insurance claims and indemnities	19,000	1,000	1,000	1,000	---	---	1,000	---	---	1,000	1,000	3,000	---	---	---	10,000
Totals	609,400,000	62,697,000	89,658,000	137,387,000	69,591,000	804,000	9,800,000	32,300,000	7,622,000	9,600,000	61,783,000	63,880,000	1,838,000	---	6,337,000	56,103,000

762-047 O - 65 (Fols. Sum 2) No 1

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1966 ESTIMATES

COMPUTATION OF PERSONNEL COSTS BY INSTALLATION AND FISCAL YEAR

(In thousands of dollars)

FISCAL YEAR 1964 ACTUAL	TOTAL NASA	J. F. KENNEDY SPACE CENTER, NASA	MANNED SPACECRAFT CENTER	MARSHALL SPACE FLIGHT CENTER	GODDARD SPACE FLIGHT CENTER	PACIFIC LAUNCH OPERATIONS OFFICE	WALLOPS STATION	AMES RESEARCH CENTER	ELECTRONICS RESEARCH CENTER	FLIGHT RESEARCH CENTER	LANGLEY RESEARCH CENTER	LEWIS RESEARCH CENTER	SPACE NUCLEAR PROPULSION OFFICE	HEADQUARTERS	NORTHEASTERN OPERATIONS OFFICE	WESTERN OPERATIONS OFFICE
Personnel Compensation:																
Permanent positions	$289,440	$14,468	$37,237	$68,967	$33,986	$194	$3,586	$19,528	$277	$5,320	$35,966	$42,557	$1,249	$22,249	$305	$3,551
Pay above the stated annual rate	2,334	113	269	576	270	2	28	164	2	42	305	361	9	160	2	31
Lapses (deduct)	-25,316	-2,904	-7,116	-4,919	-3,059	-13	-235	-1,045	-143	-205	-1,606	-1,950	-136	-1,448	-39	-498
Net cost of permanent positions	$266,458	$11,677	$30,390	$64,624	$31,197	$183	$3,379	$18,647	$136	$5,157	$34,665	$40,968	$1,122	$20,961	$268	$3,084
Other personnel compensation	22,102	1,688	4,107	8,302	1,758	10	427	395	1	502	1,261	2,001	3	1,341	12	294
Total personnel compensation	$288,560	$13,365	$34,497	$72,926	$32,955	$193	$3,806	$19,042	$137	$5,659	$35,926	$42,969	$1,125	$22,302	$280	$3,378
Reimbursable	479	---	---	5	474	---	---	---	---	---	---	---	---	---	---	---
NASA funded	288,081	13,365	34,497	72,921	32,481	193	3,806	19,042	137	5,659	35,926	42,969	1,125	22,302	280	3,378
Total personnel benefits	$20,262	$868	$2,294	$4,926	$2,308	$12	$268	$1,389	$10	$410	$2,654	$3,112	$82	$1,678	$20	$231
Reimbursable	21	---	---	---	21	---	---	---	---	---	---	---	---	---	---	---
NASA funded	20,241	868	2,294	4,926	2,287	12	268	1,389	10	410	2,654	3,112	82	1,678	20	231
Total Personnel Costs	$308,822	$14,233	$36,791	$77,852	$35,263	$205	$4,074	$20,431	$147	$6,069	$38,580	$46,081	$1,207	$23,980	$300	$3,609
Reimbursable	500	---	---	5	495	---	---	---	---	---	---	---	---	---	---	---
NASA funded	308,322	14,233	36,791	77,847	34,768	205	4,074	20,431	147	6,069	38,580	46,081	1,207	23,980	300	3,609
FISCAL YEAR 1965 ESTIMATED																
Personnel Compensation:																
Permanent positions	$320,264	$19,652	$44,456	$74,262	$36,939	$208	$3,904	$20,220	$2,799	$5,671	$37,424	$43,611	$1,389	$25,652	---	$4,077
Pay above the stated annual rate	1,260	70	163	298	134	1	15	78	10	22	175	173	6	99	---	16
Lapses (deduct)	-9,592	-1,556	-2,488	-1,565	-376	-6	-81	-39	-1,411	-122	-216	-219	-10	-1,272	---	-231
Net cost of permanent positions	$311,932	$18,166	$42,131	$72,995	$36,697	$203	$3,838	$20,259	$1,398	$5,571	$37,383	$43,565	$1,385	$24,479	---	$3,862
Other personnel compensation	25,277	2,251	5,554	8,352	2,204	28	523	441	72	647	1,443	2,045	6	1,418	---	293
Total personnel compensation	$337,209	$20,417	$47,685	$81,347	$38,901	$231	$4,361	$20,700	$1,470	$6,218	$38,826	$45,610	$1,391	$25,897	---	$4,155
Reimbursable	513	---	---	3	510	---	---	---	---	---	---	---	---	---	---	---
NASA funded	336,696	20,417	47,685	81,344	38,391	231	4,361	20,700	1,470	6,218	38,826	45,610	1,391	25,897	---	4,155
Total personnel benefits	$23,533	$1,364	$3,164	$5,475	$2,750	$16	$313	$1,500	$110	$432	$2,861	$3,314	$109	$1,834	---	$291
Reimbursable	43	---	---	---	43	---	---	---	---	---	---	---	---	---	---	---
NASA funded	23,490	1,364	3,164	5,475	2,707	16	313	1,500	110	432	2,861	3,314	109	1,834	---	291
Total Personnel Costs	$360,742	$21,781	$50,849	$86,822	$41,651	$247	$4,674	$22,200	$1,580	$6,650	$41,687	$48,924	$1,500	$27,731	---	$4,446
Reimbursable	556	---	---	3	553	---	---	---	---	---	---	---	---	---	---	---
NASA funded	360,186	21,781	50,849	86,819	41,098	247	4,674	22,200	1,580	6,650	41,687	48,924	1,500	27,731	---	4,446
FISCAL YEAR 1966 ESTIMATED																
Personnel Compensation:																
Permanent positions	$323,702	$19,767	$44,674	$74,358	$36,936	$211	$3,904	$20,220	$5,716	$5,744	$37,424	$43,610	$1,415	$25,645	---	$4,078
Pay above the stated annual rate	1,284	75	208	258	137	1	15	78	22	22	175	173	6	99	---	15
Lapses (deduct)	-4,058	-300	-511	-863	-192	-1	-81	-10	-1,527	-44	-80	-90	-3	-355	---	-1
Net cost of permanent positions	$320,928	$19,542	$44,371	$73,753	$36,881	$211	$3,838	$20,288	$4,211	$5,722	$37,519	$43,693	$1,418	$25,389	---	$4,092
Other personnel compensation	24,995	2,337	5,626	7,925	2,376	23	523	441	157	543	1,377	1,942	6	1,433	---	286
Total personnel compensation	$345,923	$21,879	$49,997	$81,678	$39,257	$234	$4,361	$20,729	$4,368	$6,265	$38,896	$45,635	$1,424	$26,822	---	$4,378
Reimbursable	716	---	---	3	713	---	---	---	---	---	---	---	---	---	---	---
NASA funded	345,207	21,879	49,997	81,675	38,544	234	4,361	20,729	4,368	6,265	38,896	45,635	1,424	26,822	---	4,378
Total personnel benefits	$24,243	$1,465	$3,328	$5,531	$2,766	$16	$313	$1,503	$332	$435	$2,889	$3,338	$111	$1,912	---	$304
Reimbursable	50	---	---	---	50	---	---	---	---	---	---	---	---	---	---	---
NASA funded	24,193	1,465	3,328	5,531	2,716	16	313	1,503	332	435	2,889	3,338	111	1,912	---	304
Total Personnel Costs	$370,166	$23,344	$53,325	$87,209	$42,023	$250	$4,674	$22,232	$4,700	$6,700	$41,785	$48,973	$1,535	$28,734	---	$4,682
Reimbursable	766	---	---	3	763	---	---	---	---	---	---	---	---	---	---	---
NASA funded	369,400	23,344	53,325	87,206	41,260	250	4,674	22,232	4,700	6,700	41,785	48,973	1,535	28,734	---	4,682

762-047 O - 65 (Fols. Sum 2) No. 2

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1966 ESTIMATES

DISTRIBUTION OF PERSONNEL POSITIONS BY INSTALLATION AND FISCAL YEAR

FISCAL YEAR 1964 ACTUAL	TOTAL NASA	J. F. KENNEDY SPACE CENTER, NASA	MANNED SPACECRAFT CENTER	MARSHALL SPACE FLIGHT CENTER	GODDARD SPACE FLIGHT CENTER	PACIFIC LAUNCH OPERATIONS OFFICE	WALLOPS STATION	AMES RESEARCH CENTER	ELECTRONICS RESEARCH CENTER	FLIGHT RESEARCH CENTER	LANGLEY RESEARCH CENTER	LEWIS RESEARCH CENTER	SPACE NUCLEAR PROPULSION OFFICE	HEADQUARTERS NASA	NORTHEASTERN OPERATIONS OFFICE	WESTERN OPERATIONS OFFICE
TOTAL EXCEPTED POSITIONS a/	415	14	35	56	40	-	1	26	-	6	36	35	3	158	2	3
General Schedule Positions:																
GS-16	4	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-
GS-15	1,612	51	191	351	190	1	5	112	6	15	137	155	20	365	3	10
GS-14	2,463	102	314	658	347	4	8	146	5	29	219	294	20	271	5	41
GS-13	3,677	243	596	942	535	1	19	193	3	41	304	536	23	180	2	59
GS-12	3,663	302	560	996	480	3	25	153	2	58	357	512	7	123	2	83
GS-11	3,179	206	485	875	467	3	27	139	-	52	411	398	3	70	1	42
GS-10	23	1	-	1	-	-	3	2	-	-	-	12	-	4	-	-
GS-9	2,463	99	396	422	391	-	22	180	1	50	448	372	2	70	3	7
GS-8	51	3	-	4	8	-	-	-	-	2	2	9	-	22	-	1
GS-7	1,693	83	341	288	223	-	41	119	1	27	215	200	2	146	2	5
GS-6	670	44	54	72	79	2	4	35	1	11	69	58	4	223	-	14
GS-5	1,816	106	296	379	250	1	46	121	3	21	179	127	14	214	2	63
GS-4	1,971	150	371	507	226	5	32	119	1	25	153	206	11	122	8	35
GS-3	1,290	94	219	402	103	1	16	58	1	5	155	149	3	73	2	9
GS-2	155	3	5	68	5	1	12	7	1	-	23	16	-	11	-	3
TOTAL GENERAL SCHEDULE POSITIONS	24,730	1,487	3,828	5,969	3,304	22	254	1,384	25	336	2,672	3,044	109	1,894	30	372
TOTAL WAGE BOARD POSITIONS	6,839	91	308	1,477	266	-	261	791	-	263	1,571	1,772	-	39	-	-
TOTAL PERMANENT POSITIONS	31,984	1,592	4,171	7,502	3,610	22	516	2,201	25	605	4,279	4,851	112	2,091	32	375
OTHER TEMPORARY POSITIONS	515	33	106	177	65	-	14	3	-	14	51	8	-	42	1	1
GRAND TOTAL POSITIONS - FY 1964	32,499	1,625	4,277	7,679	3,675	22	530	2,204	25	619	4,330	4,859	112	2,133	33	376
FISCAL YEAR 1965 ESTIMATED																
TOTAL EXCEPTED POSITIONS a/	439	15	35	54	40	-	1	29	10	6	38	35	3	170	-	3
General Schedule Positions:																
GS-16	183	9	15	41	21	-	1	17	-	3	16	17	3	39	-	1
GS-15	1,694	62	222	390	190	1	4	97	16	13	129	155	16	384	-	15
GS-14	2,707	108	398	663	383	4	8	150	50	31	222	319	20	302	-	49
GS-13	4,217	382	736	1,040	554	3	27	219	50	49	318	537	33	207	-	62
GS-12	4,024	369	664	1,052	568	5	42	169	20	54	372	490	5	132	-	82
GS-11	3,454	269	594	899	502	1	31	151	14	56	421	398	3	71	-	44
GS-10	31	1	-	1	-	-	2	5	-	-	-	12	-	10	-	-
GS-9	2,495	131	479	412	380	-	21	145	4	40	443	358	-	74	-	8
GS-8	59	3	1	4	9	-	-	-	-	-	2	11	-	28	-	1
GS-7	1,591	116	332	279	155	-	21	105	1	20	191	212	4	149	-	6
GS-6	726	47	63	75	103	1	9	34	11	16	69	58	4	223	-	13
GS-5	1,833	141	311	391	170	3	49	110	38	22	175	129	16	213	-	65
GS-4	1,889	193	339	516	180	1	26	106	34	24	152	180	8	91	-	39
GS-3	999	91	174	223	112	-	8	52	2	8	135	146	1	35	-	12
GS-2	149	7	1	69	38	-	-	6	-	-	8	10	-	9	-	1
TOTAL GENERAL SCHEDULE POSITIONS	26,051	1,929	4,329	6,055	3,365	19	249	1,366	240	336	2,653	3,032	113	1,967	-	398
TOTAL WAGE BOARD POSITIONS	6,710	101	322	1,380	272	-	268	790	-	263	1,547	1,748	-	19	-	-
TOTAL PERMANENT POSITIONS	33,200	2,045	4,686	7,489	3,677	19	518	2,185	250	605	4,238	4,815	116	2,156	-	401
OTHER TEMPORARY POSITIONS	600	37	125	169	48	3	12	20	-	14	70	32	-	65	-	5
GRAND TOTAL POSITIONS - FY 1965	33,800	2,082	4,811	7,658	3,725	22	530	2,205	250	619	4,308	4,847	116	2,221	-	406
FISCAL YEAR 1966 ESTIMATED																
TOTAL EXCEPTED POSITIONS a/	439	15	35	54	40	-	1	29	11	6	38	35	3	169	-	3
General Schedule Positions:																
GS-16	183	9	15	41	21	-	1	17	-	3	16	17	3	39	-	1
GS-15	1,724	62	222	390	190	1	4	97	46	13	129	155	16	384	-	15
GS-14	2,767	108	398	663	383	4	8	150	110	31	222	319	20	302	-	49
GS-13	4,299	382	736	1,066	554	3	27	210	114	49	318	537	33	208	-	62
GS-12	4,101	369	664	1,081	568	5	42	182	55	54	372	490	5	132	-	82
GS-11	3,475	269	594	909	502	1	31	157	19	56	421	398	3	71	-	44
GS-10	31	1	-	1	-	-	2	5	-	-	-	12	-	10	-	-
GS-9	2,541	131	479	433	380	-	21	165	9	40	443	358	-	74	-	8
GS-8	59	3	1	4	9	-	-	-	-	-	2	11	-	28	-	1
GS-7	1,578	116	332	279	155	-	21	72	21	20	191	212	4	149	-	6
GS-6	738	47	63	76	103	1	9	33	21	16	69	58	6	223	-	13
GS-5	1,865	141	311	391	170	3	49	119	39	22	175	129	18	213	-	65
GS-4	1,932	193	339	528	180	1	26	106	69	24	152	180	4	91	-	39
GS-3	1,008	91	174	224	112	-	8	46	16	8	135	146	1	35	-	12
GS-2	150	7	1	69	38	-	-	7	-	-	8	10	-	9	-	1
TOTAL GENERAL SCHEDULE POSITIONS	26,451	1,929	4,329	6,155	3,365	19	249	1,366	539	336	2,653	3,032	113	1,968	-	398
TOTAL WAGE BOARD POSITIONS	6,610	101	322	1,280	272	-	268	790	-	263	1,547	1,748	-	19	-	-
TOTAL PERMANENT POSITIONS	33,500	2,045	4,686	7,489	3,677	19	518	2,185	550	605	4,238	4,815	116	2,156	-	401
OTHER TEMPORARY POSITIONS	600	37	125	169	48	3	12	20	-	14	70	32	-	65	-	5
GRAND TOTAL POSITIONS - FY 1966	34,100	2,082	4,811	7,658	3,725	22	530	2,205	550	619	4,308	4,847	116	2,221	-	406

a/Total Excepted Positions include two (2) Special Ungraded and twelve (12) P.L. 313 positions.

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1966 ESTIMATES

ADMINISTRATIVE OPERATIONS

ANALYSIS OF REQUIREMENTS FOR PASSENGER-CARRYING MOTOR VEHICLES

The appropriation language provides for the purchase of 30 passenger motor vehicles, of which 6 are for augmentation to the fiscal year 1965 ending inventory and 24 are for replacement. All vehicles scheduled for replacement meet, or will meet, the criteria established by the General Services Administration for replacement of vehicles due either to age, mileage, annual maintenance costs, or a combination of these factors.

A summary analysis and planned procurement by class of vehicle in fiscal year 1966 is as follows:

	Total	Medium Sedans	Sedans	Station Wagons	Ambulances	Buses
On hand July 1, 1965..	183	1	47	113	11	11
Total to be procured:	30	-	7	15	-	8
(For replacement)...	(24)	-	(4)	(15)	(-)	(5)
(Disposed - not replaced).....	(3)	-	(2)	(1)	(-)	(-)
On hand June 30, 1966.	186	1	48	112	11	14

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY — BASIC RESEARCH PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The purpose of the Basic Research Program is to initiate and administer fundamental research in the physical and mathematical sciences which will provide an understanding of phenomena which are important to the development of current and future aircraft and spacecraft. This basic research is carried out in NASA's Research Centers with some contract assistance by universities, industrial and other Government laboratories. Fundamental knowledge in many fields is essential for NASA's programs to advance in an orderly manner and on a scientific basis. Basic research in NASA has, therefore, to cover a wide range of disciplines, and varies from very fundamental studies into the nature of the atomic nucleus and its internal energies to more applied research in materials for application to supersonic transports or entry vehicles. Much of the Basic Research Program cannot be specifically identified with current NASA projects. Its broad objective is to increase man's knowledge and understanding of the physical laws of nature and of their mathematical expression, definition, and interpretation.

Engineers today must frequently use materials which are inadequate to meet the special requirements of particular applications. As a result they must "over design", adding more weight to assure adequate performance. Thus the goal in materials research is to obtain construction materials which are safer, lighter in weight, more temperature resistant, and allow cheaper construction.

In the electrophysics area, superconductivity, characterized by zero electrical resistance of some metals at temperatures near absolute zero, is being studied to learn more about the mechanisms of the electron movement within the crystal structure and to discover in this way new materials which exhibit these same characteristics at somewhat higher temperatures. Many applications are awaiting results of this research; for example, superconducting devices such as a cryogenic gyroscope which will rotate for long periods of time with no power requirements, using extremely small but very powerful magnets.

In fluid physics, refinements in magnetohydrodynamic accelerators may lead to a laboratory facility which, as a wind tunnel of extreme speed, will permit more realistic simulation of reentry conditions prevailing around space vehicles returning to the Earth or entering the atmosphere of other planets. Research in this field is also leading to an understanding of the principles of electric propulsion devices, plasma flows in atomic power generators, and such fundamental phenomena as the interaction of the solar wind with the Earth's magnetosphere.

In applied mathematics, another important part of the Basic Research Program, new and improved mathematical techniques are being developed which will enable complex physical phenomena to be represented more easily and more accurately and to be studied with greater accuracy and speed on electronic computers. These techniques will, in time, lead to the solution of many important physical and mechanical problems of the kind that now are extremely time consuming or even impossible to solve with present analytical and numerical methods.

SUMMARY OF RESOURCES REQUIREMENTS:

	1964	1965	1966
Supporting research and technology	$22,653,000	$21,231,000	$22,000,000
Total	$22,653,000	$21,231,000	$22,000,000

Distribution of Program Amount by Installation:

Marshall Space Flight Center	$986,000	$916,000	$920,000
Goddard Space Flight Center	235,000	257,000	260,000
Jet Propulsion Laboratory	6,443,000	5,792,000	5,800,000
Ames Research Center	1,692,000	1,881,000	1,900,000
Electronics Research Center	---	---	200,000
Flight Research Center	---	30,000	30,000
Langley Research Center	1,466,000	1,861,000	1,920,000
Lewis Research Center	3,464,000	2,234,000	2,750,000
NASA Headquarters	7,831,000	8,260,000	8,220,000
Western Operations Office	536,000	---	---

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

	1964	1965	1966
Fluid physics	$7,887,000	$7,830,000	$8,000,000
Electrophysics	3,986,000	3,940,000	4,100,000
Materials research	9,582,000	8,156,000	8,600,000
Applied mathematics	1,198,000	1,305,000	1,300,000
Total	$22,653,000	$21,231,000	$22,000,000

Fluid Physics

The objective of basic research in fluid physics is an understanding of the fundamental processes determining the behavior of liquids and gases. Emphasis is placed on the study of processes related directly or indirectly to problems anticipated in the development of future spacecraft and aircraft. For example, problems of fluid physics are involved in the erosion of electrodes

and insulators in magnetogasdynamic propulsion devices where gas temperatures reach 50,000 degrees Fahrenheit. At these temperatures gas mixtures react chemically, interact with structural materials, and undergo molecular and atomic decompositions, causing significant alterations of the flow field and of the thermal and mechanical stresses in exposed structures. Similar problems are encountered in the hot gas cap surrounding space vehicles during atmosphere entry and result in dangerous structural stresses and severe control and communications problems. The successful solution to these and similar problems which stand in the way of minimum weight, long life spacecraft systems depends in large measure on a productive fluid physics research program.

During FY 1966 research will continue on the high temperature properties of the gases known to make up the Earth's atmosphere and of others believed to be present in the atmospheres of Mars and Venus. These properties, which will be obtained at the Ames Research Center and under contract, are essential to the prediction of flow conditions about a vehicle and hence to the structural and aerodynamic design of interplanetary spacecraft. For example, the thermal radiative properties of air and carbon dioxide nitrogen mixtures, simulating the composition of the Venusian and Martian atmospheres, show large variations at certain wave lengths in electromagnetic spectrum. Much must be learned about the characteristics, particularly in the ultraviolet wave lengths, before spacecraft designers can proceed with confidence with the design of planetary landers.

Another important high temperature characteristic of certain gases is their tendency to become ionized. Gases in this state are called plasmas and research on plasma phenomena has become an important field of fluid physics. To understand the principles involved is essential, for example, to the design of electromagnetic gas accelerators and certain energy converters. In FY 1966, plasma physics research will be focused on fundamental problems of plasma stability which are impeding the development of a number of plasma propulsive devices. Successful solution of these problems may also lead to the design and construction of a hypervelocity plasma tunnel for model testing under reentry conditions. This is the only technique so far discovered that has the potential of complete simulation of these conditions in a continuous stream. Such a facility would become a powerful tool for materials and structural research. The Langley, Lewis and Ames Research Centers, assisted by some outside contracts, are conducting the plasma physics research program.

Another important objective in fluid physics research during FY 1966 is an understanding of turbulent boundary layer behavior on hypersonic aircraft. Accurate predictions of boundary layer behavior are essential to reliable predictions of airplane performance. The present uncertainty in understanding of hypersonic boundary layers must be overcome before the feasibility of hypersonic cruise aircraft can be assessed with confidence. Hypersonic turbulent boundary layers will be studied at the Langley and Lewis Research Centers, especially under the high heat transfer conditions expected on airplane surfaces and in engine inlets and nozzles.

Electrophysics

Electrophysics includes experimental and theoretical investigations of the reactions of electronic, atomic and nuclear states of solids, liquids and gases which are influenced by the static or dynamic forces of gravitational, nuclear, magnetic and electric fields. Information from this research is generally applicable to engineering advances in such fields as space power, radiation effects and electronic communications.

Research is under way to determine and explain the mechanisms of energy transfer within the atomic levels of solids and gases. This will lead to new sources for the stimulated emission of coherent electromagnetic waves (lasers) in the region from gamma ray to millimeter wave lengths. The availability of such signal sources would substantially advance our capabilities in electronic communication and navigation for spacecraft. This research is being conducted at the Massachusetts Institute of Technology, Stanford University, University of Michigan and Johns Hopkins University, under NASA contracts.

Theoretical and experimental research in superconductivity research is being conducted to increase the critical temperature and magnetic field strength of superconductors. Superconducting coils offer a superior method with respect to weight, volume and power requirements for obtaining strong magnetic fields. These fields may conceivably be used to shield spacecraft from harmful solar particle radiation and also to confine properly the flow of ionized gases in magnetohydrodynamic and controlled thermonuclear electric power generators. Other potential uses of superconductors are for electric power transmission lines, for computers, and for rotating electrical motors and generators. The research is being carried out by the Lewis Research Center, the Jet Propulsion Laboratory, and the University of Chicago.

One outstanding accomplishment in the Basic Research Program during FY 1965 was the generation of acoustic energy in solids and liquids by high intensity pulsed light from a laser. This acoustic wave has a frequency thousands of times higher than that of ultrasonic sound waves produced by previous methods. Coherent acoustic energy may become a new research tool to probe further the behavior of electrons and ions which form the structure of solid state devices such as semiconductors, transistors and lasers. It may also be possible to adapt acoustic energy to industrial nondestructive testing techniques.

In FY 1966, the existing program will be continued. Additional emphasis will be placed on exploring nuclear reactions to obtain a better understanding of the forces binding the nuclei. Such knowledge not only will explain better the reactions of primary solar radiations impinging on spacecraft structures, but also provide new information about the secondary radiations arising from the primary reactions. This information may be helpful to spacecraft designers. Also, a more intense effort will be made to explore the energy transformations in the lattice structure due to applied electric and magnetic forces. The results may lead to greatly improved electronic circuit components for space navigation and communication systems.

Materials Research

The role of basic research in materials is to gain an understanding of the basic physical and chemical nature of solids. It is only through such understanding that NASA can continue to meet its growing needs for improved materials.

The program is broad in scope and ranges from basic studies of the electronic and atomic nature of matter to its application in airplanes and space vehicles. It deals with the thermodynamics of chemical reactions involved in the production and utilization of materials, and with the physical metallurgy and chemistry of complex alloys, ceramics, and polymers from which many devices used in flight programs are constructed. The program includes studies of the basic mechanisms by which materials deteriorate in service. One example is the study at Ames Research Center on the mechanism by which ablative materials deteriorate upon reentering the Earth's atmosphere. It is this breaking down of the ablative material that provides the heat protection to spacecraft. When the ablation process is completely understood, it will be possible to utilize current ablative materials more efficiently and to develop better ablatives for future spacecraft.

Encouraging results during the past year indicate that the entire Materials Research Program will show substantial progress in FY 1966. One aspect of this program should be particularly productive: the understanding of the electrical, chemical and physical nature of surfaces. This understanding is very important in problems involving almost all phases of materials behavior, and is finding frequent application in the development of space vehicles and high speed aircraft. For example, the 20 year backlog of scientific knowledge and experience in oxidation resistant high temperature alloys will, in FY 1966, be applied to the specific problem of designing stator and turbine blades for the engines of the Mach 3 supersonic transport. These engine components will be operating at temperatures 300 to 400 degrees Fahrenheit higher than those in current engines, a temperature region where oxidation becomes a severe problem.

Another aspect of materials research which is progressing well and should find practical application in FY 1966 is that of dispersion strengthened materials. These are metals or alloys which have been strengthened through the introduction of very small hard particles that retard slipping between the metal crystals. In the past, research on these materials has resulted in an accumulation of scientific knowledge on the mechanism by which such particles strengthen metals. A clear picture is almost at hand and will result in a dispersion strengthened nickel to be evaluated in FY 1966 for the structure of the supersonic transport airplane. This material should hasten the final design of this airplane.

Applied Mathematics

Research in applied mathematics is concerned with the development of improved mathematical techniques for the solution of physical problems. The

problems which may arise in aerospace science or engineering usually require the solution of non-linear differential equations. Fast and simple solutions are desired for planning experiments and predictive evaluation of results, because this is often the most feasible and economical way.

While substantial progress has been made in this direction, there remain many problems in the physical sciences which await mathematical formulation and solution. One of these is the problem of three bodies, that is, the question of solving the mathematical equations representing motion of, say, a lunar satellite or space probe moving under the influence of gravitational fields of two or more large masses, each having relatively large effects. Since a lunar probe or satellite is thus influenced by the Earth, Moon, and Sun, while any planetary probe will be critically influenced by some planet as well as the Sun, it is clear that the three body problem will recur for many future space missions. Already special cases of the three body problem have been solved to a satisfactory degree, and it is planned in FY 1966 to expand the work into the more general cases which are involved in space flight.

Efforts will also be made to find mathematical methods, both analytical and numerical, which could be used in determining the orbits of lunar satellites to a high degree of accuracy. The mathematical methods for determining and programming such an orbit are still untested and uncertain and preliminary considerations have shown that many types of lunar orbits will be highly unstable.

Similarly, there will also be efforts to improve the mathematical analysis of spacecraft and aircraft structures. Problems in this field include those of the strength of plates and shells for such structures, and of determining the requirements or limitations of modern aircraft to fly optimum trajectories between two airports.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1966 ESTIMATES

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY — SPACE VEHICLE SYSTEMS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objectives of the Space Vehicle Systems Program are to identify and solve the critical design problems associated with space vehicle launch and ascent through the atmosphere, flight through space, entry into the atmosphere of earth or other planets, and landing. The program seeks to advance the state-of-the-art on a broad front to permit the conception and development of advanced vehicles and at the same time to solve critical technical problems that may arise during the course of development of present generation space vehicles.

The space vehicle during launch and ascent through the atmosphere must cope successfully with a wide variety of problems which include ground-wind loads, mechanical vibration, intense acoustic noise, severe gusts and wind gradients aloft, propellant sloshing, control forces, and many others. The highest possible structural efficiency is required to achieve minimum weight while assuring no structural failure. Flight through space takes place in an environment of high energy charged particle radiations, meteoroids, high vacuum, cold space and unattenuated thermal radiation from the sun, and is further characterized by a condition of zero gravity, all of which must be understood and dealt with by proper structural and system design. Return to earth (or exploratory missions to the surfaces of other planets) is characterized by high speed atmosphere entry with its intense heating which must be well understood and accurately predicted and for which adequate thermal protective structures must be devised. Research must be carried out in aerothermodynamics, structures, and in the several disciplines associated with the space environment by means of a variety of laboratory facilities and by carefully selected flight experiments to provide the detailed technological knowledge required for the design of advanced space vehicles.

Major progress was made during the past year in a number of important areas. Significant highlights include two atmosphere entry flights; one, Project Fire which measured the heating environment at 38,000 feet per second, and the other, a Scout launched experiment which measured the behavior of an advanced ablative heat shield material in the heating environment at 28,000 feet per second. A preliminary flight program at the Flight Research Center of a simplified light weight test vehicle of the M-2 lifting body configuration was successfully completed and an extension of this program was implemented by a contract for the construction of two all metal M-2 and HL-10 test vehicles with higher and more realistic planform loadings. The Explorer XXIII meteoroid satellite was successfully orbited. An important secondary experiment to measure launch vehicle structural response to severe wind gradients aloft was successfully carried out during the Explorer XIII launch.

Substantial progress was also made in ground based research and included the generation of new structural and aerodynamic concepts for planetary entry probes and techniques for use in determining the properties and composition of the atmosphere of Mars, new high velocity particle impact results contributing to our knowledge of the meteoroid hazard, and large scale measurements of the acoustic noise field generated by the high velocity hydrogen exhaust from a nuclear rocket.

During the coming year emphasis will be placed on further advancing the technology of lifting entry flight through the extended M-2 and HL-10 flight test program and through augmented laboratory research on heat protection systems and in other areas. Corollary flight experiments to measure turbulent boundary layer heat transfer and to determine the performance of advanced ablative heat shield materials will be undertaken. Emphasis will continue on determination of the meteoroid hazard, and a major milestone in that program is expected within the coming year with the Saturn launchings of Pegasus spacecraft with their 2000 square feet of meteoroid detection area. Augmented effort will be given to research on the effects of high energy radiation on space vehicle materials, components, and subsystems in the Langley Research Center's new Space Radiation Effects Laboratory with its 600 million electron volt cyclotron.

Emphasis will also be placed during the coming year on accelerating progress in the development of critical design criteria for space vehicles incorporating the most recent results of ground based research and flight experiments in order to provide industry, the NASA, and other Government agencies with vitally needed technical guidelines.

SUMMARY OF RESOURCES REQUIREMENTS:

	1964	1965	1966
Supporting research and technology..	$24,951,000	$24,559,000	$24,000,000
Project FIRE.....	7,037,000	2,811,000	500,000
Scout reentry project.....	305,000	750,000	5,000,000
Lifting body flight and landing tests.....	1,200,000	1,500,000	1,000,000
Project Pegasus (Saturn-launched meteoroid experiment).....	9,900,000	13,690,000	2,500,000
Small space vehicle flight experiments.....	1,959,000	1,010,000	2,000,000
Scout launched meteoroid experiments.....	362,000	175,000	---
Total.....	$45,714,000	$44,495,000	$35,000,000

	1964	1965	1966
Distribution of Program Amount by Installation:			
Manned Spacecraft Center.....	$629,000	$730,000	$855,000
Marshall Space Flight Center.....	13,569,000	16,744,000	4,490,000
Goddard Space Flight Center.....	878,000	956,000	930,000
Jet Propulsion Laboratory.....	4,577,000	3,438,000	3,140,000
Ames Research Center.....	1,942,000	2,922,000	2,655,000
Flight Research Center.....	1,403,000	2,020,000	1,180,000
Langley Research Center.....	15,257,000	9,659,000	13,461,000
Lewis Research Center.....	3,186,000	2,326,000	1,770,000
NASA Headquarters.....	3,282,000	5,700,000	6,519,000
Western Operations Office.....	991,000	---	---

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

	1964	1965	1966
Spacecraft aerothermodynamics.....	$5,452,000	$5,242,000	$5,346,000
Spacecraft loads and structures.....	4,495,000	5,209,000	5,560,000
Launch vehicle aerothermodynamics...	826,000	1,264,000	1,300,000
Launch vehicle loads and structures.	3,720,000	3,350,000	3,414,000
Space vehicle environmental factors.	7,506,000	6,745,000	7,105,000
Advanced space vehicle concepts.....	2,371,000	1,949,000	550,000
Space vehicle design criteria.....	581,000	800,000	725,000
Total.....	$24,951,000	$24,559,000	$24,000,000

Spacecraft Aerothermodynamics

The purpose of this research is to provide information on aerodynamic heating and heat protection, advanced configurations, and landing and recovery. This information supports existing vehicle development programs and provides new concepts for future space vehicles.

Two successful flight research programs added materially to the aerodynamic heating technology during the past year. One of these programs was Project FIRE which measured the atmospheric entry heating at a speed of 38,000 feet per second where radiative heating is an important problem. This experiment provided highly significant new flight data for correlation with results of ground based research and theoretical predictions which have contained considerable uncertainty. In the other flight, an ablative heat shield experiment was flown on a Scout rocket at an entry velocity of 28,000 feet per second. A large spread in the predictions of heat shield performance had been obtained from ground based facilities. These flights, by providing anchor point data, are contributing greatly to a better understanding of test data obtained in ground based facilities.

In the field of manned entry vehicles, research continues on the lifting body concept. This principle provides maneuverability during entry and the possibility of conventional horizontal landing on land. Significant progress was made in the past year at Langley and Ames Research Centers in defining controllable configurations and in solving the stability problems. During FY 1966, ground based research will emphasize high speed performance, stability and control, vehicle heat protection, and problems associated with abort and emergency landings.

A preliminary flight investigation at the Flight Research Center of a light weight test vehicle of the M-2 lifting body configuration has been successfully completed. During the coming year heavier test vehicles of both the M-2 and HL-10 designs will be constructed and flown to study approach and landing problems at weights more representative of operational vehicles.

Research has continued at the Manned Spacecraft Center over the past year in an effort to provide other safe and reliable means of recovering manned spacecraft. Landing of heavy spacecraft, in the order of 10,000 pounds, would now require the use of multiple parachutes to provide a descent speed low enough to assure the safety of spacecraft and astronauts. These systems are heavy, require large stowage volumes, and are difficult to make reliable. Research has lead to a single large parachute (capable of recovering a 10,000 pound spacecraft) with greatly increased reliability. During FY 1966 this program will emphasize further reduction in weight of the single parachute system and will continue research on other concepts, such as steerable parachutes, parachute retro-rocket systems and light weight variable drag devices.

Spacecraft Loads and Structures

The purpose of this research program is to provide new concepts and new analytical and experimental tools for the structural design of spacecraft. The program encompasses: advanced structural concepts, new applications of materials, definition of loads, techniques for analyzing and testing structural response and structural failure, protection against entry heating and the hazards of space, storage of cryogens during long periods of space flight, and protection of components against vibrational environments and landing impact.

In the area of advanced structural concepts, a number of concepts have been generated which are sufficiently promising to warrant further evaluation in FY 1966. One example is an expandable airlock system which could be used for servicing or rendezvousing operations between space stations and spacecraft. The airlock is capable of compact storage and expansion by virtue of the application of elastic foam as part of its structure. A gas-tight liner prevents loss of internal air pressure. Tensile loads due to pressure are carried by a knitted structure. Protection against the space environment is achieved by a reflective outer shield and the meteoroid protection characteristics of the foam inner layers.

During the many operations of space vehicles, electronic and structural components are subjected to high frequency vibrations. This is an important

and complex problem occasionally resulting in mission failure but more often causing serious weight penalties resulting from overdesign. Methods of predicting space vehicle loads and load transmission through structures are inadequate, as are current methods of isolating vibrations and of proof testing spacecraft to ensure against failure resulting from vibrations. Research at the Goddard Space Flight Center and Langley Research Center will concentrate on these problems in FY 1966.

The importance of hydrogen as a fuel for future space missions is well recognized. The current program to meet the requirements for storage of hydrogen and other cryogens in space for periods greater than a few weeks will be continued in FY 1966. This research, under way at the Lewis Research Center and Marshall Space Flight Center, is emphasizing the important problems of thermal and meteoroid protection, selection of materials, and the design and fabrication of cryogenic tanks.

Launch Vehicle Aerothermodynamics

The Launch Vehicle Aerothermodynamics program is concerned with the study of new launch vehicle concepts and with the solution of heating, aerodynamic, and related problems of current and future launch vehicles. Among the important specific problems are base heating from rocket exhaust and the generation and propagation of intense acoustic noise.

One objective of this program is to develop feasible concepts for recoverable launch vehicles. Attention will be given to methods for recovery of present types of vehicles using auxiliary devices and to advanced types of vehicles designed to have flight characteristics appropriate to recovery.

Another current objective of the program is to find solutions to the base heating problems of large multi-engine launch vehicles. Research has shown that a contributing cause of these problems is the burning of the fuel-rich exhaust gases from the turbopumps in the base region. This will be explored further in the coming year. Research will also continue on theoretical and experimental methods of predicting the amount of radiative and convective base heating contributed by the rocket jets, the recirculation and burning of unburned gases from these jets, and the burning of entrained waste gases. The work includes the development of inexpensive experimental methods of determining base heating on models and the establishment of appropriate scaling laws.

In the area of research on noise generation and propagation, comprehensive measurements were made for the first time during the past year of the acoustic-noise field generated by the high velocity hydrogen jet exhaust from a nuclear rocket (KIWI). These, and similar experiments, will provide important information for the structural design of nuclear powered space vehicle systems and components and of test stands and surrounding buildings. Research on rocket noise generation will continue in FY 1966 with emphasis on providing improved understanding of the mechanism of noise production in high velocity jets.

In a related field, the effects of atmospheric conditions on the propaga-

tion of noise are under study. It has been found that temperature inversions and local winds cause focusing of sound waves from rocket test stands which can result in structural damage at distances from the test site normally considered safe. Research is continuing on sound propagation under a variety of atmospheric conditions quickly and accurately so that static tests of large boosters can be scheduled with less fear of building damage or disturbances to communities.

Launch Vehicles Loads and Structures

The purpose of this program is to derive and evaluate advanced structural concepts and new materials applications for launch vehicles; to define the loading to which the structures will be subjected; to improve analytical and experimental methods of determining structural response to loads; and to develop means of proof testing launch vehicles to ensure against failure.

Ground winds to which large launch vehicles are subjected on the launch pad constitute a major design load for these structures. Experimental research with scaled models in low speed wind tunnels, conducted by the Langley and Ames Research Centers, and related research at Marshall Space Flight Center, has produced important information on the nature of these loads and the structural response of launch vehicles. Approximate methods for predicting loads on full scale vehicles have been developed. During the coming year these analytical methods, and the scaled model results, will be evaluated and compared with full scale tests.

A second important objective of this program is an understanding of the dynamic loads imposed on launch vehicles during powered flight. These loads, caused by wind shear, thrust vectoring, fuel slosh, and aerodynamic flow instabilities, have caused structural failure in launch vehicles. Research on launch vehicle structural dynamics will continue at the Langley and Ames Research Centers and the Marshall Space Flight Center in FY 1966. Typical of the problems considered is that of reducing the structural loads caused by sloshing of rocket fuel in tanks during launch. Promising results are being obtained with a technique utilizing flexible baffles which inhibit sloshing.

Space Vehicle Environmental Factors

The objective of this research program is to provide understanding and detailed technical knowledge of the space environment and its effects on spacecraft and their systems to insure proper and efficient design and operation. The research includes high energy space radiation effects and shielding, the meteoroid hazard, hard vacuum, thermal radiation effects and temperature control, and the behavior and control of fluids in zero gravity.

The high energy radiation environment is detrimental to equipment and hazardous to man. A major research program is therefore being conducted to determine the effects of charged particle radiation on space vehicle equipment, to understand the damage mechanisms involved, and to develop radiation shielding techniques. The completion in FY 1966 of the Langley Research Center's new Space Radiation Effects Laboratory will greatly enhance the capability for

research on radiation effects in materials, components, and subsystems. Investigations under way to determine the shielding effectiveness of various materials against space radiation will continue. Experimental radiation penetration results recently obtained by researchers in industry and at the Oak Ridge National Laboratory under contract have compared favorably with theoretical calculations, leading to greater confidence in these methods. Theoretical and experimental laboratory research is being pursued to develop new shielding concepts involving electrostatic and electromagnetic phenomena which may result in appreciable savings in weight for future space vehicles.

Meteoroid penetration of pressurized cabins, propellant tanks, or the radiators of nuclear power systems could be catastrophic. Erosion of surface coatings by the smaller particles could have serious effects such as creating undesirable changes in the temperature balance. Current information on the meteoroid environment and on the mechanism of hypervelocity impact by meteoritic particles is seriously limited, and therefore a broad research program including both laboratory and flight experiments is under way. In the program to define the meteoroid hazard, a second satellite of the S-55 class, Explorer XXIII, was successfully orbited during the past year. A major milestone is expected during the coming year with the Saturn launchings of Pegasus spacecraft, with their 2,000 square feet of meteoroid detection area. In addition to flight experiments, meteors entering the Earth's atmosphere are being studied using radio reflection techniques by Harvard College Observatory under contract. Laboratory studies will be continued to obtain an understanding of the physics of hypervelocity impact. Preliminary data on particle size effects have been obtained by the Ames Research Center which may explain existing discrepancies found in flight between impact experiments using microphones and penetration experiments using thin wall detectors such as pressurized cells. Laboratory testing, however, is still limited by the inability to simulate meteoroid particles sizes and velocities in the most critical ranges of these quantities. Emphasis will consequently be given to the development of promising techniques for achieving better simulation.

The zero-gravity fluid behavior program involves research on the effect of weightlessness on the static and dynamic behavior and heat transfer phenomena of liquids and vapor. Problems of separating and positioning of liquids and vapors, liquid pumping, and venting of vapors are common to spacecraft systems such as propellant tanks and water supply tanks. Drop tower tests at the Lewis Research Center have produced a good understanding of the behavior of fluids and vapors in static equilibrium conditions of weightlessness. Efforts to understand the dynamics of fluids under low accelerations and to improve the capability for extrapolating small scale results to full scale systems are continuing. Flight experiments of fluids under weightless conditions are being conducted to study behavior which takes place more slowly than can be studied in the short test times provided by our drop tower research facilities.

Current evidence shows that spacecraft material properties can undergo serious detrimental changes when exposed to the extreme vacuum of space. In

the high vacuum technology area, the over-all objective is to advance our laboratory capability to simulate, maintain, and measure the very low pressure or density associated with space vacuum and thus achieve a more definitive research and development capability for testing space vehicle materials, components and systems. Research will be focused on producing cleaner deep vacuum conditions in chambers by capture of most gas molecules, and on improving of vacuum instrumentation.

An important and complex spacecraft design consideration is that of maintaining component and cabin temperatures within narrow limits. Where the solar heat input remains constant or is cyclic, passive thermal coatings can be used effectively. Where this is not the case, such as in interplanetary flight, active systems which are able to alter the thermal characteristics of the vehicle are required. Research is being carried out on thermal coatings which change their absorption or heat emmission characteristics automatically with changes in temperature, or which vary their characteristics through application of electric or magnetic fields. Major advances have been made in passive coatings which are stable in the ultraviolet space environment. The resistance of these coatings to high energy radiation is still questionable and will require further research. The ability to ground test thermal performance of spacecraft is hampered by our inability to simulate adequately the solar spectrum in laboratory facilities. The program to improve this capability includes the development of improved calibration and spectral intensity monitoring techniques, as well as improved methods of thermal balance measurement and computation.

Advanced Space-Vehicle Concepts

This program looks beyond the present generation of spaceflight projects and attempts to define problems of the next generation of spacecraft. Potentially attractive missions for future NASA spaceflight programs are analyzed with the objective of identifying those where major advances in technology will be required or where feasibility will depend upon new innovations.

During the past year studies of this type have been made in a number of important areas. These have included, for example, recoverable launch vehicles and alternate approaches to recovery which emphasize simplification to reduce booster costs, advanced logistic spacecraft of the lifting entry type, large orbiting telescopes in association with manned orbiting laboratories, new probe and probe lander concepts for determining the atmosphere of Mars, and vehicles and techniques for manned Mars exploration missions.

The studies of launch vehicle simplification have produced a potentially attractive concept involving the placement of the more complex and costly elements, such as steering controls and high energy, liquid fuel, upper stage rockets, in the spacecraft itself, which would be recovered, and reducing the lower vehicle stages to the simplest possible configuration which could be economically discarded after use.

The studies of unmanned planetary probes have produced several promising

new concepts of spacecraft and techniques for the direct measurement of the structure and composition of the atmosphere of Mars, which will be a prerequisite to the confident design of more complex unmanned spacecraft intended for soft landing on the surface of Mars.

The manned Mars mission studies resulted in the discovery of a dramatic technique for reducing markedly the total propulsive requirements for the Mars trip. The technique involves selection of a particular Earth-Mars trajectory which passes close enough to the planet Venus that the spacecraft trajectory is bent sharply by the planet's gravitational field as it passes by. This "swing-by" maneuver alters the spacecraft's direction of approach to either Mars or the Earth in such a way that the spacecraft is moving more nearly in the same direction as the target planet at the approach. The result is a much reduced relative approach velocity and hence a much lower deceleration requirement for the Mars or Earth landing.

In FY 1966 research in this program will examine in considerably greater depth the vehicle and systems design problems to identify further the technological needs and research requirements in specific problem areas such as landing systems, heat protection, communications, and aerodynamics. Particular emphasis will be given to unmanned Mars atmosphere probe technology, advanced maneuverable entry vehicles for near earth flight application, and recoverable launch vehicles.

Space Vehicle Design Criteria

Several failures of space vehicles resulting from inadequate design and testing procedures have clearly indicated the need for engineering design criteria for the guidance of the designers of future space vehicles. The basic objective of this program is to develop and disseminate such criteria, and thus to improve reliability of space vehicles and reduce costs of future space programs through the uniform application to design of up-to-date technical knowledge.

The products of this program are design criteria monographs for use by NASA and industry in the engineering design of future space vehicles. These monographs provide an important means of ensuring the availability to engineers of an appropriate formulation of the latest knowledge, based on both operating experience and research. It is expected that these design criteria documents will have an important effect in reducing or eliminating many causes of potential failure of future vehicles.

The program encompasses preparation of criteria in several areas of design, including structures, propulsion, and guidance and control; and in the terrestrial and space environments which give rise to design problems. The work is presently being carried out at six Installations; at the Jet Propulsion Laboratory; and, through contracts, at the U.S. Weather Bureau, six aerospace companies, and one university. FY 1966 funds will provide for continuing and expanding the contract program necessary to accelerate completion of urgently needed criteria.

Several criteria monographs pertaining to the structural dynamic design problems of buffeting and flutter were disseminated to industry and other Federal agencies in FY 1965. Currently about forty additional criteria monographs, dealing with other design problems and with the natural environment, are in various stages of preparation.

Project FIRE

	1964	1965	1966
Spacecraft and support services...	$7,037,000	$2,811,000	$500,000
Atlas (Launch vehicle Procurement Program).....	(1,786,000)	(972,000)	(---)
Total (including launch vehicles).....	($8,823,000)	($3,783,000)	($500,000)

This project investigates the heating environment around an Apollo shaped spacecraft during reentry at speeds near 37,000 feet per second. Flight tests are required to provide critical anchor point data for validating results from laboratory test facilities and to provide guidance for application of theoretical as well as experimental reentry data.

The FIRE I spacecraft was successfully flown on April 14, 1964. It provided the first flight measurements of total heating and radiative heating at a velocity of 38,000 feet per second on a large size body. The data defined the gross heating levels in this severe environment and provided a necessary interpretation of results from ground based facilities and theoretical predictions.

A second reentry (FIRE II) is planned near the end of FY 1965. In view of the success of the first flight, the reentry sequence has been altered to provide additional information to complement the results in hand, including measurements at maximum heating. The trajectory has also been shifted slightly to favor measuring important sources of gas radiation with a special high resolution, ground based tracking spectrograph to aid in a more complete understanding of the reentry heating environment.

FY 1966 funds are required to complete operations for FIRE II and to analyze and publish the results. Under the management of the Langley Research Center, this project employs Republic Aviation Corporation as a prime contractor for the reentry package, Ling-Temco-Vought as contractor for the velocity package, and General Dynamics/Astronautics as systems integration contractor and launch vehicle supplier.

Scout Reentry Project

	1964	1965	1966
Spacecraft and support.....	$305,000	$750,000	$5,000,000
Scout (Launch vehicle Procurement Program).....	(1,000,000)	(1,000,000)	(---)
Total (including launch vehicles).....	($1,305,000)	($1,750,000)	($5,000,000)

The performance of a reentry heat protection system is determined by a complex interaction of the physical and chemical properties of materials at high temperatures and the characteristics of the heated air surrounding the spacecraft. It is not presently possible to reproduce simultaneously, in any existing ground based facility, the proper combination of all parameters known to be of importance in the performance of a heat protection system during atmosphere reentry. This project is designed to provide a series of flight experiments, utilizing the Scout launch vehicle, which will obtain data essential to current major flight projects and will lead to more reliable interpretations of test results from ground based facilities.

The Scout reentry materials payload "Reentry D", was successfully flown in August 1964. The material flown was a candidate material for the Apollo heat shield. Ground based facilities varied in their predictions of the performance of the heat shield and none of the facilities accurately predicted the actual performance of the material. The flight provided an important anchor point for the ground based facilities and a large ground based program is now under way to determine why the material behaves as it does and why the facilities do not predict the material performance more accurately.

Scout experiment "Reentry E" will be flown early in FY 1966 with a phenolic nylon heat shield material. Phenolic nylon is probably the best understood heat shield material based on laboratory experiments, but has not been flown. The material shows great promise for certain types of flights such as the ballistic or near ballistic atmospheric entry.

Next, two different payloads plus back-up payloads will be built, using different elastomeric materials. Elastomeric materials appear promising for the long flight time of the lifting body entry and for the low density payload required for Mars missions. The payloads will be blunted cones and one payload may carry simulated flaps in order to study the region around the flap.

Another critical problem to be investigated in this series is the determination of transition Reynolds number and turbulent heating rates. The Reynolds number of transition from laminar to turbulent flow decreases with increased speed up to low hypersonic speeds, and then increases rapidly at

higher speeds. At these higher flight speeds (20,000 feet per second) there is great uncertainty as to the Reynolds number at which transition occurs. Few flight data on turbulent heating rates exist. A flight experiment will be made to provide a check of the semi-empirical turbulent heating theories at high velocities. A slender cone will be flown at 20,000 feet per second. Two payloads and one back-up are required.

Lifting Body Flight and Landing Tests

	1964	1965	1966
Flight vehicle and support services.	$1,200,000	$1,500,000	$1,000,000

The lifting body configuration as a future spacecraft promises better maneuverability on Earth reentry than Apollo and Gemini and has the capability of conventional airplane type horizontal landing.

During the past year, the light weight lifting body glider flight program was completed. This lifting body test vehicle has been built at an approximate cost of $20,000 by the Flight Research Center. The flights demonstrated that a light weight vehicle could be landed successfully.

Also during FY 1965, a fixed price contract was signed with Norair Division of Northrop Corporation to build two metal, lifting body glider configurations: one, the Langley HL-10 and the other the Ames M-2. These vehicles will be carried to an altitude of 40,000 feet and a speed of about Mach number 0.8 then released to glide back to Earth. These vehicles, which represent different concepts of lifting bodies, are being built to study the problems associated with flying at high subsonic speeds and landing a vehicle which has planform loading equivalent to what could be expected from an actual space vehicle. During FY 1966, the flight test program will begin with flights of the M-2 scheduled in the Fall of calendar year 1965. First flight of the HL-10 will be about six months later.

The funds in FY 1966 will provide for flights that will include pilot familiarization with the vehicle, and studies of effects of center of gravity change and variable planform loadings.

Project Pegasus (Saturn-Launched Meteoroid Experiments)

	1964	1965	1966
Spacecraft and support.....	$9,900,000	$13,690,000	$2,500,000

To determine the severity of the meteoroid hazard to spacecraft, direct measurements are required in the space environment to obtain actual penetration rates in spacecraft materials. The Explorer XVI (Scout launched experiment) has provided the first statistically significant penetration rates in thin materials.

These experiments, to be launched into near Earth orbits on development flights of Saturn I launch vehicles, will expose to meteoroid penetration an area almost 100 times that of the Scout launched experiments. This will permit measurements of the frequency of penetration of metal surfaces as thick as 0.016 inches, approaching nominal vehicle wall thicknesses used in propellant tanks for Apollo and other projects. FY 1966 funds will permit the launching of the third spacecraft.

The Pegasus spacecraft, operating a few hundred miles from the Earth, will provide a good measure of the penetration power of meteoroids in the near-Earth environment. While it is generally assumed that the meteoroid hazard decreases in severity with increasing distance from the Earth, not enough is known about the variation in meteoroid flux with distance from the Earth to permit taking this factor into account in spacecraft design. Some theories also indicate that there may be focusing factors, and thus points of severely increased hazard, between the Earth and the Moon. The assumptions in these theories are sufficiently uncertain that it is not possible to say whether or not these areas of increased hazard actually exist.

Upon analysis of the flight data from the Earth orbiting Pegasus spacecraft, it is planned to proceed with the study of the systems requirement for conducting similar experiments in a highly elliptical orbit to define the meteoroid penetration hazard in the region of space between the Earth and the Moon. Funds provided in FY 1966 will be used for project definition studies and preliminary design of the experiment.

Small Space Vehicle Flight Experiments

	1964	1965	1966
Behavior and handling of cryogenic propellants at zero G.	$1,050,000	$255,000	---
Wind-shear measurements	117,000	25,000	$95,000
Meteor simulation	640,000	650,000	325,000
Reentry detection	63,000	80,000	---
Materials correlation and structures tests	---	---	1,580,000
Meteoroid penetration probe	89,000	---	---
Total	$1,959,000	$1,010,000	$2,000,000

The objective of this continuing project is to provide for selected flight experiments using small rocket launch vehicles to verify results obtained in ground based facilities and to investigate problems which can only be studied under environmental conditions which occur in actual flight. Current and recently completed experiments include the following:

Behavior and Handling of Cryogenic Propellants at Zero G

Work on the handling of fuels and other fluids under weightless conditions is being pursued in flight experiments to study behavior which takes place more slowly than can be provided for in drop towers or other ground based facilities. Data from previous experiments in this project have established the rate at which heat will be transferred from the tank walls to the cold fluid, causing boil-off and resultant waste of fuel. In FY 1966 flight experiments will be conducted to extend this initial understanding to more complex problems of dynamic behavior of fluids such as fluid pumping, tank spinning or tumbling, and dynamics at engine restart.

Wind Shear Measurements

Measurements of the statistical distribution of wind velocities in the vicinity of major rocket launching bases (to provide criteria for design of launch vehicles to withstand the loads resulting from wind shear forces) are being obtained for altitudes up to 70,000 feet using Nike boosters with smoke producing nose cones.

Meteor Simulation

Experiments are being conducted to provide data at velocities up to 90,000 feet per second on the luminous efficiency, heat transfer, ablation rate, and ionization efficiency of simulated meteors of known mass, composition, material, shape and size. From the results of these tests, the gross heating experienced by natural meteors can be determined and meteoric entry phenomena can be established.

Materials Correlation and Structures Tests

The factors known to affect the performance of ablation materials are heating rate, shear stress, stream composition, duration, enthalpy and size. It is possible in existing ground based facilities to simulate simultaneously some but not all of these factors. Results of flight experiments in the past year have indicated a strong need for better comparison between results of flight test and results from ground based facilities for validation of the ground based data.

The planned flight experiments will require two payloads plus a back-up payload. The materials flown would be strong elastomeric materials suitable for Mars entry. The planned flight experiments have been formulated in such a way as to complement and extend information gained from the ground based facilities and other flight experiments.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1966 ESTIMATES

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY — ELECTRONIC SYSTEMS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objective of this program is to provide the necessary advances in technology to assure the availability of reliable and efficient electronic components for future aeronautical and space flight missions. Research is conducted in the laboratory on the problems of guidance, control, communications, tracking, instrumentation, and data processing systems. Small flight experiments are used to confirm results of laboratory research and, in some cases, to obtain solutions to problems which cannot be studied adequately in the laboratory.

SUMMARY OF RESOURCES REQUIREMENTS:

	1964	1965	1966
Supporting research and technology	$26,380,000	$23,322,000	$30,000,000
Small flight projects	2,320,000	2,100,000	4,400,000
Total	$28,700,000	$25,422,000	$34,400,000

Distribution of Program Amount by Installation:

Manned Spacecraft Center	$1,079,000	$475,000	$880,000
Marshall Space Flight Center	4,644,000	3,469,000	4,525,000
Goddard Space Flight Center	3,274,000	2,797,000	3,035,000
Jet Propulsion Laboratory	2,806,000	2,727,000	3,200,000
Ames Research Center	2,399,000	3,650,000	3,390,000
Electronics Research Center	---	1,873,000	5,000,000
Flight Research Center	1,072,000	1,103,000	1,400,000
Langley Research Center	8,848,000	6,390,000	9,120,000
Lewis Research Center	463,000	445,000	580,000
NASA Headquarters	4,087,000	2,493,000	3,270,000
Western Operations Office	28,000	---	---

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

	1964	1965	1966
Guidance systems	$4,723,000	$4,800,000	$6,200,000
Control systems	6,596,000	5,660,000	6,000,000
Communications	5,156,000	3,960,000	5,900,000
Tracking and data acquisition	2,897,000	2,750,000	3,800,000

	1964	1965	1966
Data handling and processing.....	$3,102,000	$3,040,000	$4,100,000
Instrumentation.....	3,906,000	3,112,000	4,000,000
Total.....	$26,380,000	$23,322,000	$30,000,000

Guidance Systems

The guidance system research program is directed towards the derivation of information necessary to understand and design simple, reliable and light-weight sensors, reference elements, and associated components which make up a guidance system. The program emphasizes technique and component research in inertial, optical, and electromagnetic phenomena for application to sensing and reference functions. Digital computer technology is explored as a means for implementing guidance equations and processing navigational data. Trajectory analysis provides the framework for examining energy requirements, error analyses, and sensor and data processing trade-offs for any specified space mission.

The objective of research in inertial components is to develop longlife, high performance, low power devices for future spacecraft guidance and attitude control systems. Typical uses include flight path corrections, autopilot control, and orbit plane determination. Initial investigations in one area, for example, have demonstrated the feasibility of the "frictionless" electrostatically suspended gyro (ESG); the follow-on program by Honeywell, Inc., under the direction of Jet Propulsion Laboratory will begin the development and testing of flyable prototypes.

One objective of the research on optical devices is to improve the performance of automatic space navigation equipment, such as electro-optical star trackers and star mappers. But increasing emphasis is being placed on the search for new techniques which will make on board guidance systems, particularly of manned vehicles, less dependent on complex automatic or remotely operated systems. Thus, for example, for manned space flight, the incorporation of manually operated sextants into the navigation computation loop could significantly reduce computer complexity and the size and weight of overall navigation equipment. Research at the Ames Research Center, utilizing space flight simulation techniques, is expected to lead to the development of simple hand-held sextants and the techniques for using them.

In the field of digital computer research, emphasis is currently on the problems of developing small, light weight, high performance computers for on board applications. Some of the most promising results of this research so far are coming from exploratory work on new computer concepts at the Jet Propulsion Laboratory. Included in this program are the development of a prototype magnetic-logic computer and investigations of self-organizing computer techniques. This work will continue as part of the FY 1966 research program in guidance computers.

The derivation of guidance equations and guidance system requirements is based on the analysis of trajectories related to the various mission objectives. Past work in this area has established basic trajectories to the moon and nearby planets. Continuing studies at Marshall Space Flight Center, Ames Research Center, Jet Propulsion Laboratory, Electronics Research Center, and Langley Research Center, are now seeking simplified guidance equations for use with these trajectories, and exploring new trajectory problems such as those associated with low level, long duration thrusting systems typical of electric or nuclear propulsion.

Control Systems

Research in this program establishes the technology and design requirements for control systems of aerospace vehicles. Problems studied include those of manned and automatic flight control, spacecraft attitude stabilization, and the development of improved research techniques. Along with the applied research, a program of theoretical and basic research is carried out in related fields. Specific objectives include: improvements in displays for manned vehicles, development of adaptive automatic controls, economical methods for long life satellite stabilization and more accurate pointing techniques for optical communication devices.

Research in recent years on the problems of designing control systems intended for use by man in controlling spacecraft and high speed aircraft has emphasized the need for the application of mathematical techniques to the description of human response characteristics. Mathematical descriptions of the human operator for complex control tasks are now under development at Langley Research Center, Massachusetts Institute of Technology, and the University of Michigan.

In the field of attitude stabilization, a dominant problem during the coming year will be the development of systems for long term service satellites (e.g., communications, meteorological, and navigation satellites) which require constant, or frequent, attitude reorientation. Present active methods utilizing gas jets are not satisfactory because of fuel requirements. Passive stabilization systems, which utilize natural forces as energy sources, appear promising. Gravity gradient attitude stabilization systems for satellites have been studied extensively at Ames Research Center. This principle utilizes the Earth's gravity both to establish an attitude reference and as a source of power for aligning the vehicle in the desired attitude. An application of this principle is presently being considered for use on the Applications Technology satellite. Further development of passive schemes for control purposes will continue during FY 1966.

The investigation and design of suitable components for electronic systems is an important part of the control systems research program. Electrical, electronic, and mechanical components of a wide variety are included. For example, a brushless DC motor has been developed by the Sperry Company for the Goddard Space Flight Center. The DC motor, while optimum for application to satellite electrical power systems, has not been

used because brushes wear rapidly in the vacuum of space. The brushless design has shown high reliability when operated in a vacuum and motor electrical efficiencies of 60 percent, as much as twice that available in the conventional DC motor, are obtainable over a wide operating range.

In the continuing program to refine research techniques in the control systems field, significant progress was made during the past year on the problem of processing the large amounts of data gathered from ground based simulation experiments. NASA sponsored research by Bolt, Beranek & Newman has produced a technique of using a digital computer on line with the experiment to process data immediately and display significant results. This will allow the experimenter to modify his experiment in light of results, expand his comprehension of the problem, and effect significant reductions in cost. Efforts to apply these techniques to NASA flight control simulators will continue in Fiscal Year 1966.

Communications

The objective of the NASA research program in communications is to provide the technology for increasing the data transfer capability of spacecraft by providing advanced techniques and components applicable to space-to-ground communications. Advanced satellites and deep space probes require smaller, lighter, more powerful and more reliable equipment than is presently available in order to transmit information without unduly consuming spacecraft payload weight. Particularly critical are the requirements imposed on a communications system by manned or unmanned space probes to Venus, Mars and beyond.

To improve the ability to transmit information from a spacecraft, research is underway to improve the efficiency and power handling capabilities of microwave devices. Microwave tubes to be employed as amplifiers in the ten watt range will be available in calendar year 1966. Efficient tubes in the 20-100 watt range are currently under experimental investigation by the Langley Research Center. It is expected that results of this program will provide space qualified tubes with good efficiency by calendar year 1967. Studies will be undertaken in FY 1966 for even more powerful tubes, 500-1000 watts, to meet system requirements of the mid-seventies.

During FY 1965, studies were initiated on the propagation of sub-millimeter waves. Detailed data on propagation through the Earth's atmosphere in this portion of the spectrum is not available and must be obtained before deep space-to-ground communication systems operating at these frequencies can be designed. During FY 1966, work in this area will also include component development and system studies. It is expected that the weight and size of these components will be less than those of corresponding microwave components, due to the shorter wavelength involved, and that systems operating at these frequencies will have increased data handling capability. The bulk of the research will be under the program direction of the Electronics Research Center.

One of the most important developments in the optical technology field for application to communications is the laser. A program to determine the effects of the atmosphere on optical frequencies, such as attenuation, refraction, fading, phase distortion and pulse shape distortion, is underway. This program will contribute to the understanding of these effects and permit the development of more efficient techniques for propagation of energy through the atmosphere at optical frequencies.

Thin film and microelectronics research performed to date has achieved reliable thin film and semi-conductor integrated components and circuits of less size and weight than the conventional approach. Continuing efforts to enhance the reliability of electronic circuits is required as well as techniques to achieve a family of low power devices. Research on methods to achieve micropower devices through the use of selected components and revised circuit design was initiated in FY 1965 by Langley Research Center and will be continued in FY 1966. In addition to the low power requirements, emphasis will also be placed on small size, low weight, improved reliability and increased resistance to radiation.

Applications of microelectronic devices to subsystems of the Saturn V vehicle have been initiated at the Marshall Space Flight Center. Selected electronic subsystems will be constructed using microelectronic components, and flown piggy back on developmental flights to determine performance capabilities and study potential reliability improvements. This program will continue in FY 1966.

Tracking and Data Acquisition

The objective of research in this area is to improve accuracy in the determination of the orbital parameters of a spacecraft, and to enhance data acquisition capability of ground based tracking systems. Improved accuracies of orbital parameters are necessary for the understanding of geophysical characteristics and variations in the Earth's gravitational field.

Laboratory experiments were initiated in FY 1965 on the use of optical methods for the acquisition of data from a spacecraft. Since such a system would eliminate the need for a transmitter aboard the spacecraft, it would increase reliability of the overall system and decrease spacecraft weight. Results to date have demonstrated the feasibility of data transfer through the distortion of thin Mylar membrances coated with reflecting materials. This effort will be continued in FY 1966 to improve efficiency and investigate the use of other phenomena such as molecular structure as modulation mechanisms.

During FY 1965, research in the use of optical tracking techniques was concentrated largely in laser component development and system studies. Effective use of the very narrow beams characteristic of laser devices requires extremely accurate pointing and position control. Studies of techniques for electronically sensing and controlling the position of the laser beam have been initiated. This work will be continued in FY 1966.

Research on microwave antennas to achieve increased data acquisition capability is concentrated in the improvement of spacecraft antennas and the arraying of parabolic dish antennas to obtain a large effective aperture for ground based stations. The research on antenna arraying is being conducted by the Langley Research Center and the Goddard Space Flight Center. A prototype model of a nine foot diameter spacecraft antenna erected from a one foot diameter folded package has been developed by Goodyear Aircraft Corporation under the direction of the Jet Propulsion Laboratory. This research will be continued in FY 1966. In addition, feasibility studies are planned in FY 1966 of the use of large antennas placed in space as satellites of the Earth for tracking and data acquisition as well as for radio astronomy purposes.

Data Handling and Processing

The variety and number of on-board and ground based data processing applications are increasing rapidly at the present time. Concommitantly with such broadening of application, marked changes in equipment and techniques are occurring. They include improved means of direct, rapid ("real time") communication between computers and users; higher capacity, fast data storage units ("Memories"); and greater use of data processing systems to enhance man's capability to make complex logical decisions.

In FY 1966 work will continue on the "continuous ferrite" plate memory. Recently, large single planes, each containing many elements, have been fabricated successfully by Radio Corporation of America. The problems of reproducibility of perfect planes, reliable interconnections and the design of associated microelectronics require further investigation. Both aerospace and ground based data handling capabilities will be augmented significantly as these very high capacity, small, rapid, digital memories become generally available.

The research on systems and techniques for the processing of TV signals, both on-board the spacecraft and on the ground, has been concentrated in two primary areas recently: In the one, advanced equipment has evolved for ground testing of various electronic configurations and for switching TV electrical signals among various media; oscilloscopes, magnetic tapes, optical elements, and so on. In the other, theories have been evolved, and some equipment made and successfully tested, utilizing advanced concepts in the substantial reduction of the number of data that must be transmitted from spacecraft to ground to ensure accurate recreation of the scene at the viewing terminal. Flyable prototypes are being designed at Goddard Space Flight Center.

Research on techniques to improve the efficiency of computer utilization has led to the development and acquisition of equipment to enable simultaneous, direct, "real-time" operation of computers by a number of users. Some of these devices are now in use at Langley Research Center and Lewis Research Center both as operational equipment and as research tools to study problems

related to sharing of large computer facilities among a number of users. Problems associated with cooperative solution of difficult computing problems through direct communications between the computer and scientist will also be studied. Successful solution of these problems will reduce requirements for additional programming specialists and contribute to more efficient use of large computational complexes. These efforts will continue in FY 1966.

Reduction of the amount of data transmitted from space vehicles to earth is a continuing goal of research in data compression techniques. One approach, under investigation at Jet Propulsion Laboratory, is a system known as "Previous Element Coding" for use in video data processing. In this scheme, the picture taken by the spacecraft camera is divided into elements which are classified and coded according to their relative brightness ("gray level"). The elements are automatically scanned and compared with adjacent elements. The spacecraft then transmits the coded brightness levels and the number of contiguous elements which are of the same shade. For pictures with large features of similar tonal quality, this results in an appreciable saving of communications channel capacity compared to the original technique of transmitting the brightness of each individual picture element. Reductions of 2 to 1 in data bit transmission requirements by this technique are predicted. Research on this and other techniques will continue in FY 1966.

Instrumentation

Instrumentation and measurement are fundamental to successful achievement of basic scientific objectives and to the technological advancement of engineering sciences. A strong and vigorous program to insure timely availability of instruments and measurement techniques for planned and anticipated space and aeronautical missions is essential to the ultimate success of such missions.

For density measurements of the upper atmosphere, remote sensing devices have been developed at Langley Research Center, based on the backscatter of electromagnetic radiation. Flight tests using sounding rockets have successfully demonstrated the feasibility and substantiated analytical predictions. Further developments using stronger radiation sources and improved sensing methods will be tested in subsequent flights to extend the technique to higher altitudes. During FY 1966 research on radiative sensing methods will be extended to investigate the remote measurement of other atmosphere characteristics such as pressure, temperature, and wind velocity which could lead to more accurate data for weather forecasting.

Although vacuum pumping systems have advanced significantly through the introduction of ion pumping, the accuracy with which vacuum can be measured is still orders of magnitude below the desired level. Absolute measuring methods do not exist for very low pressure and are urgently needed. The development of mass spectrometer techniques for measuring gas compositions, by the National Research Corporation, has progressed to a point where the use of intense ion sources and more advanced electronic counting systems should make it possible to increase the sensitivity of these analytic devices by several orders of magnitude. Knowledge of the qualitative and quantitative composition of gas residues in evacuated chambers can then be used to

analyze possible sources of system limitation and to investigate new techniques for measuring very low pressures. These developments will be pursued further in FY 1966.

Spacecraft subject to radiation from the sun outside the Earth's atmosphere require effective temperature control over broad portions of the electromagnetic spectrum, including the far infrared. The development of solid state physics has produced new sensing materials responding to radiation in these extended ranges. Measuring apparatus is being designed by the Naval Ordnance Laboratory at Corona, California, to enable accurate evaluation, in the far infrared, of the radiative characteristics of materials. Results of this work will lead to the development of more efficient coatings for spacecraft temperature control. This program will continue in FY 1966.

Recent progress in the design of microminiature components has produced new possibilities in electro-optical imaging concepts. Solid state image converters which do not require electron beam scanning seem feasible and may find application not only for TV but also in other fields such as horizon sensing and solid state spectral analyzing. Advances in photo multiplier design and associated electronic circuits, by Avco Corporation and the Goddard Space Flight Center, have produced improved devices for counting impinging low energy electrons. These devices will be used in the Direct Measurement Explorer Satellite. Further work will be done in FY 1966.

Bioelectronic instrumentation has benefited from the development of miniature devices and circuits for measuring cardiovascular and nerve signals through the use of implants in live subjects. Microelectronic techniques contribute to the design of these devices, but power requirements restrict applications in many cases. To alleviate this restriction, research is underway to reduce power consumption and develop alternate power sources. Efforts to replace battery power supplies by either body generated power or power radiated to the implanted sensing device from outside are under investigation at Ames Research Center and Republic Aviation Corporation.

Small Flight Projects

	1964	1965	1966
Radio attenuation measurements (RAM)	$450,000	$900,000	$3,400,000
Horizon definition research (SCANNER)	1,800,000	1,200,000	1,000,000
GEMINI optical communications experiment	70,000	---	---
Total	$2,320,000	$2,100,000	$4,400,000

Radio Attenuation Measurements (RAM)

The objective of this project is to investigate the interaction of electromagnetic waves with the plasma sheath which engulfs a spacecraft during reentry into the Earth's atmosphere and causes radio blackout. Ground simulation of reentry is not adequate to generate the type of plasma encountered by a reentering spacecraft; thus, a series of flights are being undertaken by the Langley Research Center to determine the plasma parameters and the effect of this plasma on electromagnetic radiation at frequencies from VHF to X band. These flights are examining aerodynamic shaping, magnetic fields, and material addition as means of eliminating the blackout phenomena during reentry. Preliminary results indicate that material addition may be the most effective and further experiments using this technique will be performed in FY 1966.

Data obtained to date have been in the 18,000 feet per second velocity regime. Further experiments will be concerned with reentry velocities of 28,000 feet per second and beyond.

Horizon Definition Research (SCANNER)

Passive horizon sensors are used in spacecraft stabilization and guidance as devices for determining the local vertical through accurate discrimination of the change in radiant energy between the edge of a planetary disk and the space background. The SCANNER project has the objective of making detailed measurements, from high altitudes, of the natural radiation gradients which define the Earth's horizon. These data are essential to the development of accurate horizon sensors. A secondary objective is to develop a flight proven technique for gathering statistical horizon data, possibly in Earth satellite spacecraft. The project is an extension of current laboratory research on horizon characteristics. Two experiments will be performed from suborbital ballistic trajectories using the Trailblazer II launch vehicle. Flight #1 is scheduled for August 1965 and Flight #2 is scheduled for October 1965. A backup set of payload equipment and instrumentation will be provided, permitting a possible third flight. The dual channel radiometer, operating in the 14-16 and 20-40 micron bands, will provide a spatial resolution of 2 km, a five-fold increase in resolution over that of radiometers used in earlier experiments. Star mapping techniques utilizing telescopes in the spacecraft will be used to correlate the pointing direction of the sensor with observed data. Langley Research Center has project direction.

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY — HUMAN FACTOR SYSTEMS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

This program has four major objectives: (1) to determine man's reactions to the novel environments of space and aeronautical flight, (2) to define the essential requirements for sustaining and protecting man in these environments, (3) to provide the technology necessary to develop suitable life support and protective systems, and (4) to discover means of integrating man's capabilities with those of machines to obtain composite systems of superior performance.

The first and second objectives will help establish the limits of man's usefulness in space or on the moon: To what extent will his ability to explore, observe, and experiment be encumbered by the mechanical devices and restraints necessary to sustain his life? How will his judgment and powers of perception be affected by his environment? What limitations must be placed on his exposure time to extra-terrestrial environments to avoid both immediate and long term damage? The second and third objectives together will determine the costs in weight, and therefore in dollars, of sustaining human life in space: How much food, water, and artificial atmosphere must be provided? To what extent, and at what cost in weight, can these be manufactured on board the spacecraft from human waste products? How much natural radiation can man endure and how can the required shielding be provided at least weight? The fourth objective will determine the extent to which the presence of man, with his unique capabilities, can compensate for the costs of sustaining him: How can the machine systems required to take him to the moon be made simpler, more reliable, and lighter in weight by substituting human functions for certain mechanical functions? How can man's capabilities as an observer and recorder of information be augmented by machine systems?

Answers to all of these and many other related questions are being sought in this research program. The work is done by researchers in electronics, physics, engineering, psychology, biology, and nearly every field of medicine. Many of these are NASA scientists and engineers; many more are located in university and industrial laboratories and in other Government agencies.

SUMMARY OF RESOURCES REQUIREMENTS:

	1964	1965	1966
Supporting research and technology.....	$13,200,000	$11,850,000	$13,000,000

	1964	1965	1966
Small biotechnology flight projects.....	---	$1,470,000	$1,900,000
Total.....	$13,200,000	$13,320,000	$14,900,000

Distribution of Program Amount by Installation:

Manned Spacecraft Center.....	$1,900,000	$445,000	$900,000
Marshall Space Flight Center.	235,000	220,000	300,000
Ames Research Center.....	3,820,300	4,113,000	4,680,000
Flight Research Center.....	1,342,000	2,000,000	1,500,000
Langley Research Center.....	1,834,400	3,204,000	4,450,000
Lewis Research Center.....	137,000	230,000	200,000
NASA Headquarters.....	3,931,300	3,108,000	2,870,000

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

	1964	1965	1966
Human research and performance.	$4,128,000	$3,570,000	$5,000,000
Life support and protective systems.....	5,841,000	5,400,000	4,750,000
Man systems integration.....	2,827,000	2,230,000	2,850,000
Advanced concepts.....	404,000	650,000	400,000
Total	$13,200,000	$11,850,000	$13,000,000

Human Research and Performance

Long term manned space flight will expose man to hostile environmental conditions. The objective of this research is to understand the psychological and physiological reactions of man and his organic systems to these conditions and to predict their effects on his performance and well being. The environmental phenomena considered range from zero gravity to solitary confinement and include electromagnetic and particle radiation, magnetic fields, acceleration forces, artificially produced atmospheres, temperature, humidity, and vibration.

During the past year notable progress has been made in several areas of investigation. In the field of radiobiology, research at the University of California and the Ames Research Center has produced the first meaningful information on the biological effects of the proton component in radiation likely to be encountered in space flight. These results, obtained from animal experiments in the University of California cyclotron, showed that at the lethal-dose level the biological damage mechanism of proton radiation for small animals is similar to that of gamma radiation. If these preliminary

results are confirmed with other species, the extensive knowledge of gamma radiation effects already available may become directly applicable to the problems of radiation hazards in space flight.

During the coming year, this work will be expanded to investigate the effects of lower levels of radiation over prolonged exposure periods, and to determine whether these effects are altered by variations in temperature, humidity, or vibration.

In the field of acceleration research, Ames Research Center has continued to exploit a laboratory technique which may compensate for our inability to simulate directly the effects of long term reduced gravity on physiological systems. Each of several groups of test animals is subjected to a different level of acceleration in centrifuges for a prolonged period. Resultant physiological differences among groups are then analyzed for correlation with acceleration (or gravitational) level. If significant relationships can be established between physiological phenomena and gravitational stress at acceleration levels greater than 1-G, it may be possible to predict, by extrapolation, corresponding effects at acceleration levels less than 1-G.

In the study of the effect of altered gravity environment on small animals, preliminary results, which cannot be fully interpreted at this time, indicate certain changes in growth size and body chemistry. Rats centrifuged for periods as long as one year at G loads ranging from 2.5 to 4.7 above normal, gravity did not grow to normal size. In the coming year researchers will try to verify these trends and to discover the biological mechanisms producing them.

Life Support and Protective Systems

Life support and protective systems are those systems necessary to sustain human life and prevent physical injury in a hostile environment such as that encountered by man in space. NASA's research in this field has as its objectives to develop and demonstrate new concepts which will lead to systems of lighter weight, longer duration, lower power consumption, and greater flexibility.

Spacecraft life support systems in current use are relatively heavy, short-duration, systems which require stored gases for artificial atmospheres, chemical waste treatment with waste storage, and stored food and water. Significant reductions in system weights, which may be essential to the economic feasibility of long duration manned space flight (e.g. to the planets), appear possible if the concept of "regenerative" systems can be proven. A regenerative life support system would produce the principal life sustaining requirements of man (food, water, and oxygen) by the reprocessing of his own waste and metabolic products.

Research on this principle at the NASA Langley Research Center in the past year has provided the basis for a partial regenerative system capable of supporting four men for ninety days at about one half the cost in weight

that current operational techniques would involve. The system would produce oxygen from carbon dioxide and fresh water from urine, cabin condensation, and wash water. Food would be stored. In the coming year a full-scale laboratory version of the system, produced by General Dynamics/Astronautics, will be evaluated in a series of experiments at the Langley Research Center in which four men will live and perform space mission tasks in a simulated space vehicle for as long as 100 days supplied entirely by stored food and regenerated water and oxygen.

Further refinements of the regenerative system concept may result from research at the Ames Research Center where the feasibility of bacterial reprocessing of metabolic products is under study. A successful system based upon this principle would produce food as well as oxygen and water.

Man Systems Integration

Research in man systems integration provides the technology for effective and reliable utilization of the human in man-machine systems. The program emphasizes (1) development of quantitative measures of human performance under conditions which are typical of those to be encountered during aerospace missions, (2) the development of systems design criteria which will assure maximum utilization of man as an element in the system, and (3) the evaluation of man-machine design concepts in the laboratory.

Typical of the problems considered in this program is that of determining what difficulties the low gravity environment may cause man in performing routine tasks onthe surface of the moon. It is not at all clear, for example, that he will be able to climb, run, or even walk on the moon with the same ease that he does on Earth. Muscles, conditioned to moving limbs of a given weight on Earth, may over control in the 1/6-gravity of the moon; the reduced friction between show and surface caused by reduced weight may make traction extremely difficult. To investigate problems of this kind the Langley Research Center has developed a technique with which the conditions of moving about in a 1/6-gravity environment can be fairly closely simulated. The device consists of a floor tilted up to an angle of 80.5° on which a subject walks supported in a nearly horizontal attitude by a series of cables attached to head, upper torso, hips, and legs. The cables, suspended from overhead trolleys, are parallel to the tilted floor and support most of the subject's weight so that relative to the tilted floor his apparent weight is approximately 1/6 of normal. During the coming year this technique will be used to examine numerous routine and nonroutine tasks man will be expected to perform on the moon and identify those that will require special training or equipment.

Advanced Concepts

Research on advanced concepts in any field is essential if man is to be ready to solve the next generation of problems in that field. In human factors research, many of these problems are likely to involve ways of further

integrating man into the operational systems of future aircraft and spacecraft. Several interesting possibilities have arisen in recent years, some showing enough promise to warrant serious study. The two related examples described below are representative of those that make up this advanced concepts program.

The precision control of high speed aircraft has, under certain circumstances, already taxed to the limit man's ability to coordinate sensory perception with motor response. The control tasks of complex spacecraft systems of the future could easily exceed his ability. Researchers have hypothesized that one limiting factor may be the necessity for sensory cues (visual or aural signals) to be transmitted to the brain, translated to a motor command, and re-transmitted to arms, hands, feet, etc., before a required function is executed. If a direct link could be established between, say, the eye and the system to be controlled, this limitation could be circumvented. A concept now under study for a device designed to track eye motions of astronauts as a means of obtaining data to improve the design of instrument displays has suggested a possible method for doing this.

The device would follow the motion of the eye by tracking a beam of light reflected from the cornea. The resultant motion of the light beam would be converted into electronic signals which, in turn, would be recorded as a time history of the astronaut's eye movements. If, instead of being recorded, the signals were used to command certain control operations, the astronaut could maneuver his spacecraft using eye movements alone. The eye tracking device will be developed during the coming year. If it proves feasible, a study of this future application will follow.

A second possibility, even more remote than the first at this time but still interesting as a future application of the developing technology, is the direct transmission of control signals from man to machine by nerve impulses. With such a technique, machine systems could be controlled by the brain and nervous system directly, in the same manner that movements of man's limbs are controlled. The basis for this technique would be the detection and transmission of the magnetic field components of nerve impulses. Neurological research at Georgetown University is currently defining the complete electromagnetic character of these impulses and, if successful, will provide a starting point for later studies of control applications.

Small Biotechnology Flight Projects

	1964	1965	1966
Small biotechnology flight projects.....	---	$1,470,000	$1,900,000

In many fields of aerospace technology there are problems that cannot be solved in the laboratory at all but must be solved in flight. Apparent solutions to many other problems can be found on the ground but must then be evaluated in flight before they can be accepted. This small-flight projects

program serves these essential purposes for the Human Factors Systems research program.

One problem that is becoming more acute to aerospace medical specialists as more experience is gained with man in his new space environment is that of establishing a new base of reference for many long established measures of physiological processes. The specialists are finding that clinical standards for "normal" heart rate, blood pressure, and respiration, applicable to humans under no-stress conditions, are not applicable "norms" for astronauts functioning for prolonged periods under conditions of stress. The lack of applicable standards obscures the significance of physiological data monitored during space flights and prevents accurate assessments of the astronaut's well being. A project begun this year by the Flight Research Center should ultimately supply the new physiological standards required.

The project involves the collection of physiological data on a large number of individuals who spend long periods of time under stressful conditions representative of those encountered in space flight. The subjects chosen for the experiment, by arrangement with the U. S. Air Force, were the students of the U. S. Air Force Aerospace Test Pilots School at Edwards Air Force Base, California. These are particularly appropriate subjects because their medical histories are well documented, they participate in identical training programs involving many hours of high stress flying, and they themselves represent one major source of future astronauts. Each subject will be instrumented with small self-contained sensing devices and a miniature tape recorder which will measure and record electrocardiograms, vibracardiograms, respiration, and voice data. Data will be obtained continuously during all periods of high stress activity throughout the flying careers of each subject. Since the project is to be a continuing one, successive classes at the School will participate and, in time, a statistically significant sample of data will become available from which to derive the new standards.

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY — NUCLEAR-ELECTRIC SYSTEMS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The purpose of this research is to provide the technology needed for long life nuclear-electric power systems so that advanced space missions which may benefit from use of these systems can be selected and undertaken with assurance of success.

Nuclear-electric power generating systems and electric propulsion systems have been considered as two complementary parts of this single overall program. For future manned deep space or interplanetary missions in which the high specific impulse attainable from electric propulsion would be uniquely advantageous, nuclear-electric power is the only feasible source of the megawatt power levels required for large electric thrustors. Research has also indicated potential applications of electric propulsion for attitude control and station keeping where power levels of only watts would be required, and for satellite orbit raising and unmanned space probes where power requirements would be in the kilowatt range. The lower power requirements for these applications of electric propulsion can again be provided by nuclear power generation systems, although the power systems described under Chemical and Solar Power may also be applicable.

Concepts for utilization of large nuclear reactor power systems include potential for stationary power plants on the moon and planets, and for advanced communication and other on board power requirements as well as for electric propulsion. Isotope power represents the nuclear energy contribution at low power, in the watt to kilowatt range.

The AEC is developing isotope powered systems, and it is proceeding with efforts in the range up to 250 watts. NASA is responsible for integrating such power supplies into spacecraft. Close coordination between the agencies is maintained to insure that the AEC work is directed to meet NASA's requirements and that the results will be suitable for effective integration into the spacecraft systems.

SUMMARY OF RESOURCES REQUIREMENTS:

	1964	1965	1966
Supporting research and technology	$26,749,000	$23,192,000	$24,000,000
SNAP-8 development	15,465,000	17,000,000	---
Space electric rocket test (SERT)	3,467,000	2,300,000	3,000,000

	1964	1965	1966
Small nuclear electric propulsion and power flight projects	$282,000	---	---
Total.....	$45,963,000	$42,492,000	$27,000,000

Distribution of Program Amount by Installation:

Manned Spacecraft Center.....	$94,000	$100,000	$100,000
Marshall Space Flight Center.	263,000	290,000	400,000
Goddard Space Flight Center..	1,320,000	1,142,000	1,200,000
Jet Propulsion Laboratory....	1,882,000	2,336,000	1,600,000
Langley Research Center.....	---	400,000	---
Lewis Research Center.....	41,719,000	37,038,000	22,700,000
NASA Headquarters.....	685,000	1,186,000	1,000,000

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

	1964	1965	1966
Nuclear-electric power.....	$15,218,000	$13,225,000	$14,000,000
Electric propulsion.....	11,531,000	9,967,000	10,000,000
Total.....	$26,749,000	$23,192,000	$24,000,000

Nuclear-Electric Power

Development of nuclear space power systems for non-propulsive auxiliary power and for electric propulsion power is dependent upon the research of the Nuclear Electric Power Supporting Research and Technology Program. This program provides technology for conversion of nuclear energy to electrical energy by power conversion systems such as the liquid metal Rankine cycle, the gaseous Brayton cycle, thermionic direct conversion and magnetoplasmadynamic systems. Component research, liquid metal and liquid metal vapor properties, space-environment effects, advanced concepts and mission analysis represent typical areas of research.

The program funding is divided with approximately 85 percent for industrial and university contracts and 15 percent spent in support of the in-house work at the NASA centers.

Primary research emphasis has been on the liquid metal Rankine cycle in which a liquid metal, vaporized by nuclear heat, is used to drive a turbine which in turn drives an electric generator. The Rankine cycle shows great promise as a high power (kilowatts to megawatts) energy conversion system because the excellent heat transfer and high operating temperature characteristics of liquid metals can result in relatively small and lightweight

components even when coupled with large nuclear reactors.

Work is continuing on advanced technology aimed at high temperature and high power systems. Testing of potassium-vapor turbines was initiated at General Electric Company in FY 1965. Performance testing and design evaluation will be continued in FY 1965 and endurance testing will begin in FY 1966. In other Rankine-cycle-component research, a design of a high temperature lightweight electro-magnetic pump to be used as a liquid-metal boiler feed pump was completed in FY 1965. Procurement and testing of this pump will be initiated in FY 1966. Testing is continuing at Lewis Research Center on the performance of centrifugal pumps for liquid-metal working fluids. During FY 1965, three axial flow inducers were performance tested; these inducers would be used for pressure boost devices for the main condensate pump in a liquid-metal power conversion system. Testing of a full-scale centrifugal condensate pump suitable for a one-megawatt power system will be started in FY 1966.

In comparison with the liquid metal Rankine cycle, a gaseous Brayton-cycle power conversion system may eliminate many of the problems inherent in the use of high temperature liquid metals and can draw upon the years of turbojet experience in the development of high efficiency reliable turbines and compressors. Gas-cycle turbomachinery has been designed and fabricated, and initial testing has verified the anticipated high efficiency potential of the Brayton cycle. A broad program of Brayton cycle component development is now in progress, emphasizing efficiency and reliability. Attainment of maximum efficiencies will compensate for the inherent Brayton-cycle characteristic of large size and weight, resulting from the fact that gas is a poor heat transfer medium compared with liquid metal. Brayton cycle power conversion equipment is adaptable for use with either a nuclear heat source or a solar heat source, and Brayton cycle system technology is, therefore, jointly supported by the Nuclear-Electric Power and the Solar and Chemical Power programs.

Another phase of Nuclear-Electric Program research is concerned with an ultimate goal of eliminating the rotating turbomachinery of dynamic Rankine and Brayton cycles by development of methods of directly converting nuclear energy to electric energy. Direct conversion research emphasizes thermionic conversion in which nuclear energy is utilized to heat an electrode until, as in radio tubes, it gives off electrons to another electrode and thereby establishes an electric current. In this concept an easily ionized element such as cesium is introduced between the two electrodes in order to facilitate the flow of electrons and prevent electron accumulation at the emitting electrode. Two principal types of thermionic direct conversion methods are being investigated:

(1) the thermionic fuel element, i.e., where the nuclear fuel is integral with the thermionic converter;

(2) The out-of-core converter in which the thermionic converter assembly is separated from the reactor with a heat-transfer loop transporting reactor heat to the converter emitters.

Primary research emphasis is on high temperature materials development (fuels, insulators, etc.), because temperatures beyond our current capability are required to make thermionic systems operate at attractive performance levels. Inasmuch as system goals require at least a 10,000 hour life, it is necessary to determine the dimensional stability, nuclear fuel retention, performance and operating characteristics of candidate materials and concepts over the long periods of time and high temperatures consistent with ultimate system requirements.

During FY 1965 irradiation tests equivalent to 2500 hour fuel burnup were conducted on a large number of mixed carbide nuclear fuel specimens. Longer term tests equivalent to 10,000 hours operation will be conducted in the NASA-Plum Brook Test Reactor in FY 1966. Long time life tests of electrically heated fueled converters will continue at General Atomics and General Electric. These tests complement in-pile evaluation of fueled diodes conducted by the AEC.

A novel externally fueled thermionic element, designed by Republic Aviation, that may have considerable operational advantages, successfully completed out-of-pile testing in FY 1965. Additional long term tests will be performed on this concept.

Still another energy conversion process that might eliminate rotating turbomachinery is under investigation at the Jet Propulsion Laboratory. In much the same manner that electricity is normally generated by the motion of an electric conductor through a magnetic field, a magnetoplasmadynamic system has been proposed in which a highly conductive liquid metal flows through the magnetic field. In order to attain the high fluid flow velocities required for appreciable power generation, JPL is attempting to use the high pressure of vaporized cesium to accelerate liquid lithium. Research, to extend through FY 1966, includes high temperature electrical insulation, high velocity liquid metal corrosion, and liquid vapor separation. A low temperature feasibility test has produced 12 kilowatts of power at 93 percent of the theroretical efficiency.

Electric Propulsion

The objective of Electric Propulsion research is to provide the advanced technology that will lead to the development of electric thrustor systems for spacecraft prime and ancillary propulsion. These thrustors, when developed and used in conjunction with lightweight power generation systems, offer the potential of substantial increases in payload and/or reduction in travel time generally proportional to the energy requirements of a contemplated space mission. The basis for these performance improvements lies in raising specific impulse from the few hundred seconds typical of chemical rocket systems to specific impulses up to 10,000 seconds and above with extremely low overall system weights. The only known practical method of accomplishing this is by an electric thrustor which converts electrical energy into kinetic energy of a propellant. However, because of the low thrust levels of such systems, a major requirement that must be attained for effective ap-

plication is a capability of thousands of hours of reliable operation. Also, for prime propulsion applications, attainment of high overall thrustor system efficiency is of major importance because the total power required for operation of the thrustor system, and thus the power plant weight and the mission payload capability, is dependent on thrustor system efficiency.

Electrostatic thrustor systems in which atoms (or heavy particles) are electrically charged and then accelerated by an electrostatic field, are receiving the major emphasis. Three types of electrostatic thrustors are under active investigation. Two of these, the electron bombardment and contact ion engines, differ basically in the propellant charge or ionization technique employed, whereas the third type, the colloidal engine, accelerates charged agglomerates instead of ions.

Work will continue on the ion systems to determine the performance capability, durability, clustering and scaling relations required to proceed from the present 3 to 30 Kilowatt (KW) range to the hundreds of kilowatts and into the megawatt range that will ultimately be required for interplanetary electric propulsion systems. Both clustering of 3KW ion engines and scaling in size up to 30 KW level have been demonstrated this year at the Lewis Research Center with no major difficulties indicated. Efficiencies of 60 to 80 percent have been achieved in the impulse range of 4,000 seconds to 10,000 seconds. Further scaling into the hundred kilowatt range will be continued in FY 1966.

The principal effort in the development of the electron bombardment ion thrustor has been devoted this past year to cathode life improvement. The cathode in this type of thrustor charges the propellant by bombarding it with electrons. A cesium electron bombardment thrustor, by using cesium as the propellant, employs a promising cathode design concept called the autocathode. From limited test data, it appears that this cathode may have a 10,000 hour lifetime capability. The autocathode avoids the erosion and subsequent failure of the cathode caused by ion bombardment by continuously replenishing the cathode surface with cesium. In FY 1966, both the autocathode and new coated filament cathodes will be further evaluated for durability and performance. Another promising cathode design that would eliminate cathode erosion by using a mercury pool as the cathode, is also under investigation.

Contact ion thrustor research during this past year has concentrated heavily on the ionizer. In these engines the propellant atoms are ionized (charged) by passing them through a hot porous tungsten material called an ionizer. The ionizer must be capable of remaining porous throughout the required operating lifetime, and must be capable of ionizing or charging over 99 percent of the propellant atoms. In order to produce such an efficient long life porous ionizer, porous tungsten technology must be further advanced. The Electro-Optical Systems, Space Technology Laboratory and Hughes Research Laboratory Companies are presently investigating this problem area under NASA contracts. Further efforts will continue into FY 1966.

The colloidal or heavy particle electrostatic accelerator is still in the early research phase. This concept is of interest because it offers promise of greater thrust and because the large number of electrons that can be removed from each molecule could make it possible to vary the charge-to-mass ratio and thereby optimize specific impulse in accordance with mission requirements.

In another broad category of thrustors, called electrothermal thrustors, three types are again under investigation. The resistojet and arc jet accelerate an electrically heated propellant by thermal expansion through a nozzle. The third type is an arc-jet like device whose performance depends upon electromagnetic as well as thermal effects. The principal problem areas are in achieving high performance and long life. Specific research tasks include electrode effects, materials and fabrication, propellant selection, storage and feed, understanding of basic energy transfer mechanisms, cooling techniques and configuration effects.

Space Electric Rocket Test (SERT)

	1964	1965	1966
Development and flight project..	$3,467,000	$2,300,000	$3,000,000
Scout (Launch vehicle Procurement Program).....	(500,000)	(400,000)	(---)
Total (including launch vehicles).....	($3,967,000)	($2,700,000)	($3,000,000)

The objective of the Space Electric Rocket Test (SERT) flights is to provide information on electric thrustor systems that cannot be obtained in ground based facilities and to flight qualify electric propulsion systems for mission application.

On July 20, 1964, the SERT I flight was successfully completed. The Lewis Research Center mercury electron bombardment engine operated perfectly and demonstrated conclusively that the positively-charged ion beam can be neutralized in space. The Hughes cesium contact engine failed to operate during the flight because of a high voltage breakdown. This failure did not influence the validity of the flight results, but did emphasize the need for the continued research in high voltage power conditioning included in the Nuclear Electric Systems budget. Flight test data correlated well with ground based vacuum facility results thus also confirming the validity of established ground based laboratory practice. The success of this first electric rocket engine flight obviated the need for further SERT I type tests.

The objective of the current phase of the SERT program is the evaluation and development of advanced thrustors for satellite attitude control and station keeping, which appear to be the first potential applications for electric thrustors. Analysis has indicated that for attitude control of long lived satellites, particularly those requiring very accurate attitude stabilization, the low propellant consumption inherently characteristic of electric propulsion would result in considerable weight savings as compared with the chemical propellants presently in use. Vacuum tank test of several experimental thrustor systems are being conducted and compared with chemical systems in order to permit selection of the more promising systems for further development. These systems will be further tested to determine thrust and impulse reproducibility, reliability and operating life. It is anticipated that this laboratory evaluation program will be completed in FY 1966 and that a flight verification (SERT III) of the most promising systems will be initiated.

The SERT II flight test program has been postponed indefinitely, pending definition of a primary electric propulsion application that would require flight validation of a specific electric propulsion system.

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY — NUCLEAR ROCKETS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

This program provides the research, design and engineering data, test hardware, and general technology required to assure that nuclear rocket systems can be developed at the power levels, operating times, restart conditions, and specific impulse values that will be required in advanced space exploration missions. In these systems, a nuclear reactor heats hydrogen to high temperature. The high temperature hydrogen gas is then accelerated through a jet nozzle producing thrust at high specific impulse.

The emphasis in the nuclear rockets program is on laying a technological foundation for proceeding with confidence on the development of nuclear rocket systems that will be required to accomplish heavy payload, high energy missions in space.

Nuclear rocket propulsion provides significant performance advantages for potential missions beyond Apollo such as lunar base logistics operations, very heavy deep space instrumented probes, and manned exploration of the planets. Manned planetary expeditions is considered among the major applications for nuclear rockets; a nuclear rocket propelled Mars spacecraft could be one third to one fifth the weight of a chemically propelled spacecraft.

A major part of the nuclear rockets program is the research and engineering on the nuclear reactor itself since this entire field is relatively new. In addition, emphasis is placed on the solution of problems associated with non-reactor components whose operating requirements tax the available technology and on the study of the fundamental heat transfer, fluid flow, structural design, and nuclear phenomena involved. An essential part of this program is investigation of experimental ground test engine systems required to develop a full understanding of the interaction of components in nuclear rocket engines and of the system performance characteristics. These data form a basis for eventual flight system development and provide information required by mission planners to incorporate nuclear rocket capabilities in advanced missions.

The nuclear rockets program is a joint AEC-NASA undertaking. To ensure an integrated program, the Space Nuclear Propulsion Office, established by interagency agreement between AEC and NASA, manages all aspects of nuclear rocket propulsion work for the two agencies. Research and technology work is conducted both in AEC Laboratories (e.g., the Los Alamos Scientific Laboratory and the Argonne National Laboratory) and NASA Centers (e.g., the Lewis Research Center and the Marshall Space Flight Center), although the major portion of the work is conducted by industry and some universities under contract.

761-133 O-65-21

SUMMARY OF RESOURCES REQUIREMENTS:

	1964	1965	1966
Supporting research and technology	$21,261,000	$21,731,000	$22,000,000
KIWI	1,700,000	---	---
NERVA	48,820,000	34,261,000	35,000,000
RIFT	6,645,000	---	---
Nuclear Rocket Development Station	750,000	739,000	1,000,000
Total	$79,176,000	$56,731,000	$58,000,000

Distribution of Program Amount by Installation:

Marshall Space Flight Center	$7,153,000	$1,280,000	$1,300,000
Jet Propulsion Laboratory	338,000	6,000	---
Lewis Research Center	11,330,000	10,450,000	7,800,000
Space Nuclear Propulsion Office	60,355,000	44,995,000	48,900,000

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

	1964	1965	1966
Rocket reactor research	$13,615,000	$13,356,000	$15,850,000
Nuclear rocket engine component research	6,935,000	6,775,000	4,550,000
Safety	470,000	500,000	500,000
Vehicle technology	241,000	1,100,000	1,100,000
Total	$21,261,000	$21,731,000	$22,000,000

The supporting research and technology program satisfies four basic needs: (1) supporting data for current projects (NERVA); (2) technology for the development of future generations of nuclear rocket engines and vehicles; (3) feasibility investigation of advanced nuclear propulsion concepts, and, (4) studies of special flight safety considerations of nuclear rockets.

Rocket Reactor Research

The major effort in rocket reactor research is supported by the AEC. It consists principally of the advanced graphite reactor technology program (PHOEBUS) at the Los Alamos Scientific Laboratory aimed at increased reactor performance. Also included is preliminary work on fast tungsten based reactors and more advanced concepts. The NASA program in this area is applied research directed primarily towards the development and procurement of the jet nozzles and hydrogen turbopump systems required for ground testing with the PHOEBUS reactors, and the evaluation of new and advanced nuclear rocket propulsion concepts which offer potential performance advantages for future space missions.

The KIWI reactor development project (first graphite based rocket reactor) was completed by the Los Alamos Scientific Laboratory with the successful ground testing of the KIWI-B4E reactor in August and September of 1964. The technology developed in that project serves as the basis for the NERVA reactor (NRX-A), the first power test of which was successfully run in September, 1964. The KIWI reactor technology is also the basis for the advanced graphite (PHOEBUS) reactor program.

The PHOEBUS program will provide improved, high power reactors (to 5,000 megawatts nominal power) for nuclear rockets. Mission studies indicate that clustered engines of this power level would offer the propulsion capability for manned planetary expeditions.

The first test of the PHOEBUS project will be conducted by Los Alamos at the Nuclear Rocket Development Station in calendar year 1965 using KIWI sized reactors. These tests will be run using jet nozzles developed for the KIWI program and modified KIWI hydrogen turbopumps. However, pumps and jet nozzles of increased capability will be required for later tests of the large diameter, high power PHOEBUS reactor which will begin during calendar year 1967. Development of these nozzles and pumps is being initiated in FY 1965 and will be continued in FY 1966. Included as part of the Rocket Reactor Research budget is the cost of hydrogen necessary for two KIWI sized PHOEBUS reactor experiments in FY 1966, and for development tests of the pumps and nozzles mentioned above.

The NASA program in FY 1966 will also continue evaluation of the performance potential of thermal, water moderated reactors using tungsten uranium dioxide fuel. Preliminary results of this work have indicated that extremely long operating times may be attainable with this fuel. High temperature environmental testing of fuel elements in flowing hydrogen, beginning in the second half of FY 1965, will be an important step in determining performance limitations of this fuel material and will be continued in FY 1966. It is anticipated that the work to be carried out in FY 1966 and 1967 will allow an assessment of the real performance potential of tungsten-uranium-dioxide reactors in the Nuclear Rockets Program.

Research will continue in FY 1966 on advanced nuclear propulsion concepts such as the gas core nuclear rocket propulsion concept in which the uranium fissionable material is in a gaseous rather than a solid form. The objective of this work is primarily to establish feasibility and performance potential. Emphasis will be on evaluation of promising approaches for containment of the gaseous nuclear fuel within the reactor. The approach will include experimental studies of the basic fluid mechanics of two concepts using simulated propellants and nuclear fuel. Supporting research on fundamental problems, such as the effects of temperature on fluid mechanics and on heat transfer characteristics, is being sponsored in several universities (Catholic University, Princeton, Case Institute, and Georgia Institute of Technology), industrial laboratories, and NASA Centers.

Nuclear Rocket Engine Component and System Research

The objective of this program is to establish the technology required for the development of non-reactor components for nuclear rocket engines. This component research, when combined with Rocket Reactor Research, will establish the characteristics of future generations of nuclear rocket engines and, in addition, will establish design techniques and operating data on components and engine systems. Lewis Research Center conducts the in-house work in this area and directs other work accomplished under industry or university contracts.

Research is conducted on: hydrogen flow components and systems, turbomachinery for pumping hydrogen, instrumentation and controls, engine system analysis, radiation effects, jet nozzles, bearings and seals, and hydrogen properties.

Turbomachinery research is directed at the unique problems posed by application to a nuclear rocket engine. The program at the NASA Plum Brook Station in FY 1966 will emphasize radiation effects testing of various bearing materials and bearing configurations, study of nuclear rocket dynamics through system cold flow experimentation (B-1 and B-3 Test Stands), and turbopump performance evaluation in real feed system configurations in the B-3 test stand. The results of this experimental research should provide important data to the NERVA project and a better understanding of the behavior of nuclear rocket engine systems under all conditions of operation.

The experimental engine dynamics studies carried out in the B-1 test stand will map engine performance characteristics and system control using NERVA engine hardware. Although no fission power is generated, this test stand permits full investigation under vacuum conditions of the important low flow regime encountered during startup of nuclear engines. The first nuclear rocket engine systems dynamics tests were run in this facility near the end of FY 1964 and will continue through FY 1966. Information from these experiments will be used to design a safe operating map for the NERVA engine control system as well as to provide insight into the design of improved engine systems and their startup control.

The B-3 turbopump evaluation stand at the Plum Brook Station will be ready for use near the end of FY 1965. Its first use will be to evaluate turbopump operation, including the effect on pump performance of simulated heat addition to the inlet such as would be expected from the radiation in a nuclear rocket engine.

Reliable control is essential for nuclear rocket engine systems, and it requires that both instrumentation and control components function predictably in the anticipated environment under a wide range of operating conditions. The extent to which radiation and low temperatures will affect the reliability of these components will be explored experimentally at the Plum Brook Station in FY 1966. A reactor cryogenic test loop will become available during the year for testing of nuclear rocket diagnostic and control instrumentation

with realistic reactor radiation and temperature simulation. The most promising conventional instruments are being modified to withstand this environment and will be tested in this reactor test loop. A similar loop will be used during FY 1966 to make simulated tests of NERVA control actuators. The results of these tests will help determine what modifications must be made, if any, to assure reliable operation prior to incorporation into engine tests.

The radiation effects program, conducted as part of engine component research, is exploring the behavior of candidate materials for use in nuclear rocket propulsion systems in a combined radiation and cryogenic environment. A typical problem is that of bearings, seals, and lubricants required to operate in this environment as components of high speed rotating machinery. It has been found that, under those conditions, bearing lifetimes are significantly reduced, lubricants break down, and conventional seal material loses its resiliency and sealing properties. Testing equipment has been designed and constructed for use in the Plum Brook Station reactor which will simulate operational loads on these components while they are subjected to the appropriate radiation and temperature environment. This equipment is being installed in the reactor during FY 1965 and will be producing research information by FY 1966. Results of this research support all phases of the nuclear rockets program, and are essential to the development of current systems as well as to the planning of advanced systems. A considerable amount of data will be obtained on materials which will be used in the design of the high powered PHOEBUS reactors.

The operating conditions of the KIWI reactor and the NERVA engine have required extension of our present nozzle technology. The high powered PHOEBUS reactor will require even further improvements in nozzle design, materials, and fabrication procedures. The first test facility capable of heating hydrogen to temperatures and flow rates adequate to allow testing of reduced scale nozzle concepts in a hot hydrogen stream will begin operation at the Lewis Research Center in FY 1965. This facility will allow experimental confirmation of analytical results for a number of new nozzle materials and designs. Refractory metal nozzle and coated nozzle concepts will be studied during FY 1966 to determine their adequacy for advanced higher power, higher temperature nuclear rocket engines.

Fluid property research is conducted to provide basic data on propellants and fluids used in nuclear rockets and in high energy chemical rocket engines. For several years, NASA has supported research and engineering development work related to the use of liquid hydrogen at the National Bureau of Standards' Cryogenic Engineering Laboratory. While this program is funded by the nuclear rockets program, the research and consultation services are available to all users of liquid hydrogen. The work includes the compilation of basic thermodynamic data and the evaluation of commercially available sensors for use with liquid hydrogen. These activities will be continued in FY 1966.

Safety

Flight safety analyses of nuclear rockets are being performed under the direction of Marshall Space Flight Center. These studies include the analysis

of the orbital lifetime of nuclear rocket parts and the radiation levels of such parts after reentry. Theoretical reentry analysis will be expanded to include ground testing and flight test planning. These studies when combined with nuclear analyses performed by the AEC will be used to solve unique operational problems associated with the safety of nuclear rocket flight operations. Hydrogen safety research at the U. S. Bureau of Mines (Pittsburgh) will also continue. This work includes determination of detonation and combustion limits, activation energies, kinetic and thermal energy yields, and other data on gaseous and liquid hydrogen.

Vehicle Technology

This program is providing information on new concepts relating to vehicle staging and configuration for future applications of nuclear rocket engines to spaceflight missions.

Studies of modular vehicle concepts, in which each module includes a nuclear rocket engine and propellant tank, were initiated in FY 1965 and will be extended in FY 1966. Conceptual designs of modular systems of a single size that can be clustered to provide a wide range of power availability will continue to be investigated in FY 1966. Studies are also underway of specific technological problems that will need engineering solutions before nuclear rocket powered spaceflights of long duration will become feasible. Typical of these is the problem of long term storage in space of liquid hydrogen. Although the large tanks of liquid hydrogen associated with nuclear propulsion have a reduced surface-to-volume ratio, compared with chemical propulsion system propellants, minimization of hydrogen losses through evaporation may be an important factor in determining mission capabilities. Analyses are being performed to determine optimum methods of storing liquid hydrogen, taking into account the requirements for micrometeorite protection and the effects of solar radiation, high energy charged particle radiation, and nuclear radiation. Preliminary evaluations of super insulation, slush hydrogen, and on board refrigeration systems will be expanded in FY 1966.

NERVA

	1964	1965	1966
Engine systems development.....	$4,555,000	$4,340,500	$5,000,000
Component and subsystem development.....	17,330,000	12,300,000	11,000,000
Ground test and operations support.....	23,090,000	13,570,500	14,500,000
Propellants.....	3,845,000	4,050,000	4,500,000
Total.....	$48,820,000	$34,261,000	$35,000,000

The objective of the NERVA (Nuclear Engine for Rocket Vehicle Application) project is to develop nuclear rocket engine systems that can be tested in ground based facilities to provide a complete understanding of the performance and operation of these systems and their major components under

operating conditions corresponding to those of future space missions. The work is being carried out at a nominal power level of 1,000 megawatts, corresponding to a thrust of approximately 50,000 pounds with a specific impulse over 700 seconds. The emphasis is on developing for this purpose components and systems which can lead directly to the later development of operational flight engine systems with a high assurance of success. This project is conducted principally under a joint AEC-NASA contract by the Aerojet-General Corporation and Westinghouse Electric Corporation.

Specific technical objectives for the NERVA project are to provide the reactor, engine systems, facilities and component technologies. The reactor development phase of the NERVA project includes full-scale reactor testing to determine the suitability of the reactor design for continuing technology advancement, for use in obtaining an understanding of engine system operation, and for ultimate application in a flight engine system. During FY 1965, the KIWI and NERVA (NRX) reactors successfully operated near rated power. Tests planned for FY 1966 will further evaluate the operating limits of such reactors including definition of the trade-offs among power, operating temperature, operating duration, and restart characteristics.

Engine system work includes investigations of engine system transient startup characteristics, steady state operating cycles, system dynamics of engine throttling and shutdown, and investigation of engine restart characteristics.

The development of test facility technology is necessary to provide confidence in undertaking a future nuclear rocket engine development program. The facility technology objectives include proof of the techniques for remote testing of downward firing engines and the feasibility of remote handling operations for engine system maintenance and disassembly.

Selected engine components will be developed in connection with the engine systems evaluation program, but component development will be limited to those major components which strongly influence system performance. Valves and lines will be facility or "boiler plate" types wherever possible. For the ground test program, most components will not be qualified to the high degree of reliability necessary for flight operation. However, major components such as turbopumps, nozzles with hot-bleed ports, and actuators for engine reactor control will be of flight design and will be developed to provide satisfactory performance under "flight" operating conditions.

Significant accomplishments to date in the KIWI and NERVA projects include: reactor startup and stable operation using liquid hydrogen as a coolant; demonstration of a satisfactory reactor design that avoids the flow induced vibration previously encountered; successful reactor operation for more than ten minutes at design conditions; restarting a reactor and achieving design power after a prior run at design power; and, automatic startup of a reactor from sub-critical conditions, thereby demonstrating the capability to start the nuclear rocket automatically as would be required in a flight system. Other progress includes improvement in fuel-element quality, and advances in nozzle and turbopump technology.

Engine System Development

The objective of this phase of the NERVA project is to perform the engineering, fabrication and testing of engine systems prior to their integration into complete experimental engines. The program includes cold flow tests in a non-nuclear engine simulator as well as hot flow tests conducted with operating reactors. Characteristics that will be evaluated in the cold flow simulator tests include the initial portion of engine startup with liquid hydrogen, flow stability, flow leakage, system pressure losses, and control response times. Cold flow testing of NERVA systems will be completed during FY 1966 and the test hardware will be modified for use in checkout of the Engine Test Stand in Nevada. Also during FY 1966 hot flow engine system tests will begin in one of the Reactor Test cells. Initial tests in this series will utilize an upward-firing NERVA reactor, not configured as a flight engine, but will incorporate a hot bleed port nozzle and a hydrogen turbopump system driven by reactor heated gases drawn from the bleed port.

Component and Subsystem Development

Development of components and subsystems includes those required for the experimental engine systems and some required for the experimental reactor. Principal objectives are the development of the hydrogen turbopump system, thrust chamber assembly, and engine controls. A radiation resistant turbine power control valve required to control turbopump speed will be developed. Nozzles, pressure vessels, turbopumps, controls, and associated components will be fabricated to support the engine test program. Acceptance and reliability testing of these components will be conducted.

Ground Test and Operations Support

This phase of the project provides remote handling equipment, checkout and test equipment, and maintenance equipment for all test operations. It also provides instrumentation for diagnostic and control purposes, for reliability and quality assurance testing, and for operational safety monitoring. During FY 1966, the equipment in the engine test and maintenance facilities will be checked out and used to support engine systems testing. Additional equipment and engine diagnostic instrumentation will also be provided. Technical guidance on ground test safety will be continued and safety reports and procedures will be issued.

Propellants

Funds provided under this heading will be used for procurement of propellants, primarily liquid hydrogen, required in various NERVA testing programs.

Nuclear Rocket Development Station Operations

	1964	1965	1966
General site support.....	$500,000	$589,000	$870,000
Capital equipment.....	250,000	150,000	130,000
Total.....	$750,000	$739,000	$1,000,000

The mission of the Nuclear Rocket Development Station (NRDS) is to provide a site for ground static testing of the reactors, engines, and eventually vehicles associated with nuclear rocket development. Management of the Nuclear Rocket Development Station is assigned to the Space Nuclear Propulsion Office. The major users of the Station are Aerojet-General Corporation, Westinghouse Astronuclear Laboratory, and the AEC Los Alamos Scientific Laboratory.

Technical support, maintenance, housekeeping services, and management functions must be provided at this site. These funds provide for NASA's share of the general site operations, the major part of which is now funded by the AEC.

General Site Support

General site support includes routine maintenance and operation of the facilities; for example, custodial services, maintenance of roads, grounds, and utility systems, furnishing of utilities, building operating supplies, fire protection, and cafeteria services. Included also are the services of a support contractor to maintain and operate plumbing, electrical, carpenter, welding, and machine shops. Funds in this category also cover costs of activating engine test facilities and of maintaining and operating support facilities and equipment.

Capital Equipment

Capital equipment funds are used for the procurement of shop equipment, warehousing equipment, and other pieces of major equipment required for general support of Station activities.

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY — CHEMICAL PROPULSION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

Propulsion represents one of the greatest limitations in capability for exploring space. Until now space vehicles have been propelled by chemical rockets. New propulsion devices such as a thermo-nuclear rocket and various electrical rockets will eventually advance space capabilities significantly. When operational these new types of propulsion devices will take their own places in a broadened propulsion spectrum, but will not replace all chemical systems. It is certain that most space flight advances made in the foreseeable future will depend upon chemical rocket propulsion. The research and experimental engine programs in chemical propulsion are devoted to increasing capabilities to conduct space explorations.

The technological base for new engine developments is provided by a planned process of scientific investigation progressing from concept evaluation through the gathering of engineering data to the demonstration of experimental systems. To facilitate this progression the chemical propulsion programs in both liquid and solid propellant motors have each been divided into two principal efforts: one in research and advanced technology, and one in experimental engineering.

Research and advanced technology covers basic studies and experiments related to launch vehicle and spacecraft propulsion such as measurements of chemical and physical properties of propellants, ignition and combustion phenomena, classical and non-equilibrium thermodynamic processes, the examination of new materials, and the processes of fluid mechanics, gas dynamics, heat transfer, and solid mechanics. Analyses are made of the functions a piece of propulsion equipment must perform, the performance levels that can be met and, in the broad cycle efficiency sense, the conditions under which it might best perform. New methods and design concepts are assessed. Future requirements and new problem areas are identified for further work.

The purpose of the experimental engineering program is to bridge the technological gap between propulsion research technology and the initiation of mission oriented propulsion system developments. The work involves the design, fabrication and test of model propulsion systems and of subcomponents to demonstrate their engineering practicality to meet the anticipated requirements of launch vehicle, upper stage and spacecraft engines. From such experimental system demonstrations will evolve advanced propulsion hardware designs with clearly defined maximum operating conditions and engineering limitations. A direct result of this work will be a set of preliminary engineering specifications with design criteria and fabrication process

specifications. A byproduct is a realistic assessment of possible development costs and schedules, facilities and equipment requirements, etc. The results will facilitate initiation of engine development with minimum expenditures of funds and time during the development phase.

SUMMARY OF RESOURCES REQUIREMENTS:

	1964	1965	1966
Supporting research and technology	$21,970,000	$24,762,000	$30,000,000
M-1 engine project	24,000,000	24,000,000	---
Large solid motor project	*	15,000,000	---
Small chemical propulsion flight projects	30,000	30,000	---
Total	$46,000,000	$63,792,000	$30,000,000

Distribution of Program Amount by Installation:

Manned Spacecraft Center	---	---	$500,000
Marshall Space Flight Center	$3,542,000	$3,592,000	5,100,000
Goddard Space Flight Center	375,000	550,000	800,000
Jet Propulsion Laboratory	4,296,000	4,183,000	4,700,000
Langley Research Center	1,144,000	1,480,000	1,980,000
Lewis Research Center	31,205,000	45,227,000	8,095,000
NASA Headquarters	3,194,000	8,760,000	8,825,000
Western Operations Office	2,244,000	---	---

* Previously U.S. Air Force program

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

	1964	1965	1966
Liquid rocket research and advanced technology	$10,527,000	$11,500,000	$13,000,000
Liquid rocket experimental engineering	6,640,000	6,075,000	8,500,000
Solid rocket research and advanced technology	2,760,000	4,995,000	5,000,000
Solid rocket experimental engineering	2,043,000	2,192,000	3,500,000
Total	$21,970,000	$24,762,000	$30,000,000

Liquid Rocket Research and Advanced Technology

The liquid rocket research and advanced technology program explores and extends the engineering science of propulsion for launch vehicles, upper stages, and spacecraft.

Part of the program continues to examine propulsion concepts for future launch vehicles. Two approaches to advanced launch vehicle engines have been pursued. The multi-chamber concept uses to the greater extent the technology developed in building engine equipment presently in use. The continuous chamber concept represents a greater departure from present technology but may offer a greater performance gain. The feasibility of methods for expanding combustion gases through either a forced deflection or a plug nozzle has been proven. Good engineering data required for detailed design analysis have been accumulated. Hot firing of critical components has been undertaken. Work related to cooling and pumping for engines at pressures significantly higher than current practice is in progress.

Efforts to improve spacecraft performance by use of advanced space-storable propellant combinations have been expanded. Investigations on the oxygen-difluoride/diborane combination have continued and a new project evaluating oxygen-difluoride/monomethyl hydrazine has been started.

Design guides for pressurized gas storage and propellant feed systems have been published. Work on positive expulsion technology and advanced chamber construction for use with high temperature combustion gases is being continued.

An example of propellant technology that has reached the application stage is the development of a suitable catalyst for hydrazine. This monopropellant has higher performance than hydrogen peroxide, which was used in the Mercury capsule and in other applications. This development has been cited as one of four major contributions to space technology last year.

Combustion instability continues to plague engine development programs. NASA in-house and contractual work has been increased to provide more basic data and a better understanding of the phenomenon. At the same time techniques are being explored for avoiding the instability through engine design changes.

Better rocket test instrumentation is necessary and efforts along these lines are progressing. The feasibility of instrumentation to diagnose symptoms of trouble in operating engines and to initiate automatic corrective action has been demonstrated. Tests on operational engines are forthcoming.

Work on advanced construction materials for liquid rocket engines, thermal and corrosion protective coatings, static and dynamic seals, valves, the flow of gases in nozzles, and the dynamic behavior of propellants in the feed system of engines will also receive additional emphasis in the coming year.

Liquid Rocket Experimental Engineering

This program is focused presently on auxiliary and space propulsion. The project includes an experimental auxiliary engine program to support an area which has been troublesome in the mission development programs; the continuation of a program to evolve an advanced design for Earth storable space propulsion systems; and extension of the high performance propellant research intended to provide smaller, higher energy upper stages.

The program for experimentally investigating improved space propulsion systems has been focused in three principal areas; advanced Earth storable propellant systems; high energy deep cryogenic propellant systems, and high energy space storable propellant systems.

The advanced Earth storable propellant system program, using the same class of propellants as the Apollo, Gemini and Surveyor spacecraft systems, will continue evaluation of design concepts that will significantly extend operating life, minimize complexity of components, and improve component capability. Some of these propulsion concepts have been applied to the Mariner spacecraft design.

The high energy deep cryogenic propellant systems programs are focused on the use of liquid hydrogen with liquid fluorine in upper stages. Spacecraft propulsion systems of this type can be operative up to several weeks in the space environment. The current program has demonstrated the operation of a modified oxygen-hydrogen engine with fluorine as the oxidizer. Revised designs and operating techniques that will facilitate the realization of the full performance potential of the fluorine-hydrogen combination in flight type hardware will be demonstrated. Unique hydrogen tank pressurization concepts that could minimize total system weight will also be demonstrated.

The high energy space storable propellant systems program will establish the foundation for the future space propulsion systems that must remain operative in a space environment for months or possibly years. The predominant requirement is that the propellant physical properties permit long term storage in space. One of the attractive propellant combinations is oxygen-difluoride with light petroleum gases such as methane. This propellant combination is now being examined to establish component designs that will facilitate its future use.

An auxiliary propulsion system program encompassing monopropellant systems and bi-propellant systems that employ both the Earth storable and high energy propellants will be continued. Design criteria for small rockets that have application as reentry control, spacecraft attitude control, station keeping systems. etc., will be developed. The application of new materials, coatings and fabrication processes to enhance operating life and reliability is being emphasized to improve life and design margins.

The other principal activities in the program are: (1) interface analyses to evaluate the impact of integrating propulsion systems into launch vehicle stages and spacecraft; (2) definition and classification of the hazards associated with the use of advanced propellant combinations and development of appropriate safety procedures and criteria; and (3) the development of specifications for the design, manufacture, and test of advanced propulsion systems.

Solid Rocket Research and Advanced Technology

This program provides an engineering base not only for the relatively simple solid propellant motors, with are used extensively for applications requiring extreme reliability rather than extreme performance, but also for hybrid motors, which may improve performance to be competitive with liquid bi-propellant systems for some applications. Solid propellant motor problems that apply to motors of launch vehicle size include the need for nondestructive testing techniques for inspection and qualification of loaded motors, better understanding of ignition processes, a better understanding of instability and thrust vector control systems, better methods for combustion termination, and improved processing techniques.

Candidate methods for nondestructive testing include the use of infrared detector scanning, attenuation of x-rays using scintillation detectors, low frequency ultrasonic probes, and microwave probes. During FY 1966, these and other techniques will be evaluated for use in the inspection of loaded motors prior to flight.

There is currently a need to achieve more accurate command cutoff of solid motor thrust and the capability for a limited number of stop-restart cycles. Recent advances in steady state and transient combustion theory have shed considerable light on the basic mechanisms that control combustion termination phenomena. This work may lead to the development of solid motors capable of interrupted combustion and a limited number of stop-restart cycles.

NASA's first work in hybrid propellant technology was begun in FY 1965 and will continue in the coming year. The hybrid propellant rocket usually uses a solid fuel and a liquid oxidizer although the reverse combination also falls into this classification. Potential advantages of hybrid propellants are improved space storability and the possibility of variable thrust in high propellant performance systems.

Research on steady and non-steady state combustion, propellant and metal ignition, rheological properties, degradation mechanisms, thermochemistry, high energy oxidizers and chemical binders are also conducted in this part of the program. These studies are fundamental to the development of both launch vehicle and spacecraft propulsion systems and contribute to the knowledge of the basic disciplinary sciences.

Solid propellant rockets pose a special problem because of the widespread use of metallic additives in propellant formulations which yield condensed liquid and solid particles in the exhaust. The transmission of radio beam signals of certain frequencies through the exhaust products during flight must be examined. The interaction of the rocket exhaust products with the signals in producing distortion, attentuation, or spurious noise will be studied.

The thrust behavior of solid motors is very dependent on the predictability of the burning rate of the propellant. If the burning rate is lower than predicted, the pressure, thrust, and impulse will be lower than required. Vacuum storage of spacecraft engines causes some propellant degradation that increases burning rates. Radiation degrades the oxidizer, which reduces burning rates. These competing degradation effects decrease the accuracy of the predicted performance. The burning rate deviations produced by vacuum storage will be evaluated under this program and methods to assure predictable performance will be developed.

Solid Rocket Experimental Engineering

The experimental-engineering program was established principally to support the technology related to solid-motor developments. The program includes work in the areas of spacecraft-auxiliary and controllable motors. Increased emphasis will be applied to these areas in subsequent fiscal years.

Presently the majority of the solid propellant experimental motor research is directed toward development of important subsystems applicable to first stage or booster functions. One subsystem is a malfunction detection system for warning of an impending failure in the rocket motors in time to permit escape of the astronauts. The program was started in calendar year 1963. During 1964, a major advance was made in detecting overheating which can lead to burn-through of motor cases. This new concept gives a clear signal when the hot gases in the rocket motor erode the insulation to expose a special conductive liner material. During the current year, the concept is being evaluated in small scale motors and during the coming year the engineering details for introducing it into very large motors will be defined.

A system for producing steering forces in large solid rocket motors by the injection of liquid into the exit cone is under engineering investigation. During FY 1966, an engineering analysis will be made to determine which components of existing smaller motors are directly applicable to the larger motor and which need to be further developed. A detailed engineering design will be made of a complete system which can be joined to the nozzle of the rocket motor. In the coming fiscal years, the design will be transformed into hardware and a complete thrust vector control system will be tested by static firing.

Nondestructive inspection equipment and standards for testing motor cases, propellant charge and nozzles are being experimentally evaluated under this program. An instrument for finding cracks in metal cases with ultrasonic waves has been devised, and standards for interpreting its signal established. In the current year, the method is being improved and partially mechanized, so that the very large surface of a high thrust motor may be inspected efficiently. Instruments for inspecting the critical part of the propellant charge, based upon microwave technology, will be brought from the laboratory state to breadboard development status during the coming year. In future years, this instrumentation will be extended to fully mechanized systems and the specifications and standards for its use will be established.

Current vehicle systems use many solid propellant motors to provide retro-propulsion during stage separation and to cause positive acceleration during the initiation of liquid engine operation. Other solid propellant motors are used in upper stages of small launch vehicles such as Scout and Delta. This program will undertake the definition of standard classes of solid propellant motor systems. Small attitude control rockets such as the Cap Pistol units or the Subliming Solid will be advanced to the status of demonstrated readiness for application.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1966 ESTIMATES

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY — SOLAR AND CHEMICAL POWER PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Solar and Chemical Power program provides research and technology necessary for the development of new and improved methods of solar and chemical power generation for space applications. The program includes research on all elements of complete systems: (a) the energy collection equipment such as a solar collector or a reactant supply; (b) the energy conversion devices including solar cells, thermionic generators, turbomachinery, fuel cells, etc.; (c) the energy storage unit such as a battery or thermal energy storage device; and (d) power conditioning and power management equipment.

All active space vehicles require electrical power for the operation of equipment, such as instruments, communication and data processing. For manned space missions, electric power is also required for additional functions such as life support and guidance for controlled reentry. Thus, this multi-disciplined program makes a direct and significant contribution to a broad cross section of the national space program.

SUMMARY OF RESOURCES REQUIREMENTS:

	1964	1965	1966
Supporting research and technology	$14,000,000	$13,745,000	$14,200,000
Total	$14,000,000	$13,745,000	$14,200,000

Distribution of Program Amount by Installation:

Marshall Space Flight Center	$1,429,000	$2,000,000	$1,000,000
Goddard Space Flight Center	2,170,000	2,425,000	3,075,000
Jet Propulsion Laboratory	2,381,000	3,121,000	3,105,000
Ames Research Center	105,000	191,000	170,000
Langley Research Center	710,000	690,000	740,000
Lewis Research Center	6,403,000	4,309,000	5,000,000
NASA Headquarters	630,000	1,009,000	1,109,000
Western Operations Office	172,000	---	---

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

	1964	1965	1966
Solar power generation.....	$9,343,000	$8,324,000	$8,919,000
Chemical power generation.....	4,657,000	5,421,000	5,281,000
Total.....	$14,000,000	$13,745,000	$14,200,000

Solar Power Generation

Solar cells are the most common energy conversion devices currently used for long duration space missions. However, such devices are limited by a susceptibility to damage by ionizing radiation (i.e., Van Allen electrons and protons, and solar protons), are relatively expensive, have an upper temperature limit of approximately 150°C and require on board electrical energy storage for vehicle operation out of direct sunlight. During the past three years, laboratory research at the Goddard Space Flight Center, the Lewis Research Center and the RCA and Space Technology Laboratories has determined the effect of reversing the polarity of solar cells and the effects of additives, impurities, resistivity, and junction depth on the solar cell's resistance to radiation damage. The research has shown that a controlled impurity, reversed polarity cell will have superior resistance to damage by radiation. As a result, significant progress has been made in increasing the resistance of the solar cell to Van Allen electrons, such that it has been increased by a factor of 30.

Until recently it was not possible to predict accurately the space performance of solar cells from measurements made at the Earth's surface. The solar cell responds differently to energy of different wave lengths and, as a consequence, the conversion efficiency is a function of the spectral distribution of the light source. Because of atmospheric absorption and scattering, sunlight at the Earth's surface has a different energy distribution than sunlight in space. Work under this program to launch solar cells to high altitude atop balloons, measure their performance above the atmosphere and recover the cells for use as standards, has made it possible to estimate solar cell space performance more accurately ($\pm$ 5%) from terrestrial measurements. These measurements of solar cell performance will be continued in order to obtain standards of new cells as they are developed.

In another application of solar energy, the direct conversion of heat energy to electricity by the thermionic process continues to show great promise. The concept of the thermionic converter is similar to the concept described under the Nuclear-Electric Program except that the electrode that emits electrons is heated by solar energy rather than by nuclear heat. During the past year, a 150-watt solar thermionic generator fabricated by the Thermal Electric Engineering Corp. was operated by the Jet Propulsion Laboratory at an efficiency of 10.5 per cent. This generator provides the highest conversion

efficiency that has been experimentally demonstrated to date. In conjunction with a suitable solar collector, a thermionic generator of this type, when developed, would weigh less and be less sensitive to radiation damage than a solar cell system. Thermionic investigations extend from basic research on materials and metallurgy, through surface physics and chemistry, to engineering development of thermionic devices and solar collectors.

For orbital missions with cyclic periods of sunlight and darkness, it is advantageous to keep the thermionic generator operating during the dark period, by supplying heat energy stored during sunlight. The heat stored by melting a substance with a high heat of fusion can be used to provide heat to the thermionic elements when the system is no longer in sunlight. The use of thermal energy storage eliminates the need for on board, high cycle, life batteries and reduces the thermal stresses on the thermionic generator by keeping it hot all the time. Although significant progress has been made toward identifying suitable thermal energy storage materials and compatible container materials, thermionic converters have not yet been operated with integral thermal energy storage. Such work is receiving emphasis during the present year and will be continued during FY 1966.

The design and performance characteristics of power systems based on thermoelectric conversion of solar energy are also under investigation. Thermoelectric conversion is an extension of thermocouple technology and is based on the principle that a current will flow between the junctions of two contacting materials when the junctions are at different temperatures. An example of research in this area is a flat panel fabricated by Melpar for the Goddard Space Flight Center with thermoelectric couples between the hot and cold surfaces. One surface is treated with a coating to produce a high equilibrium temperature when exposed to sunlight; the other surface is given a high emissivity coating and operates at a much lower temperature. This technique shows promise for space missions in toward the sun where temperatures would exceed the temperature limitations of solar cells.

In research on dynamic systems, the work on the mercury Rankine cycle (Sunflower) solar dynamic system was successfully concluded with the completion of a 4300 hour life test. While many problems remain to be solved, the design and performance characteristics of the system have been determined and the basic feasibility has been demonstrated. It is believed that sufficient technology now exists to permit system development if a mission requirement arises.

An alternate approach to dynamic power conversion is based on a gas (Brayton) cycle, which is expected to have higher efficiency, fewer problems with respect to zero-g start-up and operation, and longer life as a result of reduced corrosion problems. During the past year, a compressor and turbine were successfully operated on oil bearings at efficiencies slightly above those selected for the reference system. Work is in progress on both axial and radial turbomachinery that will operate on hot gas bearings. Successful completion of tests on these units will be a significant milestone in this work because the turbomachinery is usually the most critical set of components in a dynamic system.

Chemical Power Generation

Much progress has been made as a result of research on problems relating to batteries and fuel cells. Data have become available from Gulton Industries and General Electric Company to permit the design of electronic charge control circuitry which senses the signal from an added third electrode to regulate battery recharging rate. The third electrode also relieves the problem of oxygen gas pressure by dissociating excess oxygen so that it can recombine with the electrolyte. Life testing of third electrode cells is starting, and design ideas for multiple cell batteries are being evaluated. In another battery improvement program, modified cellulose and new plastic materials have been developed as battery separators to improve the life of silver-cadmium cells; preliminary indications point to at least a doubling of life as a result of impeding the migration of silver from cathode to anode.

A breadboard model of a capillary, low temperature H_2-O_2 fuel cell with passive moisture removal has completed more than 450 hours of operation on a Gemini type power profile at the Allis-Chalmers Company and is still on test. The basic design of this fuel cell has potential advantages over present spacecraft fuel cell designs because it combines features of high efficiency, zero-g start and restart capability, relatively low temperature and low parasitic power. Program objectives include the testing of flight type auxiliary hardware, construction of engineering evaluation models in the 2 kilowatt size for testing at the contractor's and NASA laboratories, and modification of the system to permit collection of water. Auxiliary equipment to permit further lowering of the start-up temperature is being developed on this contract, while very high performance electrodes suitable for use in this system are being developed by American Cyanamid Company. These electrodes may increase efficiency by 10 per cent, which would save chemical and tankage weight as well as reduce the size of the radiator.

In addition to the work on power generation, an important element of the program is the supporting research on conditioning, distribution, and control of electrical power throughout the spacecraft. High voltage arcs, short circuits, power surges, switching problems, etc. continue to plague space power systems, and insufficient emphasis on these problems is indicated. Continuing progress is being made in improving the reliability, efficiency, and other important performance characteristics of power converters, inverters, regulators, and protective devices.

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY — AERONAUTICS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The primary role of the Aeronautics program is to conduct scientific research to improve the efficiency, utility, and safety of aircraft. Continuing over-all objectives are:

1. To exercise unbiased technical leadership in the generation of advanced aircraft concepts.

2. To seek technological advances which will permit the development of improved aircraft.

3. To provide research information to industry for the design of new aircraft.

The scope of the NASA aeronautical research program includes work in aerodynamics, structures, materials, and air breathing propulsion, the operational and safety aspects associated with these disciplines and, to some extent, electronics and human factors. It is the evolutionary research in these technical disciplines that provides the fundamental knowledge needed to understand the complex problems involved in the design and construction of advanced aircraft. Understanding of these problems, in turn, aids in the determination of the likely direction of technological advances in the future. For example, the XV-5A fan-in-wing aircraft, the tilt-wing XC-142A V/STOL transport, and the variable sweep concept for the F-111 originated several years ago as promising concepts as a result of NASA research. In the years between the first indication of the value of the concept and the first flights of the vehicles, NASA aided in the detailed formulation of the concepts and in substantiating the over-all capabilities of practical vehicles based on these concepts.

In addition, NASA has conducted extensive wind tunnel tests, simulator programs, and flight investigations using appropriate testbed aircraft to substantiate predicted performance and operational characteristics of these vehicles and to aid in the solution of problems of a developmental nature. In this regard, advanced technical development in support of military and civil aircraft procurement continues to be conducted. This work is performed in cooperation with Government-sponsored contractors at the request of the cognizant Government agencies.

Research in Aeronautics in FY 1966 will include studies directed toward improvement of subsonic aircraft, for example, studies of means of improving the efficiency of transport aircraft by delaying the drag rise due to

compressibility effects at transonic speeds; studies of new materials and structural design concepts required to fabricate reliable lightweight structures suitable for a long life under high temperature conditions for supersonic and hypersonic aircraft; studies of air breathing propulsion cycles and engine components to increase efficiency and permit the design of efficient lightweight engines for V/STOL aircraft, supersonic transport, and hypersonic aircraft; studies of manned hypersonic air breathing vehicles which have the potential of providing hypersonic reconnaissance capabilities, hypersonic transport, and recoverable hypersonic air breathing space boosters; and studies directed toward improving flight safety and increasing operational flexibility of present and proposed aircraft, especially under adverse or "all weather" flight conditions.

Experimental research and development aircraft and engineering test pilot proficiency aircraft considered necessary to carry out and support the aeronautics effort are included under this program.

SUMMARY OF RESOURCES REQUIREMENTS:

	1964	1965	1966
Supporting research and technology	$9,195,000	$7,887,000	$8,300,000
X-15A research aircraft	900,000	1,425,000	900,000
Supersonic transport	8,821,000	19,953,000	16,000,000
V/STOL aircraft	2,879,000	2,850,000	2,000,000
Hypersonic ramjet experiment	---	3,125,000	5,000,000
XB-70/SST flight research project	---	---	10,000,000
Total	$21,795,000	$35,240,000	$42,200,000

Distribution of Program Amount by Installation:

Ames Research Center	$4,446,000	$4,967,000	$4,150,000
Flight Research Center	4,630,000	4,037,000	12,420,000
Langley Research Center	9,481,000	8,864,000	11,105,000
Lewis Research Center	1,852,000	13,566,000	12,700,000
NASA Headquarters	1,386,000	3,806,000	1,825,000

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

	1964	1965	1966
Aircraft aerodynamics	$1,404,000	$1,348,000	$2,000,000
Aircraft loads and structures	1,619,000	2,111,000	1,950,000
Air breathing propulsion	1,078,000	2,225,000	1,725,000
Aircraft operating problems	5,094,000	2,203,000	2,625,000
Total	$9,195,000	$7,887,000	$8,300,000

Aircraft Aerodynamics

The objective of research in aircraft aerodynamics is to improve the flight efficiency, performance, stability, and control effectiveness of aircraft. These characteristics strongly influence range, payload, economic feasibility, utility flexibility and safety of operation. In the case of very high speed flight, aerodynamic heating is an additional limitation and is a target for research.

In the subsonic speed range, particular attention will be devoted during FY 1966 to aerodynamic means for increasing the capabilities of current and future commercial and military subsonic jet transports. Theoretical and wind tunnel investigations will be made to develop new ways to increase cruising speeds which will directly increase flight efficiency, and to reduce landing speeds, to permit operation into airports which have shorter runways. Research will continue on the low speed stability and control of advanced supersonic cruise and V/STOL concepts and an investigation will be initiated of the take-off and landing characteristics of proposed configurations for hypersonic cruise vehicles.

In the supersonic speed range, refinement of theoretical analysis methods and computer programs for predicting the aerodynamic parameters used for the design of supersonic aircraft will be pursued. Basic studies of boundary layer flows on such aircraft will receive special attention with a view toward reducing the drag, flow separation, and interference effects. A better understanding of scale effects in predicting full size performance from small scale wind tunnel experimental data will be sought.

Analytical and experimental research at hypersonic speeds in FY 1966 will be directed toward refinement of the aerodynamic configurations suitable for manned sustained hypersonic cruise aircraft, reusable air breathing propelled, first-stage boosters and earth-to-orbit vehicles. Various combinations of wings, bodies, and air inlets will be evaluated in terms of lift drag ratio, stability, control, and heating rates at hypersonic Mach numbers where the high specific impulse of air breathing propulsion systems appears attractive. Concurrently, feasibility studies will be performed to help define critical basic research problems. An essential task in this regard in FY 1966 will be an assessment in depth of the need for a prototype or test bed flight vehicle in hypersonic cruise aircraft development.

The R&D funds requested will be used largely at the Ames, Flight, and Langley Research Centers for contract studies supplementing the in-house program described, and for necessary models and instrumentation used in their aerodynamic facilities. The requested funds also include those required for wind tunnel and related investigations in direct support of the Department of Defense in the development of advanced weapons systems, such as the F-111 and XV-5A aircraft which will continue in FY 1966.

Loads and Structures

Research on aircraft loads and structures is directed at improving the state of knowledge required for the design of efficient and reliable airframes for advanced flight vehicles. This includes research relating to the definition of the structural environment in terms of critical loads and temperatures, the structural characteristics and structural response under this environment, and the development and validation of better methods for design analyses for future vehicles.

Studies have been under way in FY 1965 to define more adequately the relative importance of such sources of aircraft loads as maneuvers, atmospheric turbulence, landing, etc. For example, past research on atmospheric turbulence has led to a generally adequate definition of gust loads for current subsonic aircraft, but for the safe design of future supersonic aircraft more precise information is needed on the characteristics of the atmosphere, particularly for gusts of long wave length.

As aircraft speeds increase structural fatigue is demanding increased attention. For the first time flight speeds are being reached for which the effects of temperature must be considered in the design of aircraft on a routine basis. In FY 1966 the fatigue characteristics of materials with cracks as well as simple structural specimens embodying various types of construction, such as welding and riveting, will be experimentally studied as points of stress concentrations and, therefore, sources of potential failure due to fatigue under high temperature, cyclic load conditions.

Experimental and analytical studies are being conducted of structural concepts having possible application to hypersonic cruise aircraft. Such structures must be light weight, must withstand high temperatures on the exterior, and must provide insulation to protect the low temperature, internally stored, liquid hydrogen fuel. To withstand the high temperatures associated with hypersonic flight, refractory materials are used which are inherently dense and, therefore, must be employed in an extremely efficient manner. Structural test specimens of two promising concepts are being constructed with completion expected during FY 1965. These structures will be intensively tested under realistic heating and loading conditions during FY 1966 to evaluate their strength and reliability under these conditions.

Air Breathing Propulsion

The major part of this program in FY 1966 will be directed toward the solution of problems associated with the Supersonic Transport and the Hypersonic Ramjet Experiment Projects.

The remainder of the research in this field during FY 1966 will be devoted to obtaining a better understanding of the basic phenomena involved in the complex systems required for future aeronautical vehicles. Inlets and nozzles for hypersonic propulsion systems will be investigated both theoretically and experimentally, particularly at off-design conditions.

Supersonic mixing of hydrogen and air and the resulting combustion of these gases will be studied. A program to investigate power plant structures and thermal protection systems associated with high speed propulsion systems will receive increased emphasis. Facilities capable of true simulation of all flight conditions of interest at hypersonic speeds and promising methods for modifying existing tunnels to obtain a more realistic testing environment will be investigated.

Specific military programs will continue to receive wind tunnel test support. Research leading to the improvement of existing systems will be conducted on a continuing basis. Typical of these is the testing, documentation, and possible modification of the F-111 induction and exhaust systems, and the study of the X-22A full scale ducted fan.

Aircraft Operating Problems

Research in this area is directed toward improving flight safety and increasing operational flexibility of present and proposed aircraft. Objectives of the research program are to obtain improvements in aircraft flying and handling qualities, in operational techniques during landing and take-off under all weather conditions, and in instrumentation directly related to the safety of flight. Research programs in the fields of sonic boom and aircraft noise are also included.

Experimental and analytical studies started in FY 1965 to obtain fundamental information on the generation and propagation of noise from the exhaust jets and the compressor and fan components of turbojet and turbofan engines will be continued during FY 1966. Theoretical studies show that small noise reductions in each engine component can be made, giving a total significant noise reduction. Experimental engine component studies will be made in the Noise Research Facility at the Langley Research Center to establish the effects of number of blades, blade loading, stage separation, etc., on noise generation. Inlet noise suppression and noise propagation in ducts will also be studied.

The techniques and procedures required to insure safe operation of commercial transport aircraft in turbulence or rough air are being investigated. The research program covers four major activities: analysis wind tunnel tests, flight tests, and piloted simulator tests. The program is designed to isolate the causes of aircraft upsets due to turbulence and establish adequate corrective measures. Flight and laboratory research will be carried out on airborne techniques, laser and others, for detecting regions of clear air turbulence.

The handling qualities of high performance executive type aircraft are being determined in a flight test program initiated during FY 1965. The primary objective of this research program is to formulate handling qualities

criteria which, if met, will ensure safe instrument flight operations with general aviation aircraft. Both single and twin engine aircraft representative of current production models by different manufacturers will be used in the flight program during FY 1966.

X-15 Research Aircraft

	1964	1965	1966
Aerodynamics.....	$130,000	$78,000	$40,000
Loads and structures.....	---	13,000	120,000
Operating problems.....	770,000	1,334,000	740,000
Total.....	$900,000	$1,425,000	$900,000

The X-15 Research Program, conducted in cooperation with the Department of Defense, is designed to provide data on manned, maneuverable hypersonic flight. During the course of the flight test program, through calendar year 1964, more than 100 flights have been made, including more than 75 flights at speeds greater than a Mach number of 4. Of these flights, more than 50 have been made at Mach numbers above 5.

The X-15 remains the only research facility in the world capable of studying hypersonic flight in its true environment. Experimental results to date have given basic insight into problems of aerodynamics, structures, propulsion and operations during hypersonic flight. Of major importance, the X-15 results have given, and will continue to give, confidence and guidance to research in ground based hypersonic research facilities enabling exploration in depth of many hypersonic flight problems. These ground facility studies in turn are defining probable hypersonic flight vehicles whose projected operation defines new research problems to be explored by the X-15.

In the light of the progress made in this research program, advantage was taken of a repair program initiated in X-15-2, as a consequence of damage sustained in an emergency landing, to increase its performance. As rebuilt, the aircraft can provide longer sustained flight at Mach 6.0 and can attain Mach 8.0 for short periods. The longer sustained flight expands greatly the capability in hot structures research, enabling near equilibrium temperature to be reached. The higher speed enables studies of hypersonic propulsion systems in a true environment which cannot yet be accomplished by any ground research techniques; this makes possible the Hypersonic Ramjet Experiment described elsewhere.

Past success in using the jettisonable lower ventral fin for structural research at hypersonic speeds lead to rebuilding the damaged wing tip of X-15-2 as a removable section, thus providing a valuable extension of the earlier techniques, particularly insofar as enabling structural research on lifting surfaces. Results from these 42" span instrumented wing tips will be unique as basic design data for sustained hypersonic flight vehicles.

In addition to a continuing program in basic hypersonic flight research, the operational success of the X-15 program has opened its use to space sciences as a carrier vehicle for certain experiments requiring its unique performance capabilities. For example, research on horizon seekers for satellites has been undertaken and information on stellar ultraviolet radiation has been gathered using the X-15 as a carrier vehicle.

In five and one-half years of flight test, from 1959 to December 1964, the X-15 program not only has contributed to the increased confidence of designers of current high performance aircraft, such as the YF-12A and SR-71, but has focused attention on the areas which required additional research, noted above. The future program will be directed toward these areas, to provide information for the next logical step in our flight research program--manned, maneuverable hypersonic cruise flight.

Supersonic Transport

	1964	1965	1966
Aerodynamics	$1,202,000	$1,514,000	$1,000,000
Loads and structures	308,000	157,000	700,000
Propulsion	1,605,000	16,177,000	13,300,000
Operating problems	5,706,000	2,105,000	1,000,000
Total	$8,821,000	$19,953,000	$16,000,000

The NASA role in the national supersonic transport program is to provide the necessary research information on a timely basis. During the past year the NASA program on supersonic transport configurations, for example, has provided information that shows how substantial improvements in payload or range can be achieved over what was considered possible a year ago. The contractor proposals to the Federal Aviation Agency in Phase II A of its program reflect this work. Research in FY 1966 will be an extension of work in progress last year in the areas of propulsion, aerodynamic efficiency, dynamic stability, noise, sonic boom, and structural materials.

Funding for FY 1966, for example, includes a substantial sum to continue the accelerated research program initiated in FY 1965 to provide the technology required for the design of advanced power plants needed for future operational supersonic transports and for follow-on vehicles. The work in this field in FY 1966 will be directed toward improving engine component performance, raising the present limit on turbine inlet temperatures as a means of improving engine thrust for a given engine size, and reducing engine weight. The program will concentrate on the key components of gas turbine engines, namely compressors, combustors, turbines, materials, bearings, seals, lubricants, and fuels. This research, in time, will lead to more reliable and more efficient turbine engines having thrust-to-weight ratios considerably above those of today's engines.

In the supersonic transport operating problems area, the joint NASA-FAA simulation program on supersonic transport air traffic control will be continued to determine the effects of the air traffic control systems on design requirements for the aircraft and on operating techniques. The studies will utilize various proposed supersonic transport designs in a real time, air traffic control, environment and investigate priority requirements, new air traffic control concepts, aircraft instrumentation, and possible navigation improvements. The critical nature of the fuel reserve problem and the potentially severe air traffic control requirements are expected to place heavy demands on the navigation system for precise control of flight path over the ground.

Emphasis during FY 1966 will also be placed on simulator studies to aid in defining the aerodynamic characteristics of the supersonic transport necessary to meet the handling quality requirements at high speeds. Piloted simulator studies using fixed based and three degrees of freedom motion simulators will be made to define the handling qualities of representative supersonic transport designs at or near cruising speed under normal and emergency flight conditions.

In addition to the ground based simulator studies of supersonic transport operating problems, flight tests will be conducted utilizing specially modified large jet transports to validate and extend simulation results, to define the height control requirements in flare and landing, and to evaluate the requirements for airworthiness test procedures. These programs will utilize aircraft already owned by the NASA or obtained on short term lease for this purpose.

V/STOL Aircraft

	1964	1965	1966
Aerodynamics	$509,000	$990,000	$900,000
Loads and structures	560,000	180,000	100,000
Propulsion	950,000	750,000	200,000
Operating problems	860,000	930,000	800,000
Total	$2,879,000	$2,850,000	$2,000,000

In FY 1966, greater attention will be given to the potential use of V/STOL aircraft for civil applications. Initial studies of the small STOL aircraft will be extended to additional wind tunnel investigations and to a flight evaluation of a configuration considered suitable for short-haul commercial operation into relatively small unprepared areas. Special emphasis will be given to providing research and operational information required in the development of more sophisticated, larger, V/STOL short-haul aircraft required to satisfy increasing transportation needs in congested, highly developed areas.

Continued high priority will be given to wind tunnel and, if feasible, flight investigations of high speed jet V/STOL types. For example, special study will be made of interference and engine hot-gas reingestion problems, of particular concern for jet V/STOL designs.

Investigation of the problems of all weather landing for V/STOL aircraft will be continued. Included will be a study using a high performance NASA research helicopter as a test bed to investigate basic pilot display requirements during simulated zero-zero landings. An increase in the understanding of the factors affecting minimum and optimum requirements for V/STOL handling qualities and control, under Visual Flight Rules as well as Instrument Flight Rules conditions, will also be obtained through continuing flight studies with two NASA variable-stability V/STOL aircraft and with the six-degree-of-freedom simulator; related information will be obtained through NASA participation in specific military flight evaluations (e.g. on the XC-142A tilt-wing, X-19A tilt-prop, and XV-5A lift-fan vehicles).

Flight and wind tunnel studies to investigate the characteristics of several new rotor concepts having the potential of greatly improved performance for future helicopters will continue; particular attention will be given to the non-articulated rotor, studied in flight with the NASA XH-51N helicopter.

Hypersonic Ramjet Experiment

	1964	1965	1966
Propulsion.....	---	$3,125,000	$5,000,000
Total.....	---	$3,125,000	$5,000,000

Hypersonic lifting vehicles have been studied extensively for application to various earth-to-earth and earth-to-orbit missions. Propulsion for such vehicles could be by rocket, air breathing engine, or a combination of the two. The much better specific impulse (fuel economy) of the air breathing engine, however, is an especially attractive feature of this type of engine. There is a substantial background of fundamental knowledge applicable to air breathing hypersonic propulsion concepts which indicates a theoretical capability for positive, useful thrust to orbital speeds. The next essential step is an experimental demonstration of the feasibility of these concepts for application to practical future propulsion systems.

Until very recently the design and construction of such an experimental propulsion system would not have been possible, because of the existence of large gaps in essential knowledge, such as the necessary understanding of supersonic combustion. Now, however, these gaps have been narrowed sufficiently to make such an undertaking feasible and to permit selective increases in emphasis on the study of component interaction and over-all engine functioning. Also, until very recently, the testing of such a propulsion system was impossible due to the technical inability to build an adequate

ground based research facility and the lack of a flight vehicle capable of sustained flight at the required speeds. The X-15-2, rebuilt after its landing accident, now incorporates modifications enabling sustained flight at speeds in excess of Mach number 6; although these modifications were made specifically for other research purposes, this increased performance gives NASA the opportunity of using the X-15-2 as a carrier vehicle for hypersonic propulsion systems and of accomplishing the required research on these systems. The development and flight test of such a research engine would both advance the technology and provide key information on which to base the planning of future research. This project seeks the eventual construction of a ramjet research engine for this purpose.

The ramjet principle has been selected for this study because it promises to be particularly applicable to future hypersonic transport aircraft and recoverable launch vehicles. Great advantages in reduced weight and improved flight efficiency are foreseen with the ramjet at hypersonic speeds.

The research engine to be developed will use hydrogen as a fuel and will employ supersonic as well as subsonic burning. It will provide information on ramjets operating in a speed range from Mach 3 upward into the hypersonic range.

During the first phase of the program, which was started in FY 1965 and will continue during FY 1966, selected contractors are performing independent studies to establish technical concepts and accomplish preliminary designs. These studies consist primarily of analyses such as engine cycle, inlet aerodynamics, and combustor and nozzle aerodynamics, with some small substantiating laboratory research. Based on his own selected concept, each contractor will propose complete plans, including schedules and resource requirements, for the construction and ground test of the selected propulsion system.

Evaluation of these proposals will provide the basis for a decision on the continuation of the project through construction and for selection of a single contractor.

XB-70/SST Flight Research Project

	1964	1965	1966
Aerodynamics.....	---	---	$3,000,000
Loads and structures.....	---	---	3,000,000
Operating problems.....	---	---	4,000,000
Total.....	---	---	$10,000,000

Proposed designs for supersonic transports and hypersonic vehicles center around vehicles whose operating environment (speed, altitude, duration) are significantly far removed from that which can be reproduced in a ground based facility and whose sheer size introduces wholly new problems. The B-70 as a research tool provides NASA with the ability to validate its basic aerodynamic theories and experimental results obtained in ground facilities to account for, as examples, effects of scale on skin friction and heat transfer, effects of elastic structure deformation on aerodynamics and the effect of heat soak on this deformation, effects of vehicle inertia combined with low damping (high altitude) on vehicle control requirements, effects of vehicle size on sonic boom generation and propagation, inlet control system requirements and many others. All of these problems have been and will continue to be the subject of major research efforts in analysis and ground based facilities; the B-70 program will provide vital guidance and assessment of the soundness of these programs, assuring that major programs such as the Supersonic Transport are proceeding on a sound basis.

The program is being conducted in two distinct phases. The first phase, which began in FY 1963, consisted of installation of instrumentation in the two XB-70A aircraft during manufacture and the acquisition of certain data of interest to NASA during the USAF flight test program. The second phase, beginning in FY 1966, will consist of continuation and expansion of the initial program and the initiation of research which could not be accommodated during the USAF flight program. In the first phase of this program, NASA funded only the costs associated with the instrumentation and data acquisition required for those measurements of interest to NASA. The major cost, that of operating the aircraft, was funded by the United States Air Force. In the second phase, NASA will fund all of the costs associated with the NASA XB-70/SST Flight Research Program, including the cost of operating one XB-70 aircraft.

This program is obtaining results which are useful to the Federal Aviation Agency in its role as manager of the United States Supersonic Transport program; the FAA is kept informed on the progress of the program on a continuing basis.

OFFICE OF TRACKING AND DATA ACQUISITION

TRACKING AND DATA ACQUISITION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The purpose of this Program is to provide tracking and data acquisition support to meet the requirements of flight projects. Responsive and efficient support is provided for all projects, and as mutually agreed, for projects of the Department of Defense, other government agencies, universities, private corporations, international organizations, and other countries engaged in mutual research endeavors.

Support is provided for manned and unmanned flights; for spacecraft, launch vehicles, sounding rockets, and research aircraft; for Earth orbital and sub-orbital missions, lunar and planetary missions, and space probes.

Types of support provided include tracking to determine the position and trajectory of vehicles in space, acquisition of data from scientific experiments and on the engineering performance of spacecraft and launch vehicle systems, transmission of commands from ground stations to spacecraft, communication of information between various ground facilities and mission control centers, and processing of the data acquired from the space vehicles. Without this vital support, the space research program would not be possible.

Tracking and data acquisition support is provided by a world-wide network of ground stations (including Department of Defense stations and instrumented ships), and by general purpose facilities in launch areas. These stations are linked together by a network of ground communications which provides the real-time information necessary for critical decisions. Facilities also are provided to process into meaningful form the large amounts of data which are collected from flight projects.

Tracking and data acquisition facilities are used for support of current missions. At the same time, they must be augmented to meet the requirements of missions in the immediate future. Concurrently, planning must proceed for projects which are even further in the future, and equipment and techniques must be developed to assure a sound technological approach for the support of the more complex mission requirements of the next generation.

The Research and Development Appropriation provides funds for: (a) the operation and maintenance of the world-wide facilities, (b) the procurement of equipment and modifications to adapt the facilities for new and changing flight project requirements, and (c) the development of advanced tracking and data acquisition equipment and techniques. The subsequent sections detail plans and related funding requirements to continue the Tracking and Data

Acquisition Program in each of these areas during FY 1966.

In FY 1965, the Congress authorized $261,900,000 for the Tracking and Data Acquisition Program. As indicated below, NASA has allocated an amount of $274,750,000 for the program. This is due to the transfer of general tracking and data acquisition functions and related funding authority from certain flight projects in the Space Science and Applications Program to the Tracking and Data Acquisition Program.

Responsibility for the Space Flight Operations Facility (SFOF) at the Jet Propulsion Laboratory, Pasadena, California, was transferred from the Lunar and Planetary Program. This facility provides for the performance of control functions associated with missions supported by the Deep Space Network.

Also transferred to the Tracking and Data Acquisition Program was responsibility for providing ground station support for the Applications Technology Satellite. Funds for this function were formerly included in the Applications Technology Satellites Program.

SUMMARY OF RESOURCES REQUIREMENTS:

	1964	1965	1966
Operations	$78,131,000	$102,819,000	$129,300,000
Equipment	103,326,000	157,248,000	102,400,000
Supporting research and technology	12,890,000	14,683,000	14,500,000
Total	$194,347,000	$274,750,000	$246,200,000

Distribution of Program Amount by Installation:

Marshall Space Flight Center	$2,900,000	$2,000,000	$1,500,000
Goddard Space Flight Center	132,817,000	195,201,000	173,400,000
Jet Propulsion Laboratory	42,070,000	59,799,000	53,000,000
Wallops Station	5,100,000	5,450,000	5,900,000
Flight Research Center	1,800,000	2,200,000	2,000,000
Langley Research Center	2,450,000	2,200,000	2,500,000
NASA Headquarters	7,210,000	7,900,000	7,900,000

BASIS OF FUNDING REQUIREMENTS:

Operations

	1964	1965	1966
Manned space flight network	$18,795,000	$24,258,000	$35,100,000
Satellite network	23,464,000	27,340,000	32,300,000
Deep Space Network	11,833,000	19,394,000	23,700,000
Other instrumentation	5,736,000	6,100,000	6,300,000
Communications	12,026,000	18,627,000	23,800,000
Data processing	6,277,000	7,100,000	8,100,000
Total	$78,131,000	$102,819,000	$129,300,000

Manned Space Flight Network

1964	1965	1966
$13,795,000	$24,258,000	$35,100,000

The Manned Space Flight Network was ready to support the Gemini Program on schedule. The various required equipments were installed at the stations and checked out. Training of operating staffs was completed and mission simulations were conducted to verify operating procedures and to integrate the stations into a cohesive network. Operational readiness is assured for support of the remaining Gemini launches.

The Manned Space Flight Network for support of Gemini consists of seven primary land stations at Cape Kennedy, Florida; Bermuda Islands; Grand Canary Islands; Carnarvon, Australia; Hawaii; Guaymas, Mexico; and Corpus Christi, Texas; two ships, the Rose Knot Victory and the Coastal Sentry Quebec; and six secondary land stations at Kano, Nigeria; Madagascar; Canton Island; Point Arguello, California; White Sands, New Mexico; and Eglin Air Force Base, Florida. The Madagascar station replaces the station which was removed from Zanzibar as a result of the revolution.

Bringing this world-wide network of stations to the required state of readiness for the Gemini Program has had, and is continuing to have, a direct impact upon operations costs due to required training and increases in manning levels, logistics, and general network support. This impact is causing increases in FY 1965, and additional increases will be required in FY 1966 to maintain the capability of the network during a full year of Gemini operations.

Concurrently with providing full operational support for the Gemini Program, the Manned Space Flight Network is being augmented for the Apollo Program. Not only are significant equipment additions being made to existing stations, but several new land stations, ships and instrumented aircraft are being added to the network.

The Manned Space Flight Network, as presently planned for Apollo, will consist of ten 30-foot antenna stations, three 85-foot antenna stations, two portable stations with 16-foot antennas, five ships, and instrumented aircraft. Of these facilities, the three 85-foot antenna stations, three of the 30-foot antenna stations, all of the ships, and the aircraft will be new. All of the facilities, including the Gemini stations which will be modified for Apollo, are scheduled to become operational during the period from mid-1966 through mid-1967. Staffing and training of operating personnel must begin nine to twelve months in advance of the operational dates to assure that the stations will be ready to support Apollo missions. In order to meet this schedule, significant operations costs for the Apollo Program must occur in FY 1966.

Satellite Network

1964	1965	1966
$23,464,000	$27,340,000	$32,300,000

The Satellite Network includes 13 electronic stations of the Space Tracking and Data Acquisition Network (STADAN) managed by the Goddard Space Flight Center, and 12 optical camera tracking stations operated by the Smithsonian Astrophysical Observatory (SAO). The STADAN stations provide a tracking and data acquisition ground system which tracks, determines the status of each satellite, commands the satellite functions and acquires stored or real-time data from the satellite. The optical camera tracking stations provide specialized services in precision orbital determination on certain satellites of scientific interest as well as backup support to STADAN during launch and early orbit tracking of all satellites.

Operation of the STADAN stations is accomplished through various arrangements. Stations located in the United States and certain foreign countries are operated under commercial contracts. Others are operated by foreign government agencies in close liaison with NASA.

During the first-half of FY 1965, the Satellite Network supported 31 satellites using the electronic stations of STADAN and 30 satellites using the optical capability of the SAO network. In the case of STADAN, this comprised 21 NASA projects, 3 international cooperative, 1 industrial, and 6 projects in direct support of the Department of Defense (DoD). In the case of the optical network of SAO, this included 14 satellites in support of the SAO's scientific investigations, 14 satellites to provide operational data to NASA, and 2 satellites in response to DoD requests for support on specific satellites.

In FY 1966, the Satellite Network will continue to support many of the same satellites which will still be in orbit. Several of these satellites have exceeded their estimated lifetimes and the originally planned levels of support. Adding to the workload will be launchings of new satellites, including initial flights of the Orbiting Astronomical Observatory and the Biosatellite projects, and additional flights of the Orbiting Geophysical Observatory project.

Increased operational costs in FY 1966 are caused by the need to fund the operations costs of the 85-foot antenna facility at Canberra, the second such facility at Rosman, North Carolina, and the Range and Range Rate facilities at Alaska. All of these facilities are scheduled to become operational at the beginning of FY 1966. A small, but general increase of staffing is required to meet increased workloads in support of scientific satellites at most stations.

Deep Space Network

1964	1965	1966
$11,833,000	$19,394,000	$23,700,000

The Deep Space Network provides tracking and data acquisition support for unmanned lunar and planetary space flights. The network provides tracking data which are used to determine, and make mid-course corrections to, spacecraft trajectories; acquires engineering telemetry data concerning performance of the spacecraft systems so that appropriate corrections can be made to spacecraft operations as required, transmits commands to spacecraft to execute the above functions; and records the scientific data which are acquired from the spacecraft.

Associated with the Deep Space Network is the Space Flight Operations Facility (SFOF) which is located at the Jet Propulsion Laboratory, Pasadena, California. The SFOF receives information transmitted via ground communications from stations of the Deep Space Network, processes the data, and displays the resulting information so that mission directors and associated project personnel can analyze real-time mission performance, make critical decisions concerning functions which must be executed by the spacecraft, and transmit instructions to the stations for commands that must be sent to the spacecraft.

The SFOF was established and initially operated by the Office of Space Science and Applications as part of the Lunar and Planetary Program. In recognition of the close relationship between the Deep Space Network and the SFOF during actual operations, management responsibility for the SFOF, on December 1, 1964, was transferred to the Office of Tracking and Data Acquisition. Coincident with this change, all FY 1965 funds, which were allocated for mission-independent functions of the SFOF in the Lunar and Planetary Program, were moved to the Tracking and Data Acquisition Program. The FY 1966 request includes funds for continuation of these functions.

During FY 1966, the initial flights of the Lunar Orbiter, Surveyor, and Pioneer projects will occur. To meet the flight schedule, the Deep Space Network and the SFOF for the first time must be prepared to support more than one mission at the same time.

At the beginning of FY 1966, the Deep Space Network will consist of two operational 85-foot antenna facilities at each of the three longitudinal locations required to maintain continuous surveillance of a lunar or planetary mission. Two of these facilities (Madrid, Spain and Canberra, Australia) will become fully operational in the second half of FY 1965 so that full operational costs will occur for the first time in FY 1966. Additional operations funds will be required in FY 1966 to provide early operations personnel for the prototype 210-foot antenna facility nearing completion at Goldstone, California, and the spacecraft checkout facility which will become operational at Cape Kennedy.

Other Instrumentation

1964	1965	1966
$5,736,000	$6,100,000	$6,300,000

This category provides funds for operating instrumentation systems used for support of sounding rocket programs conducted by Fort Churchill, Canada, and Wallops Station, Virginia, and for the flight research programs at the Flight Research Center, California. General purpose tracking, telemetry, data acquisition, recording, timing, plotting, and communications systems are used as well as special purpose optical and sound ranging (acoustical) equipment for specific missions.

The instrumentation required for support of missions launched from Wallops Station is operated by NASA contractors and by other government agencies such as the Weather Bureau, the National Bureau of Standards, the U. S. Navy, the U. S. Air Force, and the Military Sea Transportation Service. Increased operations costs for FY 1966 are due primarily to the ship operation costs of a ship borne sounding rocket expedition to the broad ocean areas of the southern hemisphere. At Fort Churchill, the instrumentation is contractor operated and is funded jointly by the Department of Defense and NASA as a cooperative effort. Activity will continue in FY 1966 at about the same rate as in the current year.

The Flight Research Center's Aerodynamic Test Range includes three sites located in the Nevada and Eastern California area. The site at Edwards Air Force Base is staffed by NASA personnel augmented by some contractor personnel. The Ely and Beatty sites in Nevada are contractor operated. Among the programs to be supported in FY 1966 will be the Lunar Lander Research Vehicle, the Lifting Reentry Research Vehicle, and the space sciences experiment program using the X-15.

Communications

1964	1965	1966
$12,026,000	$18,627,000	$23,800,000

The tracking networks are dependent upon reliable and rapid communications between the stations and their control centers. Acquisition, command, and control data must be sent from the centers to the stations and the stations must relay tracking and telemetry data back to the control centers for rapid analysis of spacecraft performance so that corrective measures can be taken quickly if problems develop aboard the spacecraft.

As spacecraft have become larger and have been designed to perform many additional and alternative functions, realtime monitoring and control of the spacecraft by the mission control centers has become an increasingly important requirement. To support these advanced missions, the requirements for volume and reliability of communications between mission control centers and network stations have been steadily increasing.

In order to minimize the actual growth of communications lines and facilities, the operational communications system has been consolidated into a single system to support all networks. Communications switching centers have been established at major locations such as Goddard Space Flight Center; London; and Australia to provide the maximum capability of sharing circuits. Maximum use is being made of alternate voice and data sharing of circuits. However, still further increases in communications capacity are required.

In the case of Apollo, additional voice-grade circuits and nine teletype circuits to overseas tracking locations will be needed over the present Gemini requirements. The major portion of these circuits will be installed during FY 1966. To further support Apollo, two wide-band data links must be installed during FY 1966 between Cape Kennedy and Houston to provide near real-time telemetry. Initial communications arrangements will be started in FY 1966 to meet ship-to-shore requirements for project Apollo.

Also during FY 1966, additional wide-band data circuits will become operational from Goddard Space Flight Center to Rosman (North Carolina) to support the Orbiting Geophysical Observatory and the Orbiting Astronomical Observatory; and between Cape Kennedy and Huntsville in support of the Launch Information Exchange Facility which will operate as a subcontrol center to the Mission Control Center at Houston to analyze and recommend actions for the Saturn IB and Saturn V launch vehicles.

Data Processing

1964	1965	1966
$6,277,000	$7,100,000	$8,100,000

Information received in the form of tracking and telemetry from satellites and space probes must be processed into a form that is useful to both those performing the real-time control of the space vehicle and those responsible for analyzing the scientific data acquired by the spacecraft.

Tracking data are processed to provide orbital elements which are used to supply stations with predictions on future passes of the spacecraft and to provide position information that can be used by the scientific experimenters to determine where in the trajectory the scientific measurements were made.

Telemetry data must be processed to separate the information from the various scientific experiments aboard the spacecraft, to consolidate information from each experiment, to apply the necessary scaling factors and calibrations of the measuring instruments, and to correlate these measurements with the position data mentioned above. Processed data presented to the experimenters is the primary objective of the spacecraft missions which are undertaken to explore and understand space.

During FY 1964, data were processed at an average of 8,000,000 data points per day. Based upon the first half of the year, it is expected that additional launches will occur during FY 1965 which will increase the data processing workload to an average of 70,000,000 data points per day.

During FY 1966, the data processing workload is expected to increase to 200,000,000 data points per day. This additional data processing workload will result primarily from the increase in observatory satellites, the Eccentric Geophysical Observatory (EGO), Polar Orbiting Geophysical Observatory (POGO), and Orbiting Astronomical Observatory (OAO), plus the normal launching of Explorer type satellites whose reliability has increased over the years so that they continue to supply useful scientific data for several years.

Equipment

	1964	1965	1966
Manned space flight network..	$56,234,000	$114,217,000	$64,000,000
Satellite network.....	15,297,000	17,250,000	14,700,000
Deep space network.....	12,004,000	11,520,000	9,800,000
Other instrumentation.....	4,690,000	5,300,000	5,500,000
Communications.....	4,036,000	4,110,000	4,400,000
Data processing.....	11,065,000	4,851,000	4,000,000
Total.....	$103,326,000	$157,248,000	$102,400,000

Manned Space Flight Network

	1964	1965	1966
Receiving systems.....	$8,613,000	$8,388,000	$10,700,000
Transmitting systems.....	3,142,000	444,000	1,500,000
Ranging systems.....	3,811,000	7,530,000	2,000,000
Antenna systems.....	7,915,000	2,115,000	4,200,000
Command systems.....	585,000	5,645,000	6,600,000
Data handling systems.....	8,339,000	12,675,000	10,300,000
Demodulation systems.....	7,123,000	8,800,000	10,100,000
Communications equipment.....	165,000	---	3,200,000
Ship modifications.....	4,452,000	37,700,000	---
Aircraft modifications.....	---	21,700,000	---
Control centers.....	2,395,000	---	4,200,000
General network support.....	6,405,000	5,949,000	5,400,000
Maintenance, spares, and repairs.....	3,289,000	3,271,000	5,300,000
Total.....	$56,234,000	$114,217,000	$64,000,000

Originally implemented as the Mercury Network, the Manned Space Flight Network has now been augmented for support of the Gemini Program in the areas

of tracking, telemetry, command, and communication. Additional augmentation of the network to meet the vastly increased requirements for support of the Apollo Saturn IB and Saturn V programs was initiated in FY 1964 and is continuing in fiscal years 1965 and 1966.

Apollo mission requirements encompass instrumentation to provide: (1) from the early ballistic and earth orbital missions, the engineering data needed for the efficient development of the lunar landing capability, and (2) for the later lunar missions, information for making the complex mission decisions in real-time and to provide data for subsequent analysis of systems behavior.

The planned augmentation of the Manned Space Flight Network for Apollo will result in ten 30-foot antenna stations, three 85-foot antenna stations, two transportable stations with 16-foot antennas, five ships, and eight instrumented aircraft. This network configuration will provide the ground instrumentation support necessary to fulfill the presently defined Apollo Program requirements; however, specific mission definition and associated tracking and data acquisition requirements definition is a continuing effort and additions may be necessary in future fiscal years.

During calendar year 1964, Apollo mission planning has been continued in greater detail as the various spacecraft and launch vehicle characteristics have become better defined. As a result, additional support requirements have been identified. For example, communications and tracking coverage requirements during the period immediately after launch have been evaluated for compatibility with newly available spacecraft and launch vehicle antenna patterns. Transportable command and telemetry stations must be added at Grand Bahama and Grand Turk Islands to close gaps in coverage and thus provide the needed flight control capability during this important mission phase.

As another example, a review of command and display requirements for mission flight control at the network stations has indicated that the meter type displays currently used for similar functions in support of the Gemini Program will not be adequate for the increased amount of data from the Apollo spacecraft and launch vehicles. At remote stations with limited capability for communication with the Integrated Mission Control Center, it will be necessary to provide data processors and numeric presentation of critical control parameters so the flight controllers can rapidly select and assimilate the large amounts of data they need to make the decisions on which the success of the mission depends. Similar detailed reviews of support capabilities have led to identification of other needed additions to standard network systems.

Receiving, transmitting, and ranging systems will provide the capabilities for transmission and reception of voice and telemetry signals, provide data for antenna directing, and enable measurement of the positions and velocities of the spacecraft and launch vehicles. In FY 1966, sensitive maser preamplifiers will be incorporated in the stations at Carnarvon,

Australia, and at Ascension Island to provide increased receiving sensitivity sufficient to fill gaps in instrumentation support during the critical transposition maneuver of the Command/Service Module (CSM) and the Lunar Excursion Module (LEM). Additional receiving and transmitting channels will be added at eight land stations and three ships to meet the additional requirements for instrumentation support for the SIVB stage during Apollo/Saturn V operations.

Antenna systems augmentation in FY 1966 will include UHF/VHF antennas and feed modifications for support of the SIVB stage. Two 16-foot diameter S-band antenna systems are planned for the transportable stations to be used for launch area support, and equipment is needed to augment the training and engineering facility at the Goddard Space Flight Center.

Command and data handling systems consist of digital display and computation equipment for monitoring telemetered spacecraft equipment performance and astronaut status and for coding and sequencing of commands. These systems include recorders for storage of telemetry data and station status information. The augmentation planned for FY 1966 includes provision of digital command remote terminal equipment for the transportable stations at Grand Bahama and Grand Turk Islands, additional consoles and displays needed to provide numeric displays for use by the flight controllers, and additional consoles and recorders for use in support of the SIVB stage during the Apollo Saturn V program.

Demodulation equipment extracts the telemetry, communications, and tracking information from received signals and prepares it for storage and for input to the data handling systems and communications terminal equipment. The major element of demodulation systems augmentation in FY 1966 consists of the provision of additional Pulse Code Modulation (PCM) telemetry decommutation systems for support of the SIVB stage.

Communications equipment consists of terminal equipment necessary for compatibility with common carrier facilities. Since the equipment is standard in nature and readily available, its procurement for support of Apollo was not planned for prior years. Funds are requested for the equipment needed for the various network stations in FY 1966.

The control center funds requested will provide equipment which must be added to the existing network control centers to enable operational control of the network during nonmission periods and simulations, and to provide the capability to assess network performance during mission periods. Funds are requested in FY 1966 for equipment to be installed for Apollo support in the Integrated Mission Control Center at the Manned Spacecraft Center; the Manned Space Flight Network Control Center at the Goddard Space Flight Center; and the Space Flight Operations Facility at the Jet Propulsion Laboratory.

Funds requested for general network support are those necessary to meet expenses for the systems engineering effort, for the shipment of equipment to the network stations, for the provision of network descriptive documentation, specifications, and operational manuals, and for the provision of

standard test equipment. Those requested for maintenance, spares, and repairs are primarily for the establishment of spare parts inventories needed to preclude long periods of station downtime during mission periods.

Satellite Network

	1964	1965	1966
Tracking systems	$2,333,000	$2,332,000	$2,550,000
Telemetry systems	3,790,000	2,721,000	2,455,000
Command and control systems	566,000	1,081,000	781,000
Recording and display systems	1,707,000	965,000	896,000
Test, calibration and checkout equipment	1,654,000	967,000	965,000
Timing systems	815,000	1,030,000	975,000
Real-time data handling systems	649,000	266,000	538,000
Applications technology satellite requirements	452,000	4,950,000	2,400,000
Control center	153,000	350,000	550,000
General network support	1,681,000	1,174,000	1,370,000
Maintenance, spares, and repairs	1,497,000	1,414,000	1,220,000
Total	$15,297,000	$17,250,000	$14,700,000

For the past three years, the Satellite Network has been enlarged and updated with new facilities and equipment to meet the support requirements of the second generation scientific and applications satellite projects. The major objectives of the equipment program are to provide the network with the capability for highly precise satellite tracking up to lunar distances, for acquiring and handling high data output rates, and for performing the more intricate command and control functions required by the more advanced satellites, particularly those of the large observatory class.

The major item in the tracking systems category in FY 1966 will be for the modification of existing Range and Range Rate Systems. These modifications are due to: (a) incorporation of greater gain capability which operating experience on the first Orbiting Geophysical Observatory has indicated is required, and (b) reassignment of the frequencies on which the system operates, directed by the international Extraordinary Administrative Radio Conference of 1963. The changes will require modification of the transmitters, antennas, and receivers of the existing Range and Range Rate Systems.

Forthcoming satellites of the observatory and Explorer class will have orbits with greater eccentricity and therefore will require longer, continuous periods of tracking and data acquisition by the viewing stations. Additionally, these satellites will transmit increased quantities of data to adequately sample the more numerous and complex experiments. It is planned to support these requirements with a network of high performance telemetry data links.

Implementation of the high performance links was initiated with FY 1963 funds and is phased to meet the operational requirements of the flight projects as they occur. FY 1966 funds will provide sufficient data links to meet the presently known requirements through calendar year 1967.

Also included in the FY 1966 request are funds for an air transportable telemetry station. Transportable stations are employed to provide support for unanticipated requirements or when total requirements do not justify establishment of a permanent station.

The modernization program for command and control equipment will continue in the next fiscal year. FY 1966 funding will provide sufficient command links to meet the workload anticipated during calendar year 1967.

In FY 1966, additional recording units are required to complement the increased data link capability. Also, additional magnetic tape evaluators and display units will be purchased to monitor station telemetry performance.

Calibration equipment for maintaining the accuracy of network stations and major equipment subsystems will be required in FY 1966. Along with the calibration function, test and monitoring are continuing programs. Prior to acceptance and installation of new or replacement equipment in the network, it is necessary to thoroughly evaluate the units for field use. Specialized spacecraft checkout equipment is required for telemetry, communications, and command subsystems to verify performance at the Eastern and Western Test Ranges of the Department of Defense to ensure compatibility between the spacecraft and the ground systems.

Continuously available, accurate timing signals at each station are of critical importance for experiment analysis and orbit determination. In FY 1966, improved and more reliable transistorized time standards will be procured for five sites as part of a program to improve time standards throughout the network.

With the augmentation of the network with equipment to receive pulse code modulation telemetry from spacecraft, a program is being initiated in FY 1966 to outfit selected stations with general purpose on-site data handling equipment. These general purpose units will be capable of data compiling and formatting for real-time transmission to the central control facility as well as to the spacecraft itself.

During FY 1965, the function of providing ground station support for the Applications Technology Satellite project was transferred from the Applications Technology Satellites Program to the Tracking and Data Acquisition Program. Related funding authority also was transferred. The purpose of this transfer is to assure maximum coordination and integration of equipment and facilities required for support of the Applications Technology Satellite project with other NASA tracking and data acquisition facilities. FY 1966 funds are required to continue efforts initiated with prior year funds. These efforts include procurement of the transportable communications

station and the telemetry and command stations, augmentation of the second 85-foot antenna facility at Rosman, North Carolina, and modification of the Satellite Network facility at Mojave, California, to support the Applications Technology Satellite project.

FY 1966 funds are required to continue implementation of a multi-purpose control center at Goddard Space Flight Center to handle the numerous scientific satellite projects. It will contain equipment to provide real-time control of spacecraft and will eliminate the need for separate control centers now being used.

General network support is a continuing effort. Minor station augmentations such as antenna hardstands, improved intra-site cabling for power distribution, and increases in the station air conditioning and heating equipment to accommodate new equipments are necessary in FY 1966.

In a similar manner, maintenance, spares, and repairs is a continuing program. Funds in this category provide for spares, modifications, and repairs to network equipment.

Deep Space Network

	1964	1965	1966
Transmitters	$409,000	$78,000	---
Receivers	4,815,000	2,146,000	$165,000
Station monitoring and control equipment	1,328,000	2,338,000	3,885,000
Antennas	1,495,000	1,830,000	914,000
Tracking data handling systems	342,000	690,000	---
Recording and display systems	489,000	223,000	---
Timing systems	225,000	320,000	490,000
Control center	---	838,000	1,758,000
General network support	1,276,000	948,000	782,000
Maintenance, spares, and repairs	1,625,000	2,109,000	1,806,000
Total	$12,004,000	$11,520,000	$9,800,000

Use of the L-band frequency for support of lunar and planetary missions will be discontinued after the last Ranger flights which are scheduled for the first six months of calendar year 1965. Conversion to full S-band capability will be accomplished at that time. The Pioneer, Surveyor, and Lunar Orbiter programs all employ S-band systems and are scheduled to be supported by the Deep Space Network beginning in FY 1966. The Mariner 1964 operation is being supported by three Deep Space Network stations previously converted to an interim S-band configuration.

Procurement of equipment for S-band transmitters has been funded in prior years and no funds for this purpose are required in FY 1966. Similarly, S-band receiver procurement requires no funding except for minor modifications at each of the six main stations and the purchase of an additional "suitcase" telemetry receiver.

The major item of FY 1966 Deep Space Network equipment cost is for station monitoring and control equipment. This equipment is necessary to provide the required reliability, flexibility, and operational readiness to support multiple lunar and planetary missions. The present schedule indicates a distinct possibility that Pioneer, Lunar Orbiter, and Surveyor will all be in flight at the same time, and will require simultaneous coverage by the network to meet mission requirements.

This new equipment will provide continous, semi-automatic monitoring of the performance of each station, enabling immediate identification of components which are approaching marginal performance with respect to predetermined limits. Status of station operations will be reported in real-time to the network director at the Space Flight Operations Facility (SFOF) so that he can make necessary decisions and initiate corrective actions promptly. Further, stations may be directed to quickly switch coverage from one spacecraft to another without loss of significant data.

In a two-phase program which was initiated in FY 1964, station monitoring consoles, on-site data processors, and associated equipment are being installed at all stations. FY 1966 funds are required to complete equipping the stations at Goldstone, Woomera, Canberra, and Madrid with a full capability for network support of multiple flight operations. The other stations of the network will be partially equipped this year but funding required for completion will be deferred until FY 1967 since the support by these stations will not be necessary until calendar year 1967.

An antenna pointing system will be installed at Johannesburg, Woomera, and Canberra to meet the more stringent requirements of the Lunar Orbiter and Surveyor projects. Previously evaluated at Goldstone, this system provides for automatic antenna positioning from a pre-computed tape.

Antenna structural modifications are required to complete conversion to standard S-band configuration. These consist of additional electronic component housings, improved bearings, and new structural members for increased strength and stiffness. A spare Cassegrain cone, which is a major antenna subsystem containing the low noise maser and transmitter, will be procured and maintained at Goldstone as a network emergency standby.

The timing system at each Deep Space Network station will be replaced by a more reliable and accurate clock to function as the master Greenwich Mean Time (GMT) clock at the site. In addition, frequency synchronizer units will be provided to each of the stations. These improvements will make possible the more accurate tracking data required by later Surveyor and Lunar Orbiter flights.

The Space Flight Operations Facility (SFOF) was used in support of Ranger VII, and also in support of the 1964 Mariner operation. Some changes in control center equipment are necessary as a result of these operational experiences. Further, for the planned combined Pioneer, Lunar Orbiter, and Surveyor operations, additional equipments will be required which were not previously anticipated. Display consoles and communications end-instruments are required to provide for the simultaneous support of multiple missions. In addition, expansion of the data handling system is necessary to accommodate the simultaneous support requirement.

Funds requested for general network support include those necessary to meet interface requirements of the Surveyor, Lunar Orbiter, and Pioneer mission-unique equipment. Among these are such miscellaneous items as cables, junction boxes, and line amplifiers. In addition, a secondary standards laboratory will be established at each of the four overseas sites for purposes of maintaining adequate calibration of test equipment to assure readiness of the equipments for support of scheduled operations. The calibration standards at the secondary laboratories will be checked periodically against the primary standards maintained at Goldstone.

Maintenance, spares, and repairs are required for all technical systems and facilities at the Deep Space Network stations, as well as the SFOF, in order to maintain the equipment in a proper operational status.

Other Instrumentation

1964	1965	1966
$4,690,000	$5,300,000	$5,500,000

A wide variety of fixed and mobile equipment is used to provide instrumentation support at Wallops Station and points off the main station, and at the Flight Research Center. This equipment is under a continuous preventive maintenance program to assure the necessary reliability for mission support. In addition, an improvement program is undertaken whereby individual subassemblies or components of major systems are modified or replaced to improve the range, speed, accuracy, and flexibility of the systems. The requirement for these improvements is generated by the large number and types of rockets in the current and planned flight schedules of Wallops Station and by the high performance characteristics of the flight projects supported by the Flight Research Center.

The major effort at the Flight Research Center during FY 1966 will be to continue the program initiated in FY 1964 to update the telemetry system by modifying the Pulse Code Modulation (PCM) ground equipment to handle several data formats through the use of programs stored in the core memory. In addition, pre-detection recording will be utilized to allow for increased data recovery by the application of various demodulation schemes. These conversions are necessitated by the requirement for higher performance telemetry systems to meet the data output requirements of the advanced test programs which must be supported.

At Wallops Station, a considerable quantity of non-recoverable flight hardware is required in support of the missions. These include not only the small meteorological rockets launched in association with other primary flights to obtain last minute wind profiles used for launch azimuth and elevation angle corrections, but also the radar beacons, transponders, antennas, and command-destruct receivers installed in launch vehicles.

Communications

1964	1965	1966
$4,036,000	$4,110,000	$4,400,000

The major project in the communications equipment program has been the conversion from manual to automatic, solid state switches at the Goddard Communications Center and secondary locations (London, England, and Canberra, Australia) which are the focal points for incoming communications. This conversion, which was started in FY 1964, will provide faster and more reliable transmission at a lower unit cost for the incoming data than was previously possible. In addition to removing the manual phase of the operation, these switching units are capable of handling upcoming flight project requirements for high speed, large volume data transmission from overseas locations. Funds requested in FY 1966 will provide for a switching unit at Hawaii and for additions to the existing switching center at Goddard.

In conjunction with the conversion program, certain data terminal equipments are required primarily for Apollo support to permit high speed data to be transmitted between stations, secondary switching centers, and the Goddard Communications Center. Included in the FY 1966 request are funds for the purchase of signal simulators, high speed data modulation/demodulation devices, error detection and correction units, data quality monitors, and distortion measuring sets.

The funds requested in FY1966 also will provide for needed improvements in teletype and voice equipment. Examples of such improvements are: (1) the present wire line between Carnarvon and Geraldton, Australia, which barely meets minimum reliability requirements, must be expanded to meet Apollo requirements; (2) voice digitizing equipment is necessary for installation on four radio circuits to improve the intelligibility of voice communications; and (3) the voice network is being updated to provide selective signaling, circuit supervision, and assurance information to overseas stations.

Data Processing

1964	1965	1966
$11,065,000	$4,851,000	$4,000,000

With FY 1964 and FY 1965 funding, the procurement of major equipments required for processing large amounts of data and for the conversion from an analog to a digital system will be essentially completed. While the

purchase of some peripheral equipment associated with the computers will be necessary in FY 1966, the major portion of the FY 1966 program consists of the modification and expansion of existing systems to meet the increasing data processing workload.

The operational data processing equipment will continuously require minor redesign, modifications, and improvements as well as normal maintenance and repair. Funds requested in FY 1966 will allow such modifications and improvements, including a maintenance test laboratory, standardized display devices, and evaluators and analyzers to decrease downtime of present equipment.

Signal recovery equipment is required for the processing of data which would otherwise be lost through weak signals. Much of this data is obtained when the spacecraft is in the apogee phase of its orbit and is scientifically very important. With recently developed signal recovery equipment, the retrieval process involving the reprocessing and refining of data is considerably shortened. Funds requested in FY 1966 will provide eight Pulse Frequency Modulation (PFM) and Pulse Code Modulation (PCM) signal recovery units in this program.

Special purpose data processing and display equipment is necessary for unusual or unique data from individual flight projects. The data requirements vary considerably between flight projects such as Orbiting Astronomical Observatory (OAO), Orbiting Solar Observatory (OSO), Interplanetary Monitoring Probe (IMP), and Nimbus, resulting in the need for special data and video processors in both FY 1965 and FY 1966.

The evaluation of analog telemetry tapes is necessary to sort out improperly recorded tapes and to monitor ground station recording performance. With the increasing number of tapes to be evaluated, present equipment and facilities are inadequate. Equipment procurement for tape evaluation which was begun in FY 1965 will continue through FY 1966.

Increases in projected data processing volumes make high density storage and recording essential for both economy and accessibility to the data. Funds requested in FY 1966 will provide the necessary storage, recording, multiplexing, and formatting equipment.

Supporting Research and Technology

	1964	1965	1966
New systems	$2,610,000	$1,375,000	$1,500,000
Integrated systems analysis, development, and test	2,446,000	2,912,000	3,024,000
Antenna subsystems	2,211,000	2,534,000	2,076,000
Receiver and transmitter subsystems	2,412,000	3,301,000	2,426,000
Data handling and control subsystems	1,608,000	2,004,000	2,529,000
Data processing and display subsystems	778,000	1,060,000	1,246,000
Spacecraft subsystems	825,000	1,497,000	1,699,000
Total	$12,890,000	$14,683,000	$14,500,000

Supporting Research and Technology is the activity whereby the Office of Tracking and Data Acquisition develops a technology of advanced systems, components and techniques which are then used to implement the various networks to meet the requirements of new flight projects, both manned and unmanned. Complementary spacecraft subsystems are developed as well as new equipment for ground instrumentation support. Operation of development sites is conducted so that the performance and reliability characteristics of new components and subsystems are proven before the equipment is committed to the network. Supporting Research and Technology effort is also directed at reduction of rising operations costs by investigating techniques which lead toward eventual station automation.

New Systems

In FY 1966, one major project will be completed and two new developments initiated. The Airborne Range and Orbit Determination (AROD) system which was initiated in FY 1963 will be concluded with the purchase of one flight test and evaluation unit to demonstrate full system capability.

One new system development to be initiated during FY 1966 is an acquisition aid. Among the technical approaches to be investigated are an interferometer system and the use of over-the-horizon radar system techniques. One of these techniques will be selected for full investigation early in FY 1966. During a spacecraft's reentry into the Earth's atmosphere, a blackout of normal tracking and communications occurs. It is imperative to reacquire the spacecraft's signal immediately after this period. This equipment, when developed, will be capable of rapidly providing pointing data for the major tracking antenna once the spacecraft comes out of the blackout.

Previous re-entering vehicles were of the Earth orbiting type. As a result, they had relatively low velocities which produced short blackout periods and they had followed simple orbital paths so that their general locations after blackout could be anticipated accurately. This acquisition aid equipment is needed for future spacecraft such as Apollo which have long blackout periods because of their much higher reentry velocities and which have a capability to maneuver such that their position cannot be extrapolated.

A second new system development is concerned with spacecraft-to-spacecraft communications. As the investigation of space continues, missions such as Voyager, or lunar and Mars orbiters will be flown which will, in turn, launch probes or landers to examine the surface of the body. Direct communication between Earth and the secondary vehicle is not practical, in view of the distances involved, and the parent spacecraft must act as a relay between the two. In FY 1966, a system development will be undertaken to provide for communications between two unmanned spacecraft.

Integrated Systems Analysis, Development, and Test

Included in this category is the integration into working systems of the components, techniques, and subsystems which are developed under the

various disciplines of the supporting research and technology program. Overall problems that are unique to a network rather than a specific discipline are also included in this effort.

One objective of this area of effort is the continued development of techniques needed for future tracking capability. As the exploration of deep space expands small inaccuracies result in large absolute errors at planetary distances. For various in-flight maneuvers of single spacecraft, and for rendezvous assistance of multiple spacecraft, these errors must be reduced.

Another objective is improvement of communications with spacecraft in deep space. Present capabilities limit the rate of information transmission to eight bits per second at a Mars distance and, at greater distances, the rate is exponentially reduced. The requirement for improved systems is imperative. In FY 1966, studies will be undertaken to evaluate the relative merits and costs of improvements in several areas such as transmitter power, receiver sensitivity, etc., which contribute to the improvement of the space instrument.

Broad investigations are underway to analyze and develop corrective procedures for the growing problem of radio frequency interference (RFI) at tracking and acquisition sites. As the number of spacecraft emitting signals increases, the difficulty of receiving only the signals from the proper spacecraft increases. This situation is further compounded by the growing amount and complexity of station equipment of extremely high power which also emits extraneous signals which can interfere with reception of the desired signal. The presence of this RFI is especially severe aboard instrumentation ships where even greater concentration of equipment exists. In FY 1966, the nature and magnitude of the radio frequency interference problem at the various network facilities will be examined and corrective procedures instituted.

Antenna Subsystems

The antenna subsystems category continues to be one of the most critical areas for development. The design and construction of a prototype 210-foot diameter antenna, funded from the FY 1963 Construction of Facilities appropriation, will be completed in calendar year 1966. At present, an antenna of this diameter appears to be as large as is economical and practical to build from a mechanical standpoint. However, future missions will undoubtedly require still higher gain antenna systems.

In FY 1966, antenna design concepts, including feeds, structures, pedestals, servo drives, and interface problems with the basic foundation itself will continue to be investigated under this project. All of these techniques will be applicable to the realization of higher-gain ground antenna systems when required.

Receiver and Transmitter Subsystems

This category of effort includes development and test of prototype hardware whose performance characteristics reflect the requirements determined by the integrated systems analysis for more accurate and reliable tracking and data acquisition support.

To afford a maximum of flexibility to the spacecraft designer where weight, size, and power are of prime importance, a major effort is being made to improve ground receiving and transmitting subsystems. This is accomplished by investigating modulation techniques which better utilize transmitter power, developing components which produce more transmitter power, exploiting results of advanced efforts which reduce noise generated within receiver and preamplifiers, and improving demodulation techniques which permit better recovery of weak signals from noise.

A second objective is the realization of frequency sources which are sufficiently stable and reliable under operational conditions to meet the support requirements of prolonged space flights. Because of the infinitesimal power received from planetary-distance transmissions, ground equipment with very narrow bandwidths is required. This minimizes accompanying noise and permits recovery of the weak signals. However, the narrow bandwidths place stringent stability requirements on spacecraft frequency sources so that the signal will remain within the passband capability of the receivers.

Data Handling and Control Subsystems

The functions of telemetry, tracking and command of spacecraft all require the generation and handling of data. Two aspects of data handling are considered under this category: the development of techniques and equipment to handle the data more accurately and more rapidly, and data compression.

An effort started in FY 1965 will continue on a highly efficient, but more complex telemetry system utilizing feedback control to adapt spacecraft and ground systems conditions to changing data needs as they occur. Also, further development of the control center concept using centralized computations will continue with emphasis on economies in operations and recording and storage for support of future spacecraft. Development of "quick look" capabilities for the stations will also continue.

Data compression is being studied to determine the optimum method to realize the advantages of this technique. These advantages included reduced bandwidth with attendant greater range and decreased data quantities and accompanying reduction in cost and time of processing.

Data Processing and Display Subsystems

The volume of data requiring processing continues to increase. Data processing facilities will handle 70,000,000 data points per day during FY 1965 and this is projected to increase to 200,000,000 data points per day in FY 1966.

In FY 1966, effort will be directed toward building up the existing telemetry data reduction capability to match the increasing requirements. In order to reduce, efficiently and reliably, the tremendous amount of data from these high data-rate spacecraft, it has become necessary to develop several general purpose processing and reduction lines capable of handling a variety of projects.

In FY 1966, development and evaluation of prototype hardware for improvement to these lines will continue. In addition, techniques will continue to be developed for recovering telemetry signals when conditions of extreme range reduce the signal level from a spacecraft. New data reduction techniques will be investigated including a study of trade-offs between various concepts of deep space network operations and data systems design characteristics.

Spacecraft Subsystems

The forthcoming deep space and extended-stay-missions require high, long lived performance. Therefore, the integral associated portion of the tracking and data acquisition system which is on the spacecraft must also have the same quality and reliable performance. The numerous, independent mission functions performed on the spacecraft in support of tracking, data acquisition, command and communication disciplines are investigated and developed under this category of effort.

In FY 1966, efforts will be continued to develop second generation spacecraft transponders, one having a fraction of the weight of the current system now required for Earth satellites with highly eccentric orbits, and the other to meet the system performance requirements for planetary missions. Efforts will also be continued on the development of a family of standard on-board transmitters, receivers, data handling modules, and memory units. Associated investigations will be aimed at effecting economies through on-board data compaction and pre-processing especially for spacecraft producing a large volume of data. Development of a standard and reliable spacecraft command subsystem for Voyager and subsequent spacecraft will continue. Evaluation of launch vehicle telemetry equipment will continue, including techniques for on-board data storage, principally in support of the Saturn program.

OFFICE OF ASSISTANT ADMINISTRATOR FOR TECHNOLOGY UTILIZATION

TECHNOLOGY UTILIZATION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The primary objective of the Technology Utilization Program is to provide for the widest practical and appropriate dissemination to industry of information concerning NASA activities and their results. The NASA program offers U. S. industry unique opportunities to improve existing industrial techniques and to develop new products and methods. It is the purpose of Technology Utilization to assist in identifying quickly these many opportunities and to insure their expeditious dissemination for the benefit of American industry, and ultimately the individual U. S. citizen. Technology Utilization also includes projects to study and evaluate those factors which will improve our understanding of the implications of the space program.

SUMMARY OF RESOURCES REQUIREMENTS:

	1964	1965	1966
Identification: Technology searches and surveys.....	$1,090,000	$1,300,000	$1,400,000
Evaluation of innovations.....	580,000	700,000	700,000
Regional information dissemination projects.....	950,000	1,850,000	1,900,000
Analysis of technology transfer; research and development management; the long range implications of the space program.....	880,000	900,000	1,000,000
Total.....	$3,500,000	$4,750,000	$5,000,000

Distribution of Program Amount by Installation:

NASA Headquarters.....	$3,500,000	$4,750,000	$5,000,000

BASIS OF FUND REQUIREMENTS:

One of the important elements of the technology utilization program is the identification and reporting of new technology resulting from NASA activities. This is accomplished primarily by NASA personnel but in certain circumstances by specialists from research institutes, universities and industry. The identification and reporting of new technology also includes a state-of-the-art survey effort. This effort is organized around broad scientific

areas and disciplines. Surveys are now underway in a number of fields including inorganic coatings, tape recording and data processing, microelectronics, antennas, and membrane phenomena. To evaluate reported innovations for originality and potential value to industrial users, the technology utilization program utilizes the services of a number of industrial research institutions. Commercially oriented reports of these developments are then prepared and published in a number of formats. In FY 1966 the identification and evaluation efforts will be pursued at about the same levels as FY 1965.

In addition to the normal method of dissemination via libraries and mailing lists, seven pilot projects in regional information dissemination are being supported. These dissemination centers, in most instances, are operated by universities. Center personnel review, interpret and convert new technology to the industrial needs of participating organizations. Using the latest NASA capabilities (printed index journals, microfiche, computer tapes and programs, etc.) these centers provide pertinent technological information on a selective basis to industrial users. The Midwest Research Institute (MRI) pilot project was initiated in early FY 1962. MRI has employed a broad approach to dissemination serving more than 1000 firms. From this experience, MRI is now developing more intensive working relationships with selected firms using back-up computer support from the Aerospace Research Applications Center (ARAC) at Indiana University. The Aerospace Research Applications Center is now nearing the end of its second year of operation. This center charges companies a membership fee for the services the center offers. The three primary services are the Retrospective Search Service, the Selective Dissemination Service, and the Industrial Applications Service. All but two of the original 29 member companies have renewed their memberships and the center has considerably expanded its enrollment in the second year. During FY 1964, five centers in addition to MRI and ARAC were established. These are at Wayne State University (Detroit), the University of Pittsburgh, University of Maryland, the North Carolina Science and Technology Research Center and Southeastern State College (Durant, Oklahoma). All seven centers are pilot programs designed to implement those elements appropriate to the industrial needs of their respective areas. In addition to these seven centers, it is planned that several new pilot programs will be started with FY 1966 funds.

Beginning in fiscal years 1962 and 1963, a number of universities received grants for research in the management of research and development. At the University of California (Berkeley) an attempt is underway to establish a computer simulation of the process of scientific inquiry including literature search, information retrieval and analogous reasoning. At the Massachusetts Institute of Technology studies on complex problem solving, interpersonal conflict, multiple task assignments and decision making have been initiated. Other studies underway include research in contracting systems and procedures, project management, cost estimation and budgeting.

The impact of the space program upon the national economy particularly with respect to its effect upon the different geographic, industrial, and civilian sectors of the economy; upon national economic growth; and upon the alloca-

tion of scientific and engineering manpower has been studied within the Technology Utilization Program. A study recently started at the University of California (Los Angeles) is attempting to analyze the shifting geographic patterns of primary first-tier and second-tier contracting. Another study funded at Washington University (St. Louis) attempts to analyze the national impact of alternative assumptions concerning the level and composition of governmental spending streams with particular emphasis being laid upon the nature of the expenditures.

NASA expenditures have had a major impact on the economy of the Cape Kennedy area, especially on the functioning and development of local governmental units, school boards, planning boards, and utility services. This impact is being studied in both an empirical and a qualitative sense to learn the types and magnitude of the problems created by the space center build-up. In another case, NASA expenditures have stimulated rapid growth of a major scientific laboratory in Boulder, Colorado. Many changes in the economic base of the community, population, and local attitudes have resulted. A study now underway at the University of Colorado will analyze these changes in considerable depth throughout the community.

It is to be emphasized that the Technology Utilization Program at its present stage is still very much an experimental program. Future plans, therefore, call for careful review of every phase of the present Technology Utilization Program in order to determine the effectiveness of the current approaches which are being pursued. Future plans also call for feasibility studies of the numerous additional ideas generated by the Program, ideas which offer promising new avenues whereby new science and technology emanating from the space program can be more readily transferred to the non-space community.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1966 ESTIMATES

ELECTRONICS RESEARCH CENTER

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Summary	CF 2-2
Office of Advanced Research and Technology Projects:	
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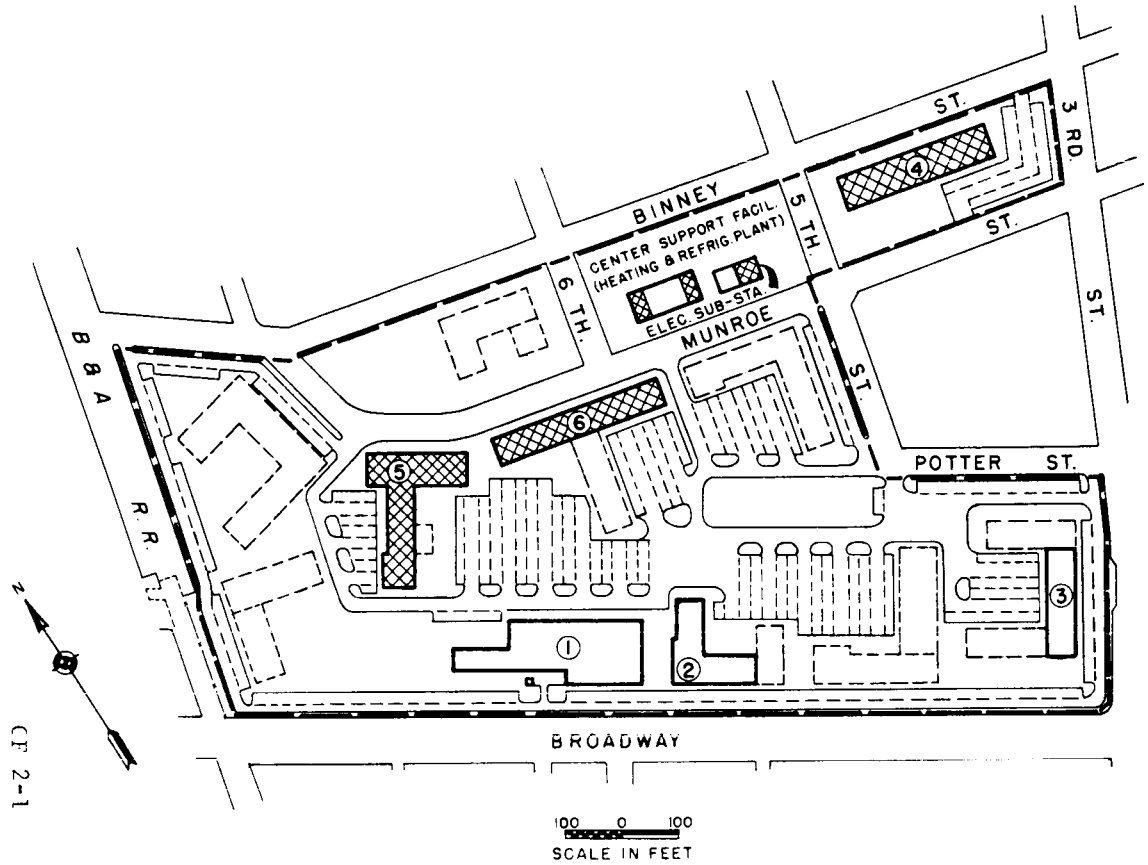
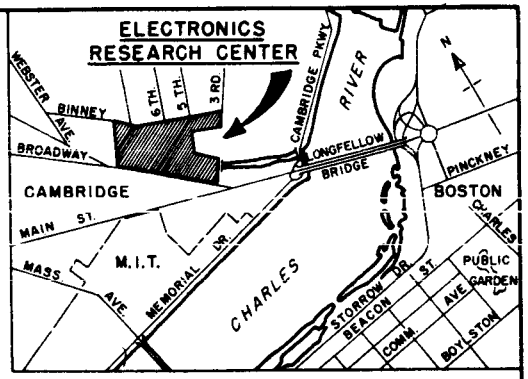
Optical communications laboratory	CF 2-7
Microwave radiation laboratory	CF 2-11
Center support facilities, second phase	CF 2-15

ELECTRONICS RESEARCH CENTER
FISCAL YEAR 1966 ESTIMATES

LOCATION PLAN

CAMBRIDGE, MASS.
(CONDITIONAL)





1. ENGINEERING & ADMINISTRATION BUILDING
2. ELECTRONIC COMPONENTS LABORATORY
3. QUALIFICATIONS & STANDARDS LABORATORY
4. MICROWAVE RADIATION LABORATORY
5. SPACE GUIDANCE LABORATORY
6. OPTICAL COMMUNICATIONS LABORATORY

LEGEND

- FY-65 FACILITIES
- FACILITIES PROPOSED IN 1966 ESTIMATES
- FUTURE FACILITIES
- PROJECT BOUNDARY

CF 2-1

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 19 66 BUDGET ESTIMATES

(Dollars in thousands)

NASA INSTALLATION	COGNIZANT PROGRAM OFFICE FOR INSTALLATION	LOCATION OF INSTALLATION	COUNTY	NEAREST CITY
Electronics Research Center	Advanced Res. & Tech.	Cambridge, Mass.	Middlesex	----------

INSTALLATION MISSION

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

PERSONNEL STRENGTH	FY 1964	FY 1965	FY 1966
NASA PERSONNEL *(End of Year)*	25	250	550
CONTRACTOR AND OTHER PERSONNEL	-	-	-
TOTAL ALL PERSONNEL	25	250	550

LAND	NO. ACRES
NASA-OWNED	-
OTHER GOVERNMENT AGENCY-OWNED	-
NON-FEDERAL *(Leases, easements)*	-
TOTAL LAND	-
TOTAL CAPITAL INVESTMENT *(Including NASA-Owned Land) (as of June 30, 19 64)*	$ -

PROJECT LINE ITEM	COGNIZANT OFFICE	FY 19 59 THRU CURRENT YEAR	FY 1966 *(Estimated)*	FUTURE YEARS *(Estimated)*	TOTAL ALL YEARS *(Estimated)*
Space Guidance Laboratory	OART	110.0	3,900.0	-0-	4,010.0
Optical Communications Laboratory	OART	98.0	2,100.0	-0-	2,198.0
Microwave Radiation Laboratory	OART	100.0	3,000.0	-0-	3,100.0
Center Support Facilities (Second Phase)	OART	85.0	1,000.0	-0-	1,085.0
ALL OTHER PROJECTS	OART	14,875.0			
TOTALS		15,268.0	10,000.0		

NASA FORM 1029 (REV. NOV 64) PREVIOUS EDITIONS ARE OBSOLETE.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1966 ESTIMATES

SPACE GUIDANCE LABORATORY

AUTHORIZATION LINE ITEM: Electronics Research Center

PROGRAM OFFICE FOR THE PROJECT: Office of Advanced Research and Technology

LOCATION OF PROJECT: Cambridge, Middlesex County, Massachusetts

COGNIZANT NASA INSTALLATION: Electronics Research Center

TYPE OF CONSTRUCTION PROJECT: New

FUNDING:

FY 1965 and Prior Years	$110,000
FY 1966 Estimate	3,900,000
Total Funding Through FY 1966	$4,010,000

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$1,562,000
Laboratory	Sq. Ft.	46,400	$32.39	1,503,000
Site preparation	LS	---	12,300	12,300
Roads and parking	LS	---	14,600	14,600
Utilities	LS	---	32,100	32,100
Equipment				$2,338,000
Inertial test equipment	LS	---	995,000	995,000
Instrumentation equipment	LS	---	827,000	827,000
Analysis equipment	LS	---	200,000	200,000
Special electronic support	LS	---	316,000	316,000
Design	---	---	---	---
Fallout Shelter (Not feasible)	---	---	---	None
		TOTAL		$3,900,000

PROJECT PURPOSE:

This project will provide laboratory facilities and equipment for electronic research to advance the state-of-the-art related to space guidance systems and components.

PROJECT DESCRIPTION:

The two-story building provides laboratory office space, major equipment and special purpose testing space, with approximately 46,400 square feet of floor area. 30,000 square feet on the first and second floors will be devoted to laboratory facilities and related office space, and 5,000 square feet of basement area will be used for utilities, maintenance requirements and limited storage. 11,400 square feet will contain air-bearing test tables, precision centrifuges and specialized calibration and alignment equipment. Special building provisions to maintain the environment essential to the operation of the research equipment in this laboratory will be provided. 148 parking spaces will be included as a part of the site development. Building utilities will be connected to the central systems for heating, chilled water, water distribution, electric power, sanitary sewers, communications, and drainage provided at the Center.

Laboratory equipment will be provided to analyze, test, simulate and generate concepts, techniques and elements for future space navigation and guidance systems. Specialized test and simulation devices will include equipment for sensing and generating velocities, accelerations, angular rates, gravity forces and inertial references as well as analog and digital data collection and reduction equipment. Cryogenic, and vacuum and magnetic field control equipment will be included for research on new types of guidance sensors.

PROJECT JUSTIFICATION:

The laboratory will conduct research in guidance and navigation techniques and concepts, and new guidance instrumentation. The building will be occupied by 190 personnel. Theoretical studies, investigations, experimentation and tests in trajectory analysis, inertial reference and sensory techniques, navigation and guidance components and techniques as well as the testing of electromagnetic and optical guidance devices on a component and subsystem basis will be undertaken.

Present space guidance systems were originally developed for aircraft and ballistic missiles which required very high accuracy for short duration flights. This technology has been extended and applied to present space missions. For example: the Saturn guidance system is an extension of Redstone and Pershing technology, and the Apollo guidance system is an outgrowth of developments for Polaris. While the extended performance of these missile-guidance systems is satisfactory for present missions, there is a pressing need to do research in guidance techniques optimized for long duration planetary flights. These new techniques must yield very reliable,

lightweight systems capable of operating for extremely long periods without serious degradation in performance.

In order to achieve this high level of reliability, future guidance systems must incorporate long-life components with few moving parts, negligible drift rates, and low power requirements. Basic research toward securing these objectives is beginning; e. g., the use of coherent light beams in laser gyros is being explored; the gyroscopic properties of atomic nuclei and rotating fluids are being studied; and, the characteristic motion of a vibrating piezoelectric cylinder, acted upon by external forces, is being analyzed. The chief aim of research of this nature is to contribute to the NASA mission by discovering advanced concepts leading to more reliable, less complex, and cheaper guidance systems.

ESTIMATED FUTURE YEAR FUNDING FOR THIS PROJECT: None

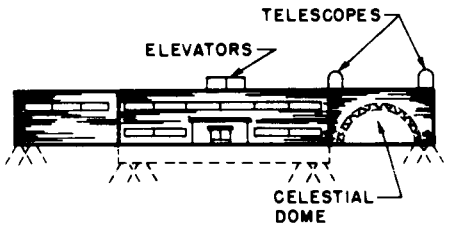
ELECTRONICS RESEARCH CENTER

FISCAL YEAR 1966 ESTIMATES

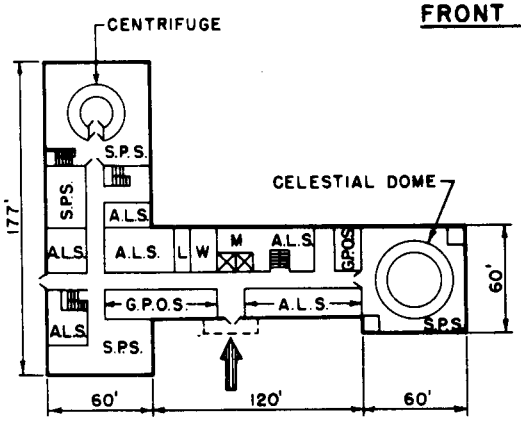
SPACE GUIDANCE LABORATORY

SCALE IN FEET

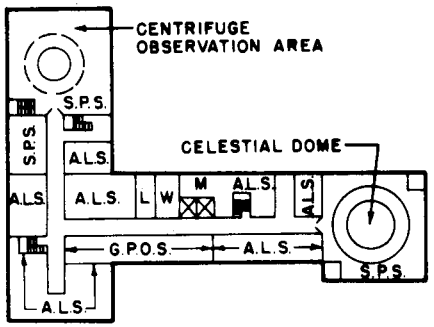
0 10 25 50 75 100



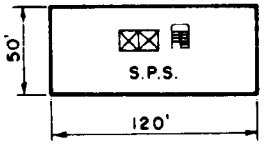
FRONT ELEVATION



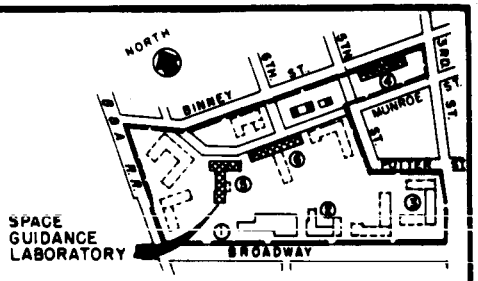
FIRST FLOOR PLAN



SECOND FLOOR PLAN



BASEMENT PLAN



SITE PLAN

0 200 400 600

SCALE IN FEET

1. ENGINEERING & ADMINISTRATION BUILDING
2. ELECTRONIC COMPONENTS LAB.
3. QUALIFICATIONS & STANDARDS LAB.
4. MICROWAVE RADIATION LAB.
5. SPACE GUIDANCE LAB.
6. OPTICAL COMMUNICATIONS LAB.

SYMBOLS

- FY-65 FACILITIES
- FACILITIES PROPOSED IN 1966 ESTIMATES
- FUTURE FACILITIES
- PROJECT BOUNDARY

LEGEND

- ELEVATOR
- STAIRWAY
- G.P.O.S. GENERAL PURPOSE OFFICE SPACE
- A.L.S. ANALYSIS-LABORATORY SPACE
- S.P.S. SPECIAL PURPOSE SPACE
- M MEN'S LAVATORY
- W WOMEN'S LAVATORY
- L WOMEN'S LOUNGE
- MAIN ENTRANCE
- PILE FOUNDATION

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CONSTRUCTION OF FACILITIES

FISCAL YEAR 1966 ESTIMATES

OPTICAL COMMUNICATIONS LABORATORY

AUTHORIZATION LINE ITEM: Electronics Research Laboratory

PROGRAM OFFICE FOR THE PROJECT: Office of Advanced Research and Technology

LOCATION OF PROJECT: Cambridge, Middlesex County, Massachusetts

COGNIZANT NASA INSTALLATION: Electronics Research Center

TYPE OF CONSTRUCTION PROJECT: New

FUNDING:

FY 1965 and Prior Years	$98,000
FY 1966 Estimate	2,100,000
Total Funding Through FY 1966	$2,198,000

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$809,000
Laboratory	Sq. Ft.	32,000	$23.75	760,000
Site preparation and foundations	LS	---	17,350	17,350
Roads and parking	LS	---	17,000	17,000
Utilities	LS	---	14,650	14,650
Equipment				$1,291,000
Optical transmission equipment	LS	---	207,200	207,200
Optical reception equipment	LS	---	512,300	512,300
Optical analysis equipment	LS	---	328,000	328,000
Optics preparation and material equipment	LS	---	243,500	243,500

	Unit of Measure	Quantity	Unit Cost	Total Cost
Design	---	---	---	---
Fallout Shelter	---	---	---	-0-
		TOTAL		$2,100,000

PROJECT PURPOSE:

This project will provide laboratory facilities and equipment for electronic research to advance the state-of-the-art, related to optical communications systems and components.

PROJECT DESCRIPTION:

The building will be single story with full basement. The ground floor (16,000 square feet) and 10,000 square feet of the basement area will be used for laboratory and office space. The remaining 6,000 square feet of basement area will be used for utility and storage.

Dark rooms and shielded rooms for protection of personnel from high intensity light radiation sources and elimination of undesired optical interferences from natural and man-made sources will be provided. The facility will contain optical test chambers and spectrographic analysis equipment. Building provisions to maintain the environment essential to the operation of the research equipment will be included. Site development will include 96 parking spaces. The building utilities will be connected to the central heating, chilled water, water supply, electric power, communications, alarm, and storm and sanitary sewer systems.

The laboratory will contain equipment for the measurement, analysis, generation and reception of optical energy in the 100 Angstroms to 100 microns wave length region. An analog computer in addition to other data collection and reduction equipment is required for extracting, restoring and analyzing information from laser-pulsed sources. Standard equipment such as spectrographs, optical benches and interferometers will be complemented by high intensity light sources, sensors, and special detectors for generating and analyzing the ultra-violet, infra-red and visible emissions.

PROJECT JUSTIFICATION:

This laboratory will conduct research on optical radiation sources and components, data transmission and recovery techniques, and propagation phenomena. The building will be occupied by approximately 125 personnel.

The revival of interest in optics, together with the emergence of the laser, indicates that the wavelength band between 100 Angstroms and 100

microns offers an impressive potential for the solution of problems related to space exploration. Applications of optical concepts include communication, guidance and control, computers and displays, power transmission, and workshop technology. Few of these concepts have progressed beyond basic research. The need for a better understanding of natural laws is evident.

The theoretical limits of the optical method have not been realized. Tracking and pointing accuracies of 0.1 seconds of arc at system sensitivities of 0.01 seconds of arc are theoretically possible with interferometric techniques, compared with minutes of arc for existing astronomical antennas. Ranging with a pulse rise time of 10^{-8} seconds may become feasible over considerable distances with accuracies of a few meters, affording capability for topological soundings of the moon, or planets, from orbiting spacecraft. Lasers, used in conjunction with birefringence scanners, image converters and image orthicons, may be useful for reconnaissance on the dark side of planets.

The vertical distribution of radiation near the earth, as well as the spectrum of the sun and stars are largely unknown. Such unknowns have caused malfunctions of infrared horizon seekers. They affect the performance of passive optical communication devices and introduce undesirable complications into the critical beam orientation procedures for optical communications. Optical instruments do not operate reliably in space when pointed within a few degrees of the sun, because intensity and spectrum of background radiation and stray light caused by the solar corona are not known with sufficient accuracy to be considered in the design of seekers. These data once established will help solve many of the problems of space exploration.

Laser and associated concepts for optical communication provide access to a frequency band that is at least three orders of magnitude wider than the entire R-F band. This facility will be used in the conduct of a program to explore the potentialities of this region for space application and to develop the technology to exploit this potential. In addition a program of laser technology development, including optical communication concepts utilizing the laser will be conducted. Research will be conducted on passive optical techniques, radiation detectors, and information theory. The laboratory program will provide the base for the development of light weight, precise optical systems which will enable space vehicles to operate for long periods of time at great distances.

<u>ESTIMATED FUTURE YEAR FUNDING FOR THIS PROJECT</u>: None

ELECTRONICS RESEARCH CENTER

FISCAL YEAR 1966 ESTIMATES

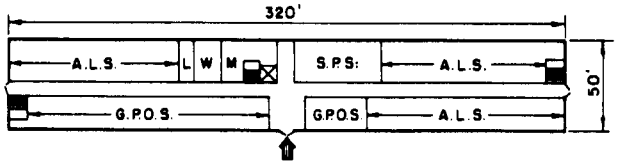
OPTICAL COMMUNICATIONS LABORATORY

SCALE IN FEET

0 10 25 50 75 100

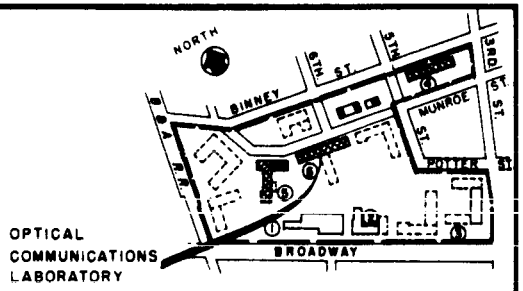
FRONT ELEVATION

ROOF PLAN



FIRST FLOOR PLAN

BASEMENT PLAN



SITE PLAN

0 200 400 600

SCALE IN FEET

1. ENGINEERING & ADMINISTRATION BUILDING
2. ELECTRONIC COMPONENTS LAB.
3. QUALIFICATIONS & STANDARDS LAB.
4. MICROWAVE RADIATION LAB.
5. SPACE GUIDANCE LAB.
6. OPTICAL COMMUNICATIONS LAB.

SYMBOLS

- FY-65 FACILITIES
- FACILITIES PROPOSED IN 1966 ESTIMATES
- FUTURE FACILITIES
- PROJECT BOUNDARY

LEGEND

⊠	ELEVATOR
	STAIRWAY
G.P.O.S.	GENERAL PURPOSE OFFICE SPACE
A.L.S.	ANALYSIS-LABORATORY SPACE
S.P.S.	SPECIAL PURPOSE SPACE
M	MEN'S LAVATORY
W	WOMEN'S LAVATORY
L	WOMEN'S LOUNGE
⇒	MAIN ENTRANCE
	PILE FOUNDATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1966 ESTIMATES

MICROWAVE RADIATION LABORATORY

AUTHORIZATION LINE ITEM: Electronics Research Center

PROGRAM OFFICE FOR THE PROJECT: Office of Advanced Research and Technology

LOCATION OF PROJECT: Cambridge, Middlesex County, Massachusetts

COGNIZANT NASA INSTALLATION: Electronics Research Center

TYPE OF CONSTRUCTION PROJECT: New

FUNDING:

FY 1965 and Prior Years	$100,000
FY 1966 Estimate	3,000,000
Total Funding Through FY 1966	$3,100,000

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$1,028,000
Laboratory	Sq. Ft.	40,000	$24.95	998,000
Site preparation	LS	---	8,000	8,000
Roads and parking	LS	---	10,000	10,000
Utilities	LS	---	12,000	12,000
Equipment				$1,972,000
Microwave measurements and analysis equipment	LS	---	965,600	965,600
Microwave transmission equipment	LS	---	277,100	277,100
Microwave reception equipment	LS	---	604,500	604,500
Data collection and reduction	LS	---	53,300	53,300
Microwave materials and preparation equipment	LS	---	71,500	71,500

	Unit of Measure	Quantity	Unit Cost	Total Cost
Design	---	---	---	---
Fallout Shelter	---	---	---	-0-
		TOTAL		$3,000,000

PROJECT PURPOSE:

This project will provide laboratory facilities and equipment for electronic research to advance the state-of-the-art, related to microwave radiation.

PROJECT DESCRIPTION:

The building will be two-story with a partial basement. Approximately 20,000 square feet on the first and second floors will be devoted to laboratory facilities, and approximately 10,000 square feet to office space. The basement, approximately 10,000 square feet, will be divided for laboratory, utility and storage space. Screened rooms and anechoic chambers for protection against undesirable electromagnetic interferences will be provided. This facility will be used to conduct both transmission and reception experiments. Building provisions to maintain the proper environment required for research equipment will be included. The building utilities will be connected to the central heating, chilled water, water supply, electric power, sanitary sewers and communications systems. Access roads, walks, and parking for 100 autos will be provided.

The laboratory includes equipment for the measurement, analysis, generation and reception of electromagnetic energy over the range of centimeter, submillimeter, and pseudo-optic wavelengths. Equipment for extracting, restoring, and analyzing intelligence from complex electromagnetic propagation is complemented by special computer simulation equipment, both digital and analog. Standard correlation computers, cryogenic equipment, and standard microwave test equipment are included. A precision machine shop and electronic shop provide an in-house capability for building, assembling, packaging and checkout of special microwave components and circuits.

PROJECT JUSTIFICATION:

This laboratory is required for the conduct of research on microwave radiation sources, components, data transmission and recovery techniques, and propagation phenomena. The facility will be occupied by 180 personnel.

The primary objective of the laboratory is to develop techniques for providing reliable microwave links. Present technology falls far short of program objectives. A transmission from the moon that requires 3 watts requires

1000 watts for Mars. Methods to achieve much larger effective antenna apertures must be developed. Lightweight spacecraft antenna materials capable of withstanding high temperatures in space are required. Spacecraft antennas must have a high degree of dimensional stability over a long period of time, survive meteoroid bombardment, be highly radiation resistant, and fit compactly into the payload package.

Further investigations required to fulfill future space objectives include: minimizing multipath spurious response during lander-orbiter relay link operation, research toward prevention of ionic breakdown in antennas, refinement of theoretical models of R-F attenuation resulting from dust storms and meteorological effects, techniques for minimizing the effect of occultation, and prevention of plasma blackout during lander entry.

ESTIMATED FUTURE YEAR FUNDING FOR THIS PROJECT: None

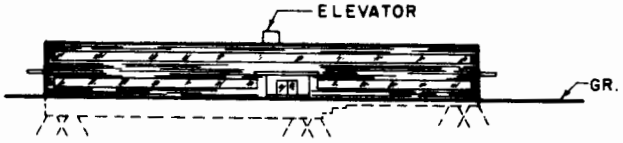
ELECTRONICS RESEARCH CENTER

FISCAL YEAR 1966 ESTIMATES

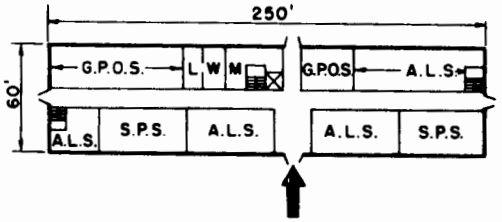
MICROWAVE RADIATION LABORATORY

SCALE IN FEET

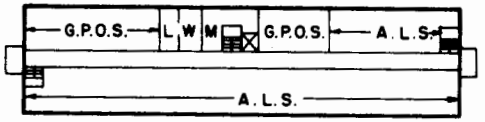
0 10 25 50 75 100



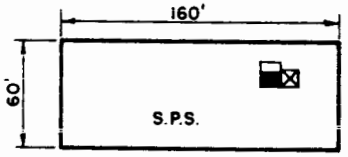
FRONT ELEVATION



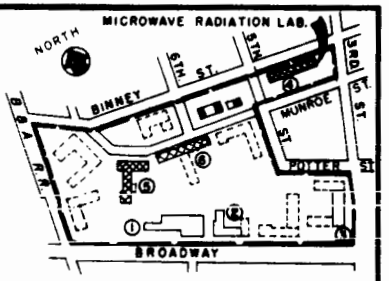
FIRST FLOOR PLAN



SECOND FLOOR PLAN



BASEMENT PLAN



SITE PLAN

0 200 400 800

SCALE IN FEET

1. ENGINEERING & ADMINISTRATION BUILDING
2. ELECTRONIC COMPONENTS LAB.
3. QUALIFICATIONS & STANDARDS LAB.
4. MICROWAVE RADIATION LAB.
5. SPACE GUIDANCE LAB.
6. OPTICAL COMMUNICATIONS LAB.

SYMBOLS

- FY-65 FACILITIES
- FACILITIES PROPOSED IN 1966 ESTIMATES
- FUTURE FACILITIES
- PROJECT BOUNDARY

LEGEND

- ELEVATOR
- STAIRWAY
- G.P.O.S. GENERAL PURPOSE OFFICE SPACE
- A.L.S. ANALYSIS-LABORATORY SPACE
- S.P.S. SPECIAL PURPOSE SPACE
- M MEN'S LAVATORY
- W WOMEN'S LAVATORY
- L WOMEN'S LOUNGE
- MAIN ENTRANCE
- PILE FOUNDATION

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CONSTRUCTION OF FACILITIES

FISCAL YEAR 1966 ESTIMATES

CENTER SUPPORT FACILITIES, SECOND PHASE

AUTHORIZATION LINE ITEM: Electronics Research Center

PROGRAM OFFICE FOR THE PROJECT: Office of Advanced Research and Technology

LOCATION OF PROJECT: Cambridge, Middlesex County, Massachusetts

COGNIZANT NASA INSTALLATION: Electronics Research Center

TYPE OF CONSTRUCTION PROJECT: New

FUNDING:

FY 1965 and Prior Years	$85,000
FY 1966 Estimate	1,000,000
Total Funding Through FY 1966	$1,085,000

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$1,000,000
Addition to Center heating and refrigeration plant	LS	---	$295,000	295,000
Site preparation	LS	---	150,000	150,000
Utilities	LS	---	525,000	525,000
Roads	LS	---	30,000	30,000
Equipment	---	---	---	---
Design	---	---	---	---
Fallout Shelter (Not feasible)	---	---	---	None
		TOTAL		$1,000,000

PROJECT PURPOSE:

This project will provide site development and utility support facilities

to support the Electronics Research Center laboratories proposed for FY 1966.

PROJECT DESCRIPTION:

This project is the second phase of the site development and provision of support facilities for the Electronics Research Center located on an urban tract in Cambridge, Massachusetts. The site development and utility construction and installation covered in this project relate to the FY 1966 construction projects of the Center.

Site development includes additional site clearing, grading, top soil and seeding, security fencing, storm drainage, utility tunnels, roads, walkways and street lighting, required to support the additional laboratories requested in FY 1966.

The utility support facilities consist of the addition to the Center heating and refrigeration plant, warehouse-maintenance building, additions to the underground heat and chilled water distribution systems, sewage collection and disposal, underground electrical distribution systems, transformers, communication systems, and water systems. As in the case of the utilities previously provided for the Center, the heat, chilled water, electrical and water distribution systems will be constructed in utilidors to facilitate operation and maintenance of Center utilities.

PROJECT JUSTIFICATION:

The Center Support Facilities, Second Phase, are required to operate the individual laboratories of the Electronics Research Center requested in the FY 1966 Budget. Without these necessary site-developments and utility support, the laboratories requested cannot function.

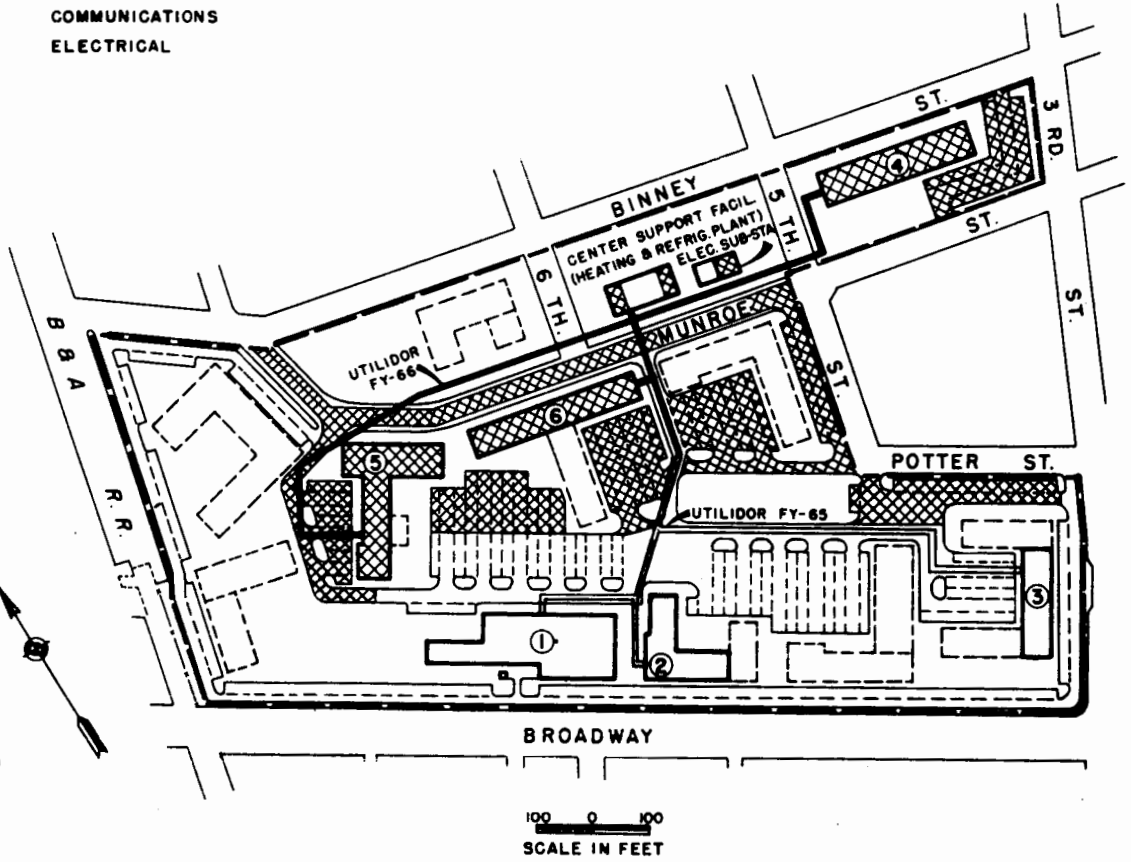
ESTIMATED FUTURE YEAR FUNDING FOR THIS PROJECT: None

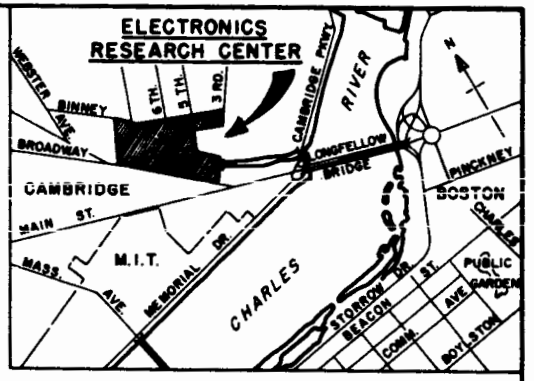
ELECTRONICS RESEARCH CENTER
FISCAL YEAR 1966 ESTIMATES

CENTER SUPPORT FACILITIES
SECOND PHASE

UTILITY SERVICES IN UTILIDOR

- HEAT LINES
- COOLING LINES
- WATER SUPPLY
- COMPRESSED AIR
- INDUSTRIAL WASTE
- SANITARY SEWER (PRESSURE SYS.)
- COMMUNICATIONS
- ELECTRICAL





0 0.1 0.2 0.3 0.4 0.5
SCALE IN MILES

1. ENGINEERING & ADMINISTRATION BUILDING
2. ELECTRONIC COMPONENTS LABORATORY
3. QUALIFICATIONS & STANDARDS LABORATORY
4. MICROWAVE RADIATION LABORATORY
5. SPACE GUIDANCE LABORATORY
6. OPTICAL COMMUNICATIONS LABORATORY

LEGEND

- FY-65 FACILITIES
- FACILITIES PROPOSED IN 1966 ESTIMATES
- FUTURE FACILITIES
- PROJECT BOUNDARY

CF 2-17

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1966 ESTIMATES

LANGLEY RESEARCH CENTER

Page No.

Location plan..... CF 5-1

Summary..... CF 5-3

Office of Advanced Research and Technology Projects:

Flight control research facility..... CF 5-4

Light support technology laboratory..... CF 5-8

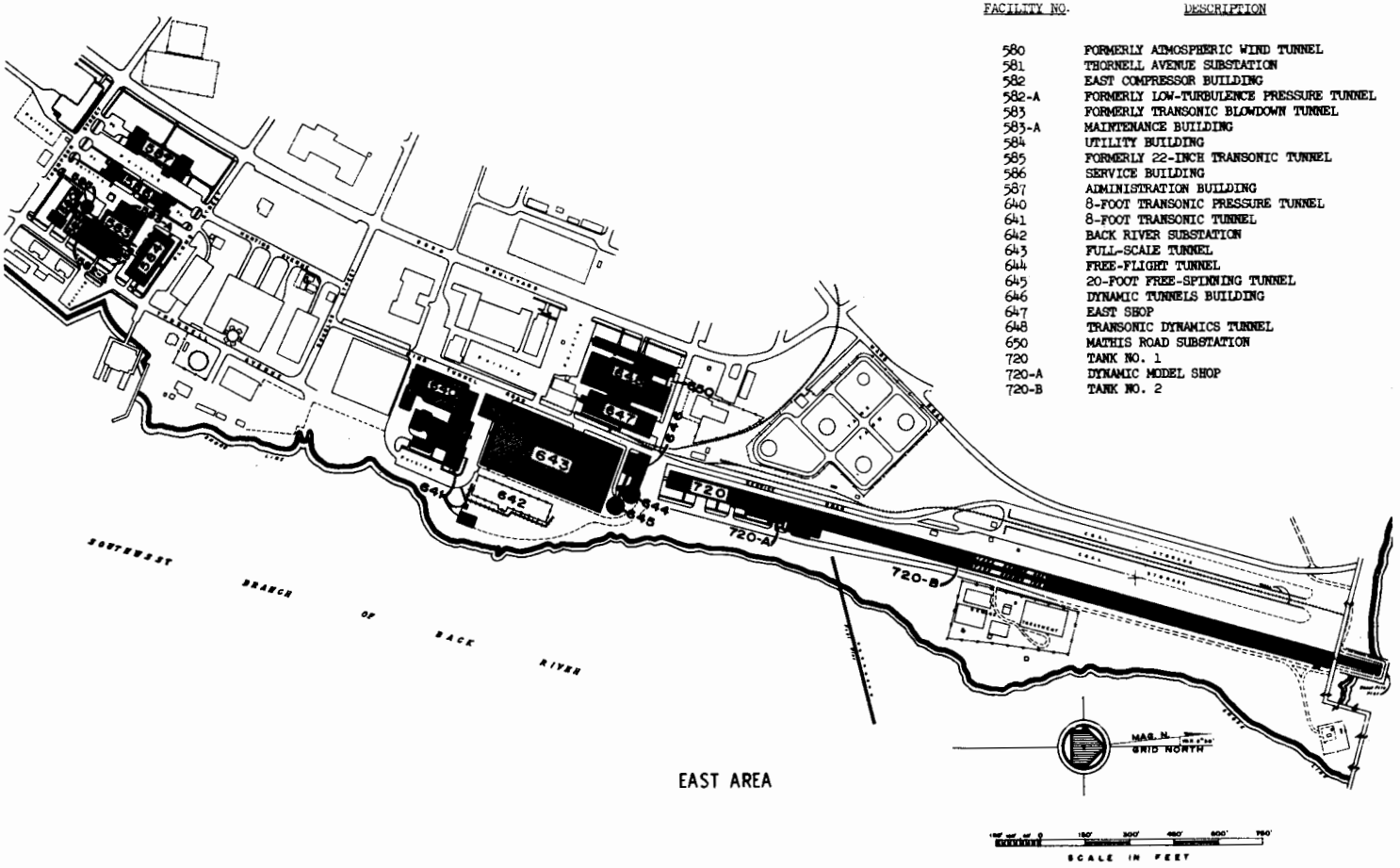
Increased capabilities of 20 inch mach 6 and mach 8.5 tunnels.... CF 5-12

Magazine and test area for highly reactive chemical materials.... CF 5-15

LANGLEY RESEARCH CENTER
FISCAL YEAR 1966 ESTIMATES

LOCATION PLAN

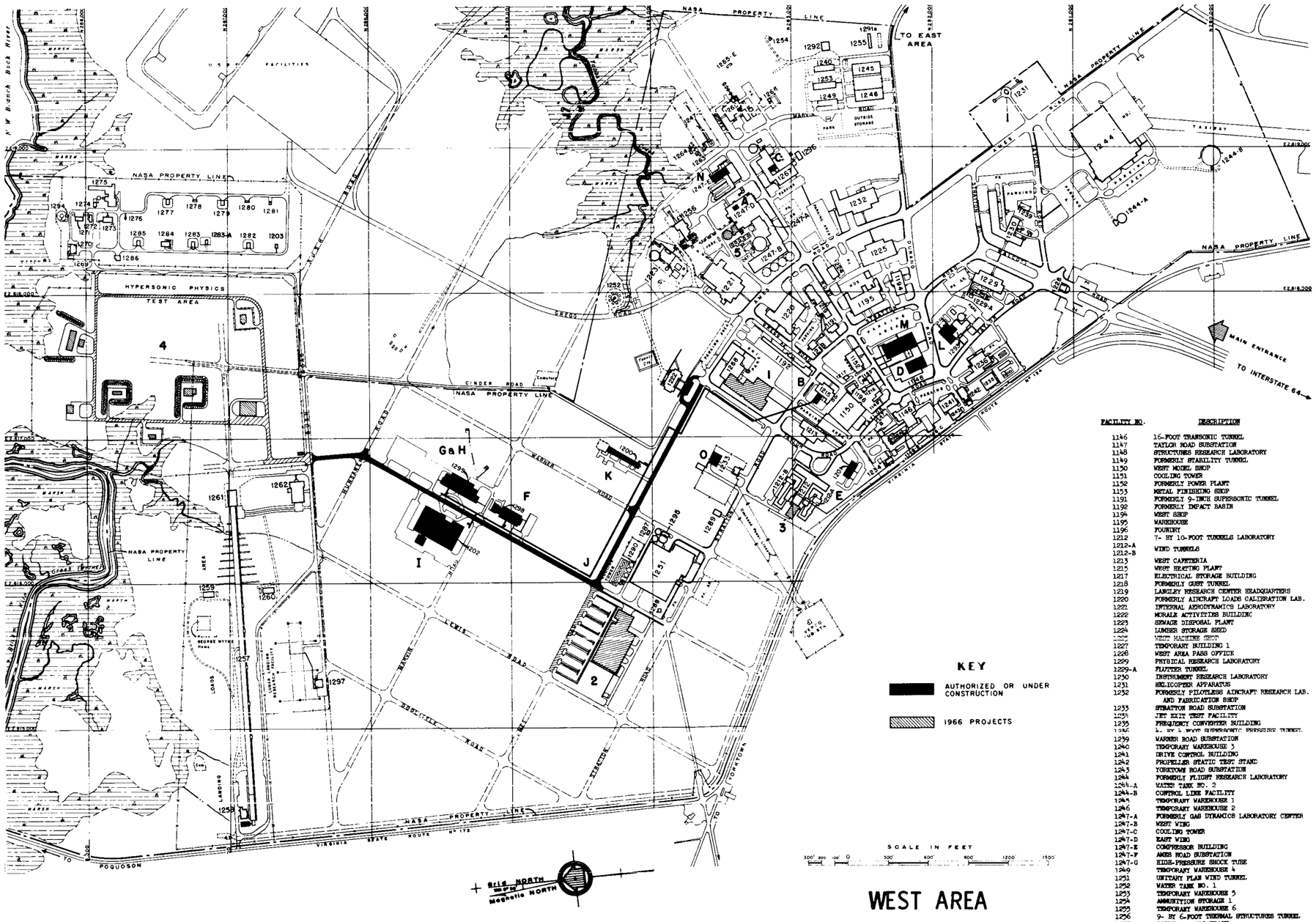
FACILITY NO.	DESCRIPTION
580	FORMERLY ATMOSPHERIC WIND TUNNEL
581	THORNELL AVENUE SUBSTATION
582	EAST COMPRESSOR BUILDING
582-A	FORMERLY LOW-TURBULENCE PRESSURE TUNNEL
583	FORMERLY TRANSONIC BLOWDOWN TUNNEL
583-A	MAINTENANCE BUILDING
584	UTILITY BUILDING
585	FORMERLY 22-INCH TRANSONIC TUNNEL
586	SERVICE BUILDING
587	ADMINISTRATION BUILDING
640	8-FOOT TRANSONIC PRESSURE TUNNEL
641	8-FOOT TRANSONIC TUNNEL
642	BACK RIVER SUBSTATION
643	FULL-SCALE TUNNEL
644	FREE-FLIGHT TUNNEL
645	20-FOOT FREE-SPINNING TUNNEL
646	DYNAMIC TUNNELS BUILDING
647	EAST SHOP
648	TRANSONIC DYNAMICS TUNNEL
650	MATHIS ROAD SUBSTATION
720	TANK NO. 1
720-A	DYNAMIC MODEL SHOP
720-B	TANK NO. 2



EAST AREA

LANGLEY RESEARCH CENTER
FISCAL YEAR 1966 ESTIMATES

LOCATION PLAN



WEST AREA

PROPOSED FISCAL YEAR 1966 PROJECTS

1. FLIGHT CONTROL RESEARCH FACILITY
2. LIFE SUPPORT TECHNOLOGY LABORATORY
3. V/STOL RESEARCH LABORATORY
4. MAGAZINE AND TEST AREA FOR HIGHLY REACTIVE CHEMICAL MATERIALS
5. INCREASE RESEARCH CAPABILITY M = 6 AND 8.5 TUNNELS

FACILITY NO.	DESCRIPTION
1146	16-FOOT TRANSONIC TUNNEL
1147	TAYLOR ROAD SUBSTATION
1148	STRUCTURES RESEARCH LABORATORY
1149	FORMERLY STABILITY TUNNEL
1150	WEST MODEL SHOP
1151	COOLING TOWER
1152	FORMERLY POWER PLANT
1153	METAL FINISHING SHOP
1191	FORMERLY 9-INCH SUPERSONIC TUNNEL
1192	FORMERLY IMPACT BASIN
1194	WEST SHOP
1195	WAREHOUSE
1196	FOUNDRY
1212	7- BY 10-FOOT TUNNELS LABORATORY
1212-A	WIND TUNNELS
1212-B	
1213	WEST CAFETERIA
1215	WEST HEATING PLANT
1217	ELECTRICAL SERVICE BUILDING
1218	FORMERLY GUST TUNNEL
1219	LANGLEY RESEARCH CENTER HEADQUARTERS
1220	FORMERLY AIRCRAFT LOADS CALIBRATION LAB.
1221	INTERNAL AERODYNAMICS LABORATORY
1222	MORALE ACTIVITIES BUILDING
1223	SEWAGE DISPOSAL PLANT
1224	LUMBER STORAGE SHED
1225	WEST MACHINE SHOP
1227	TEMPORARY BUILDING 1
1228	WEST AREA PASS OFFICE
1229	PHYSICAL RESEARCH LABORATORY
1229-A	FLUTTER TUNNEL
1230	INSTRUMENT RESEARCH LABORATORY
1231	HELICOPTER APPARATUS
1232	FORMERLY PILOTLESS AIRCRAFT RESEARCH LAB. AND FABRICATION SHOP
1233	STRATON ROAD SUBSTATION
1234	JET EXIT TEST FACILITY
1235	FREQUENCY CONVERTER BUILDING
1236	4- BY 4-FOOT SUPERSONIC PRESSURE TUNNEL
1239	WARNER ROAD SUBSTATION 1
1240	TEMPORARY WAREHOUSE 3
1241	DRIVE CONTROL BUILDING
1242	PROPELLER STATIC TEST STAND
1243	YORKTOWN ROAD SUBSTATION
1244	FORMERLY FLIGHT RESEARCH LABORATORY
1244-A	WATER TANK NO. 2
1244-B	CONTROL LINE FACILITY
1245	TEMPORARY WAREHOUSE 1
1246	TEMPORARY WAREHOUSE 2
1247-A	FORMERLY GAS DYNAMICS LABORATORY CENTER
1247-B	WEST WING
1247-C	COOLING TOWER
1247-D	EAST WING
1247-E	COMPRESSOR BUILDING
1247-F	AMES ROAD SUBSTATION
1247-G	HIGH-PRESSURE SHOCK TUBE
1249	TEMPORARY WAREHOUSE 4
1251	UNITARY PLAN WIND TUNNEL
1252	WATER TANK NO. 1
1253	TEMPORARY WAREHOUSE 5
1254	AMMUNITION STORAGE 1
1255	TEMPORARY WAREHOUSE 6
1256	9- BY 6-FOOT THERMAL STRUCTURES TUNNEL
1257	LANDING LOADS TRACK

FACILITY NO.	DESCRIPTION
1258	LANDING LOADS TRACK COMPRESSOR BUILDING
1259	NORTH ARRESTING GEAR HOUSING
1260	SOUTH ARRESTING GEAR HOUSING
1261	LANDING LOADS TRACK SHOP
1262	HIGH-SPEED HYDRODYNAMICS OFFICE AND SHOP
1263	CERAMIC-HEATED JET (PILOT MODEL)
1264	HIGH-TEMPERATURE MACH 7 JET (PILOT MODEL)
1265	8-FOOT HIGH-TEMPERATURE STRUCTURES TUNNEL
1266	MOFFETT ROAD SUBSTATION
1267	HIGH-TEMPERATURE MATERIALS LABORATORY
1268	DATA REDUCTION BUILDING
1269	GATE HOUSE (HYPERSONIC PHYSICS TEST AREA)
1270	ROCKET PROPELLANT TEST UNIT, HPTA
1271	OPEN SHED, HPTA
1272	HEATING PLANT, HPTA
1273	OPERATIONS CENTER, HPTA
1274	CERAMIC-HEATED MACH 15 JET, HPTA
1275	IMPACT AND PROJECTILE TEST UNIT, HPTA
1276	IGNITER ASSEMBLY BUILDING, HPTA
1277	STORAGE A
1278	STORAGE B
1279	STORAGE C
1280	STORAGE D
1281	STORAGE E
1282	STORAGE F
1283	STORAGE G
1284	ROCKET PROPELLANT TROUBLESHOOT UNIT (TTU), HPTA
1285	STORAGE H
1286	ROCKET ASSEMBLY AND PROPELLANT ALTERATION BUILDING
1287	TEMPORARY SHED
1288	SOLAR ENERGY COLLECTOR
1289	TEMPORARY STORAGE
1290	SUBSTATION
1291	PUMP STATION
1292	FACILITIES MAINTENANCE BUILDING
1293	DYNAMICS RESEARCH LABORATORY
1294	ROCKET MOTOR TEST APPARATUS
1295	SHOP AND INSTRUMENTATION FOR 60-FOOT SPHERE
1296	SHOP BUILDING
1297	LUNAR LANDING RESEARCH FACILITY

FACILITIES AUTHORIZED AND UNDER CONSTRUCTION

A	EQUIPMENT FOR MAGNETOPLASMADYNAMICS RESEARCH
B	ADDITION TO HEATING PLANT
C	ADD. POWER SUPPLY AND IMPROVED ARC CHAMBER FOR 10-MEGAWATT ARC TUNNEL
D	ENVIRONMENTAL RESEARCH FACILITIES FOR SPACECRAFT COMPONENTS AND MATERIALS
E	PARTICLE ACCELERATOR FOR SIMULATION OF MICRO-METEOROID IMPACT
F	STABILIZATION AND CONTROL EQUIPMENT LABORATORY
G&H	VEHICLE ANTENNA TEST FACILITY AND ADDITION TO VEHICLE ANTENNA TEST FACILITY
I	ELECTRONIC INSTRUMENTATION LABORATORY
J	UTILITY INSTALLATIONS
K	HOT GAS RADIATION RESEARCH FACILITY
L	THERMAL CONTROL HOUSING AND BUILDING ADDITION FOR DYNAMICS RESEARCH LABORATORY
M	FATIGUE RESEARCH LABORATORY
N	CENTRAL HIGH-PRESSURE AIR SUPPLY
O	UTILITY IMPROVEMENTS

CF 5-2

762-047 O - 65 (Fols. CF 5-1)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1966 BUDGET ESTIMATES

(Dollars in thousands)

NASA INSTALLATION	COGNIZANT PROGRAM OFFICE FOR INSTALLATION	LOCATION OF INSTALLATION	COUNTY	NEAREST CITY
Langley Research Center	Office of Adv. Research & Tech.	Langley AFB Hampton, Virginia		Hampton, Virginia

INSTALLATION MISSION

LRC Mission - Undertake research to provide a technical base for such missions as: (1) Manned and unmanned exploration of space; (2) Improvement of performance and utility of airborne flight; plan, develop and operate necessary facilities; generate new and advanced concepts; provide research advice and assistance to other branches of the Government; disseminate scientific and technical information; search for and identify potential industrial applications involved in the course of research.

PERSONNEL STRENGTH	FY 1964	FY 1965	FY 1966
NASA PERSONNEL *(End of Year)*	4330	4308	4308
CONTRACTOR AND OTHER PERSONNEL	482	502	566
TOTAL ALL PERSONNEL	4812	4810	4874

LAND	NO. ACRES
NASA-OWNED	540
OTHER GOVERNMENT AGENCY-OWNED	3618
NON-FEDERAL *(Leases, easements)*	72
TOTAL LAND	4230
TOTAL CAPITAL INVESTMENT *(Including NASA-Owned Land) (as of June 30, 1964)*	$ 249,776.0

PROJECT LINE ITEM	COGNIZANT OFFICE	FY 1959 THRU CURRENT YEAR	FY 1966 *(Estimated)*	FUTURE YEARS *(Estimated)*	TOTAL ALL YEARS *(Estimated)*
Flight Control Research Facility	OART	201.0	3,576.0	-0-	3,777.0
Life Support Technology Laboratory	OART	164.0	2,492.0	-0-	2,656.0
Increase Research Capabilities of M-6 and 8.5 Tunnels	OART	50.0	682.0	-0-	732.0
Magazine and Test Area for Highly Reactive Chemical Mats.	OART	90.0	1,500.0	-0-	1,590.0
ALL OTHER PROJECTS		58,488.0			
TOTALS		58,993.0	8,250.0		

NASA FORM 1029 (REV. NOV 64) PREVIOUS EDITIONS ARE OBSOLETE.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1966 ESTIMATES

FLIGHT CONTROL RESEARCH FACILITY

AUTHORIZATION LINE ITEM: Langley Research Center

PROGRAM OFFICE FOR THE PROJECT: Office of Advanced Research and Technology

LOCATION OF PROJECT: Hampton, Virginia

COGNIZANT NASA INSTALLATION: Langley Research Center

TYPE OF CONSTRUCTION PROJECT: New

FUNDING:

FY 1965 and Prior Years	$201,000
FY 1966 Estimate	3,576,000
Total Funding Through FY 1966	$3,777,000

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$2,238,000
Building	Sq. Ft.	72,420	$21.48	1,555,400
Raised floor	LS	---	89,100	89,100
Air conditioning	LS	---	266,600	266,600
Elevator	LS	---	40,000	40,000
Site work and paving	LS	---	68,900	68,900
Mechanical utilities	LS	---	30,400	30,400
Electrical utilities	LS	---	187,600	187,600
Equipment				$1,311,000
Projection spheres	LS	---	183,000	183,000
Fixed base study stations	LS	---	202,000	202,000
Visual cue generation	LS	---	470,000	470,000
Signal distribution and recording	LS	---	406,000	406,000
Building furnishing and equipment	LS	---	50,000	50,000

	Unit of Measure	Quantity	Unit Cost	Total Cost
Design	---	---	---	---
		Subtotal		$3,549,000
Fallout Shelter	---	---	---	27,000
		TOTAL		$3,576,000

PROJECT PURPOSE:

This project provides research capability in the guidance and control aspects of future manned flight missions and fundamental investigations leading to the optimization of man's performance in aerospace systems.

PROJECT DESCRIPTION:

This facility will be equipped with research devices including visual cue generation, projection and display subsystems; a signal conditioning and transmission network to connect the centralized equipment with study stations in the facility and with special purpose simulators at other Langley sites; modularly designed, quick change cockpits for use at the study stations. The facility will include flexibility to accommodate a large number of widely varied studies and features to permit rapid test setup and configuration changes. The facility, to be housed in an addition to the Data Reduction Center, will provide space for:

1. A high ceiling area for two visual cue projection spheres.

2. The visual cue generation and simulation control equipment, fixed-base crew stations (wherein the crew remains stationary and the visual cues and simulation provide the effect of motion and supporting cockpit assembly), checkout and program preparation areas.

3. A human performance laboratory to study such problems as information sensing, display, interpretation and decision making, and human characteristics in man-machine systems.

4. The effective integration of existing computing equipment into the simulation complex, together with new equipment.

5. The personnel to conduct the manned flight control and human performance research as well as the allied research and development work in computing techniques and advanced simulator technology.

PROJECT JUSTIFICATION:

Effective integration of the astronauts into the spacecraft system is a major factor in the reliability, safety, and achievement of the research objectives of future space flight missions. Extensive research is required to determine optimum control techniques, to improve methods of displaying information to flight crews, to determine man's capability and function in the control system, and to determine the effect of guidance and control on the design of spacecraft and missions. The use of simulators offers the only means for providing an accurate and realistic representation of the flight environment.

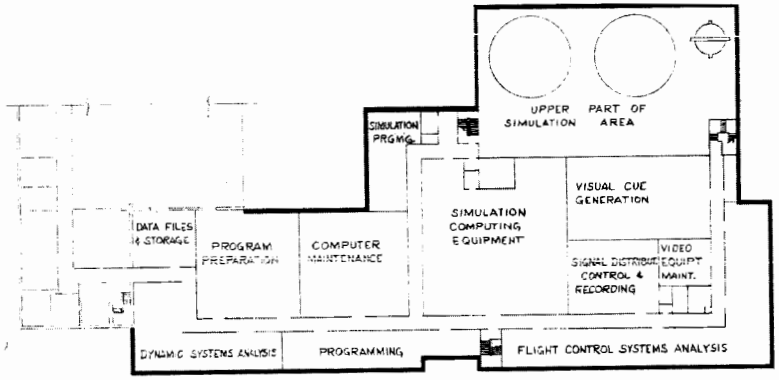
The primary effort at Langley in this area has been concerned with the role of man in the control of spacecraft. These studies have been made through the implementation of special-purpose, mission-oriented facilities such as the Rendezvous Docking Simulator, the Lunar Orbit-Lunar Approach Apparatus, the Lunar Landing Research Facility, and the 4-man Supersonic Transport Simulator. These facilities, although useful for simulation of specific missions, do not provide the flexibility and accessibility needed for the development of advanced display and control concepts.

The Flight Control Research Facility will provide the basic tools for conducting advanced research for future manned missions. It will incorporate a variety of simulators and computing equipment into a well integrated, flexible complex capable of handling research studies with the necessary accuracy and completeness. It will also allow for integration of the existing special purpose simulators into the new complex to carry out the needed research in an economical and efficient manner.

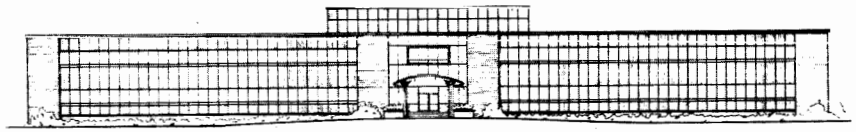
ESTIMATED FUTURE YEAR FUNDING FOR THIS PROJECT: None

LANGLEY RESEARCH CENTER
FISCAL YEAR 1966 ESTIMATES

FLIGHT CONTROL RESEARCH FACILITY

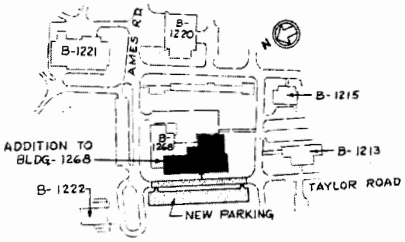


SECOND FLOOR PLAN



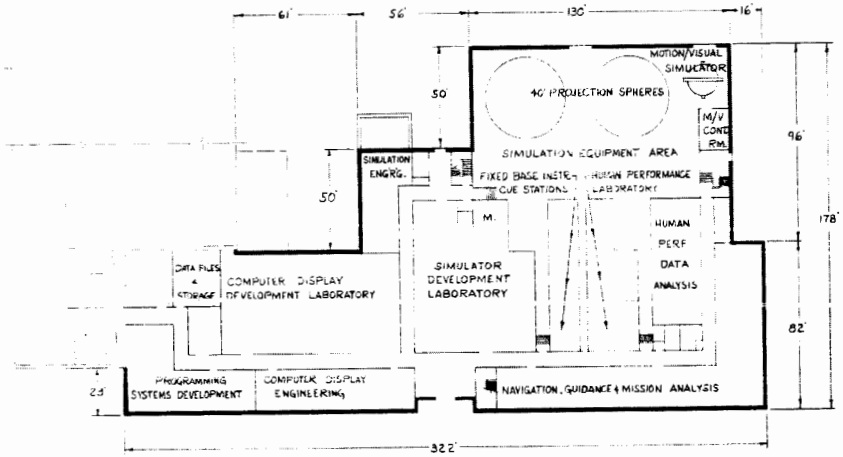
FRONT ELEVATION

0 20 40



PLOT PLAN

0 200' 400'



FIRST FLOOR PLAN

0 20 40

LEGEND
EXISTING CONSTRUCTION
NEW CONSTRUCTION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1966 ESTIMATES

LIFE SUPPORT TECHNOLOGY LABORATORY

AUTHORIZATION LINE ITEM: Langley Research Center

PROGRAM OFFICE FOR THE PROJECT: Office of Advanced Research and Technology

LOCATION OF PROJECT: Hampton, Virginia

COGNIZANT NASA INSTALLATION: Langley Research Center

TYPE OF CONSTRUCTION PROJECT: New

FUNDING:

FY 1965 and Prior Years	$164,000
FY 1966 Estimate	2,492,000
Total Funding Through FY 1966	$2,656,000

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$1,617,000
Building	Sq. Ft.	42,000	$25.44	1,068,400
Special building equipment	LS	---	92,800	92,800
Grading, paving, landscaping	LS	---	73,200	73,200
Mechanical utilities	LS	---	168,700	168,700
Electrical utilities	LS	---	213,900	213,900
Equipment				$834,000
Environmental simulators	LS	---	757,200	757,200
Laboratory equipment	LS	---	23,400	23,400
Laboratory mechanical systems	LS	---	53,400	53,400
Design	---	---	---	---
		Subtotal		$2,451,000

	Unit of Measure	Quantity	Unit Cost	Total Cost
Fallout Shelter	---	---	---	41,000
		TOTAL		$2,492,000

PROJECT PURPOSE:

This project will provide research capability to obtain and apply the technology necessary to equip future manned space vehicles of extended duration with optimum life support systems.

PROJECT DESCRIPTION:

The Life Support Technology Laboratory will contain approximately 42,000 square feet of laboratory. Included in this facility will be:

1. An advanced systems experimental laboratory to initiate and develop promising concepts for life support processes, components, and subsystems,

2. A laboratory for the conception and initial evaluation of instrumentation to monitor and control advanced life support subsystems and integrated systems,

3. Laboratories for the evaluation and testing of advanced concepts concerned with water reclamation from biological wastes, humidity control, and wash facilities,

4. A laboratory for making test setups, and instrumenting systems and subsystems for evaluation,

5. An environmental component and systems laboratory for the testing and evaluation of advanced components and subsystems for the control of the environment within the spacecraft,

6. A full scale integrated systems test area which will contain a large test chamber required for the evaluation and subsequent modification of complete and integrated manned life support systems including environmental control, water recovery, food provision, and waste management,

7. A major subsystems test area for the checkout and evaluation of vehicle structures, airlocks, erectable and deployable structures, and functional mockups of various projected missions as well as for dynamics and stability studies associated with manned vehicles,

8. A temperature control laboratory for the research and scale testing associated with both passive and active thermal control concepts for manned space vehicles,

9. A test laboratory to determine the physical, mechanical, and degradation characteristics of candidate materials for manned spacecraft and to evaluate their toxic characteristics,

10. A food and waste management systems laboratory for research on optimum methods of preparing and dispensing food and processing the associated refuse and biological wastes,

11. A contaminant control and biological test laboratory for research on detection, analysis, and control of gas, vapor, biological and particulate toxic substances occurring in spacecraft environments.

PROJECT JUSTIFICATION:

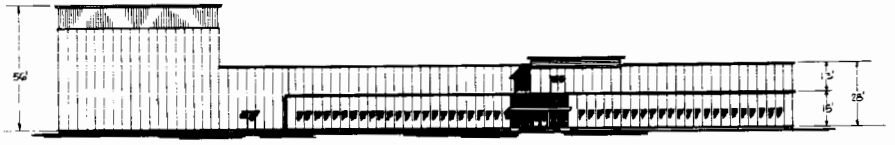
In future years man will engage in space explorations of extended duration at increasing distances from the earth. Planning for these longer-duration missions has established the need for improved life support systems. Present life support systems used on the Mercury vehicle and planned for Gemini and Apollo are relatively simple containing chemical absorbers, high-pressure gas storage, and simple humidity controls. These non-regenerative systems are inadequate for space missions beyond about 30 days. For longer missions regenerative and reclamation type systems must be used to avoid excessive weight penalties. Longer duration missions will also demand that these systems, which will be quite complex, also be extremely reliable. New concepts must be explored and new technologies established in order to provide these missions with optimum life support systems.

The primary effort for life support technology has been concentrated at the Langley Research Center. However, this effort has been hampered because of the lack of adequate laboratory space and equipment to accomplish the planned objectives in this area. This project will provide the laboratory space needed to undertake a concentrated research program. Research to be accomplished will include the development of promising concepts into tested hardware, the integration of this hardware into working prototype systems, and the evaluation of these systems in simulated mission exercises. Other research will deal with the sensing and control of contaminants and the pertinent aspects of repair and maintenance. In addition to these investigations, coordination and integration of these experiments and systems must be carried out with other spacecraft systems such as the instrumentation, structures, and control systems which influence the final configuration.

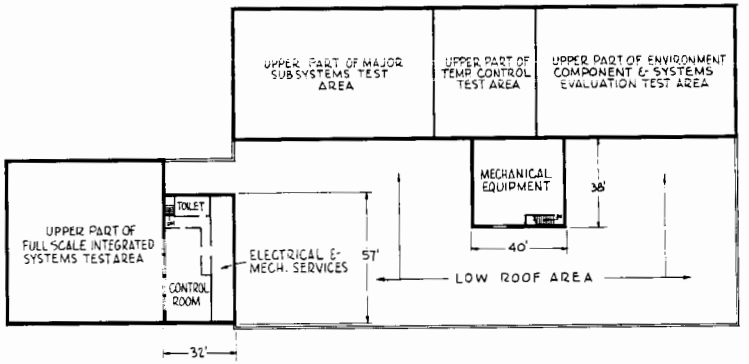
ESTIMATED FUTURE YEAR FUNDING FOR THIS PROJECT: None

LANGLEY RESEARCH CENTER
FISCAL YEAR 1966 ESTIMATES

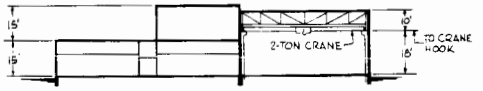
LIFE SUPPORT TECHNOLOGY LABORATORY



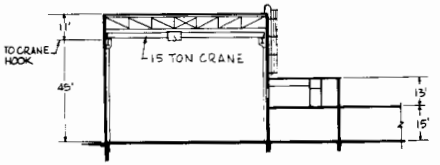
FRONT ELEVATION



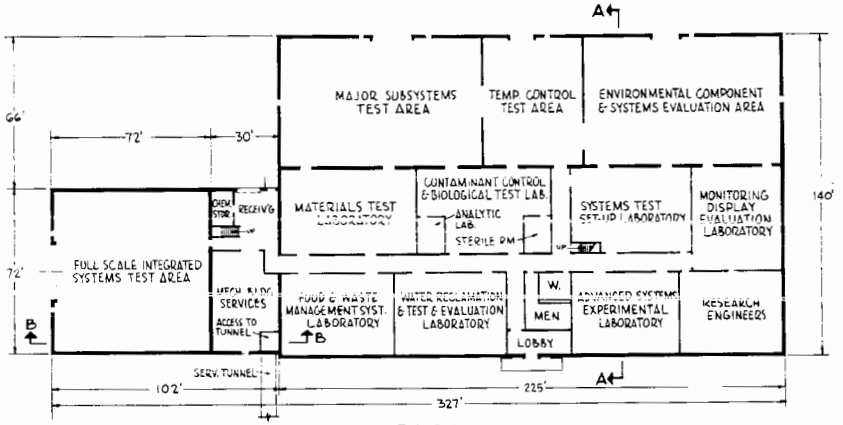
ROOF PLAN



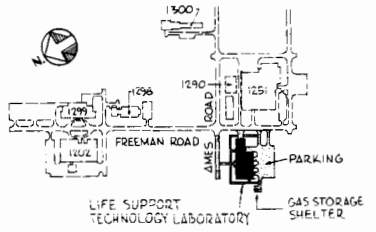
SECTION A-A



SECTION B-B



FIRST FLOOR PLAN



LOCATION PLAN

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1966 ESTIMATES

INCREASED CAPABILITIES OF 20-INCH MACH 6 AND MACH 8.5 TUNNELS

AUTHORIZATION LINE ITEM: Langley Research Center

PROGRAM OFFICE FOR THE PROJECT: Office of Advanced Research and Technology

LOCATION OF PROJECT: Hampton, Virginia

COGNIZANT NASA INSTALLATION: Langley Research Center

TYPE OF CONSTRUCTION PROJECT: New

FUNDING:

FY 1965 and Prior Years	$50,000
FY 1966 Estimate	682,000
Total Funding Through FY 1966	$732,000

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$223,070
Building	Sq. Ft.	2,488	30.37	75,550
Foundations and exhaust tube support	LS	---	27,870	27,870
Site work and paving	LS	---	8,880	8,880
Electrical utilities	LS	---	67,630	67,630
Mechanical utilities	LS	---	43,140	43,140
Equipment				$458,930
Vacuum storage sphere	LS	---	154,500	154,500
Air coolers	LS	---	128,750	128,750
Vacuum system	LS	---	134,280	134,280
Equipment installation	LS	---	41,400	41,400

	Unit of Measure	Quantity	Unit Cost	Total Cost
Design	---	---	---	---
Fallout Shelter (Not feasible)	---	---	---	None
		TOTAL		$682,000

PROJECT PURPOSE:

This project will provide for increasing the research capabilities of the 20-Inch Mach 6 and 8.5 tunnels in the following respects:

Reducing starting and stopping loads so that winged hypersonic vehicles may be studied.

Providing an order of magnitude increase in available Reynolds number range.

PROJECT DESCRIPTION:

This project will provide a 60-foot diameter vacuum sphere to increase the research capabilities of the 20-Inch Mach 6 and Mach 8.5 tunnels. An existing 41-foot diameter sphere, which does not presently serve these facilities, will be connected to the proposed 60-foot sphere to allow combined use of both spheres. A pumping system utilizing existing pumps and motors will be used to evacuate these spheres. A weathertight shelter will enclose the pumps, associated equipment, and exhaust air coolers.

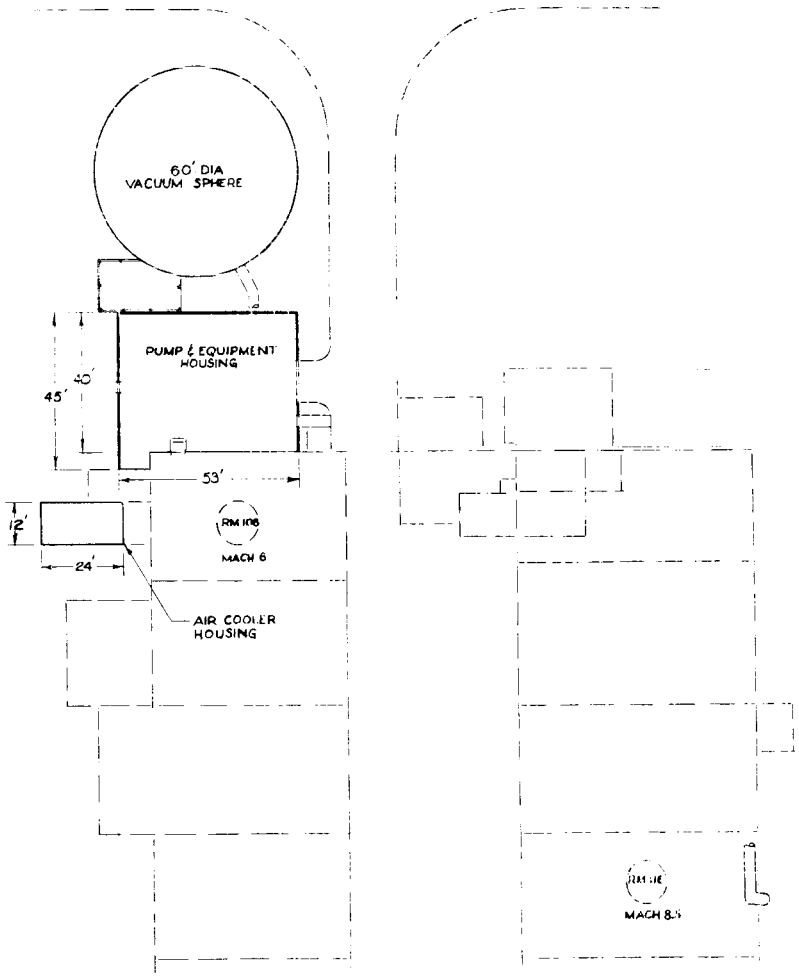
PROJECT JUSTIFICATION:

Theoretical studies of winged vehicles capable of achieving sustained hypersonic flight speeds indicate very promising applications in the area of recoverable boosters and earth-to-orbit flight. Experimental aerodynamic studies are required to ascertain if this theoretical potential can be realized. The presently constituted tunnels at Langley are not suitable for obtaining the required information. The 20-Inch Mach 6.0 and 8.5 tunnels are correctly sized, and operate in the required Mach number range of 5.5 to 8.5, however, the method by which these intermittent type tunnels operate imposes such severe starting and stopping aerodynamic loads that experiments with winged vehicles are not possible. These limitations can be overcome by reducing the back pressure at the downstream end of the tunnels. This reduction can be accomplished by increasing the vacuum capacity at the tunnel exit.

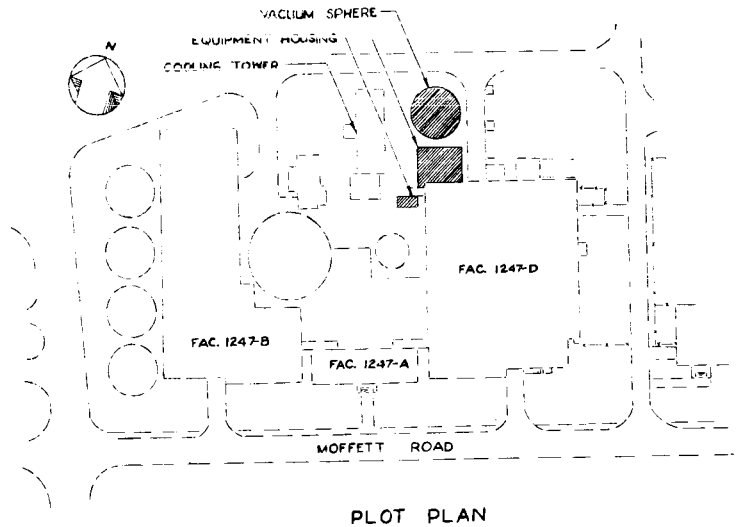
ESTIMATED FUTURE YEAR FUNDING FOR THIS PROJECT: None

LANGLEY RESEARCH CENTER
FISCAL YEAR 1966 ESTIMATES

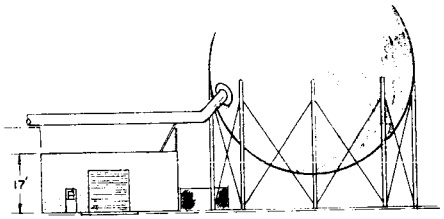
INCREASE RESEARCH CAPABILITY OF 20-INCH MACH 6 AND MACH 8.5 TUNNELS



FACILITY PLAN
0 25 FT.



PLOT PLAN
0 100 FT.



EAST ELEVATION

LEGEND
EXISTING CONSTRUCTION
NEW CONSTRUCTION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1966 ESTIMATES

MAGAZINE AND TEST AREA FOR HIGHLY REACTIVE CHEMICAL MATERIALS

AUTHORIZATION LINE ITEM: Langley Research Center

PROGRAM OFFICE FOR THE PROJECT: Office of Advanced Research and Technology

LOCATION OF PROJECT: Hampton, Virginia

COGNIZANT NASA INSTALLATION: Langley Research Center

TYPE OF CONSTRUCTION PROJECT: New

FUNDING:

FY 1965 and Prior Years	$90,000
FY 1966 Estimate	1,500,000
Total Funding Through FY 1966	$1,590,000

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$1,500,000
Rocket magazine	LS	---	$122,400	122,400
Rocket test facilities	LS	---	337,200	337,200
Rocket assembly building	LS	---	245,000	245,000
Chemical magazine	LS	---	222,600	222,600
Site development	LS	---	572,800	572,800
Equipment	---	---	---	---
Design	---	---	---	---
Fallout Shelter (Not feasible)	---	---	---	None
		TOTAL		$1,500,000

PROJECT PURPOSE:

This project will provide permanent type facilities that will permit the safe conduct of solid rocketry testing with high energy modern propellants. The facilities and test area will supplement the existing facilities in the hypersonic physics area.

PROJECT DESCRIPTION:

This project will provide small rocket test facilities, a rocket assembly building to support the test facilities, a rocket magazine, and chemical magazines. Locations, distances, and design features will be in accordance with current safety codes to permit continuation of ongoing effort. The test facilities will include three test cells and a control house with barricading and distances suitable for a rocket using 3,000 lbs. of class 9 propellant material. Concrete and steel structure of the test stands will be designed to withstand peak stresses possible in the event of rocket malfunctions. The rocket assembly building will permit operations on a rocket of up to 3,000 pounds of class 9 propellant. The rocket magazine will be designed for a maximum of 9,000 pounds of class 9 solid rocket propellant. The chemical magazine facility will provide segmented areas for various flammable chemicals utilized in the varied research activities. This entire facility will be located on an existing isolated site.

PROJECT JUSTIFICATION:

The primary requirement for this project is to permit continuation of ongoing program activities in full compliance with current safety codes and safe operational procedures. The Langley Research Center has conducted programs of rocket motor development and flight programs utilizing rocket motors for 20 years.

The missions requiring the Langley rocket facility support include:

1. National procurement agency for the solid fueled Scout rocket (developed at Langley)

   Evaluating, trouble-shooting, failure analysis
   Improving performance

2. Flight re-entry projects, such as:

   Apollo support
   Communications blackout
   Detection, and
   re-entry heating

3. Orbital projects, such as:

   Micrometeoroid study satellites

4. Atmospheric and space probes

5. Support of solid propulsion rocket development

This Center has developed a competence in solid rockets which is unique and does not duplicate support available in industry or in other government laboratories with which Langley staff frequently consult. The particular competence may best be illustrated by noting that it has contributed greatly to the perfect performance of the 4-stage Scout vehicle in the last 10 launches. The contributions were based in part on analysis and static firings of individual stages in ground test facilities.

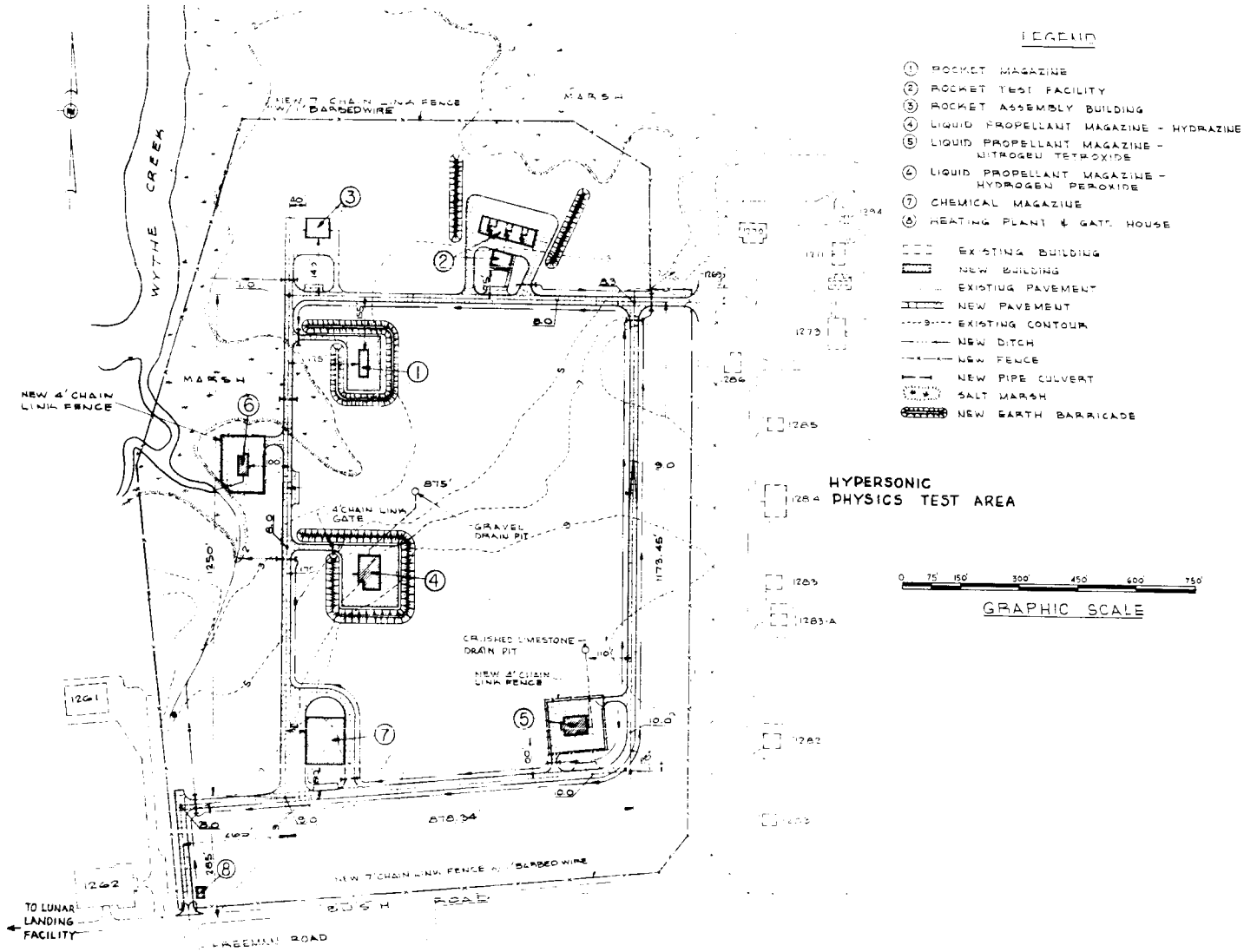
Existing Langley rocket facilities will be retained for use as needed but with smaller motor limits in accordance with revised safety standards.

The Center has no chemical magazine area for the many chemicals used in modern technology which are toxic or flammable. The number and use of such chemicals, many in plastic fabrication applications, has proliferated. Although stringent safety procedures are enforced, good management requires that a suitably restricted magazine be provided for receiving and dispensing such chemicals.

ESTIMATED FUTURE YEAR FUNDING FOR THIS PROJECT: None

LANGLEY RESEARCH CENTER
FISCAL YEAR 1966 ESTIMATES

MAGAZINE AND TEST AREA FOR HIGHLY REACTIVE CHEMICAL MATERIALS



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

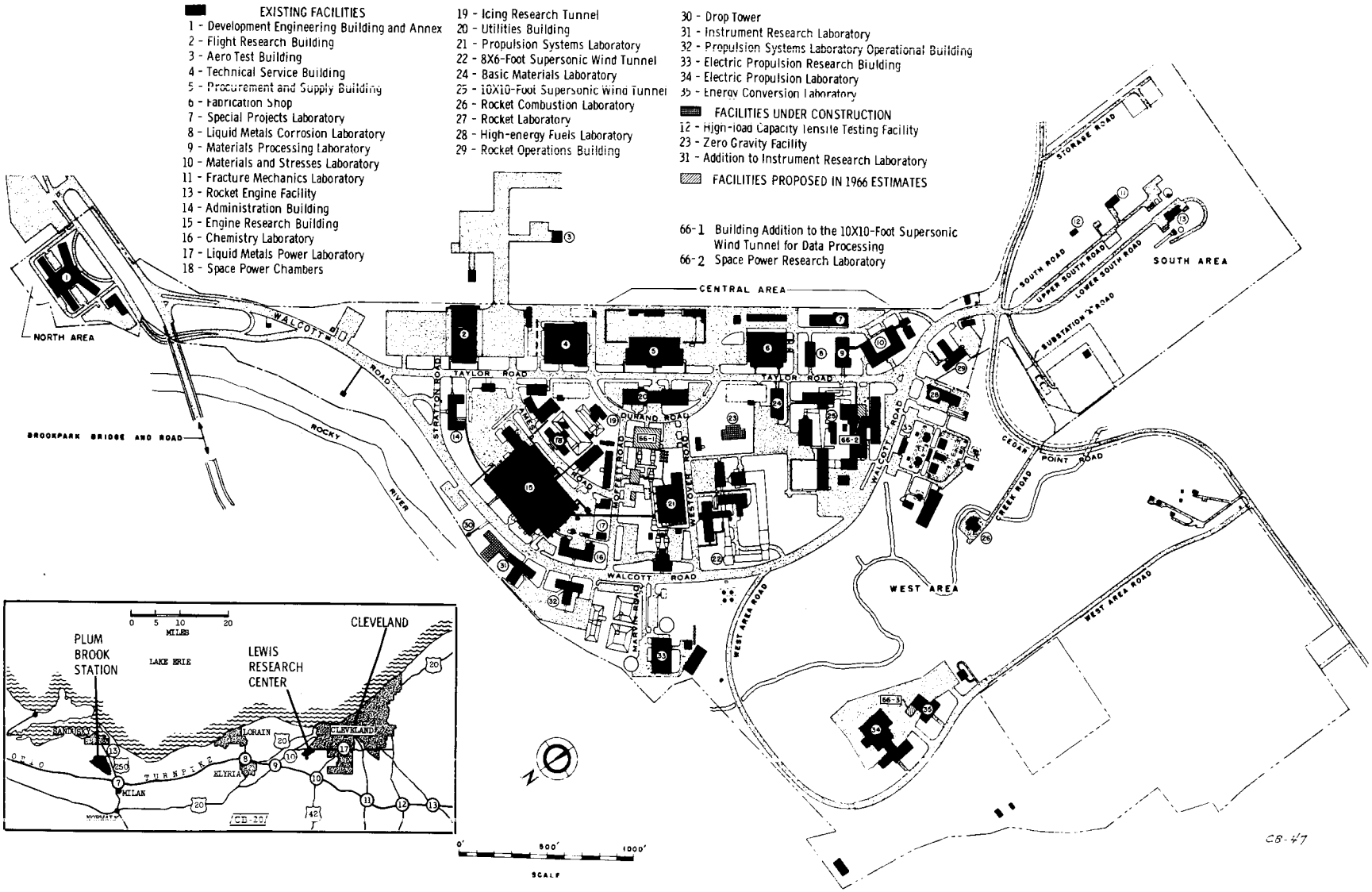
FISCAL YEAR 1966 ESTIMATES

LEWIS RESEARCH CENTER
(Plum Brook Station)

	Page No.
Location plan	CF 6-1
Summary	CF 6-3
Office of Advanced Research and Technology Projects:	
Building addition for the 10x10 foot supersonic wind tunnel for data processing	CF 6-4
Space power research laboratory	CF 6-8

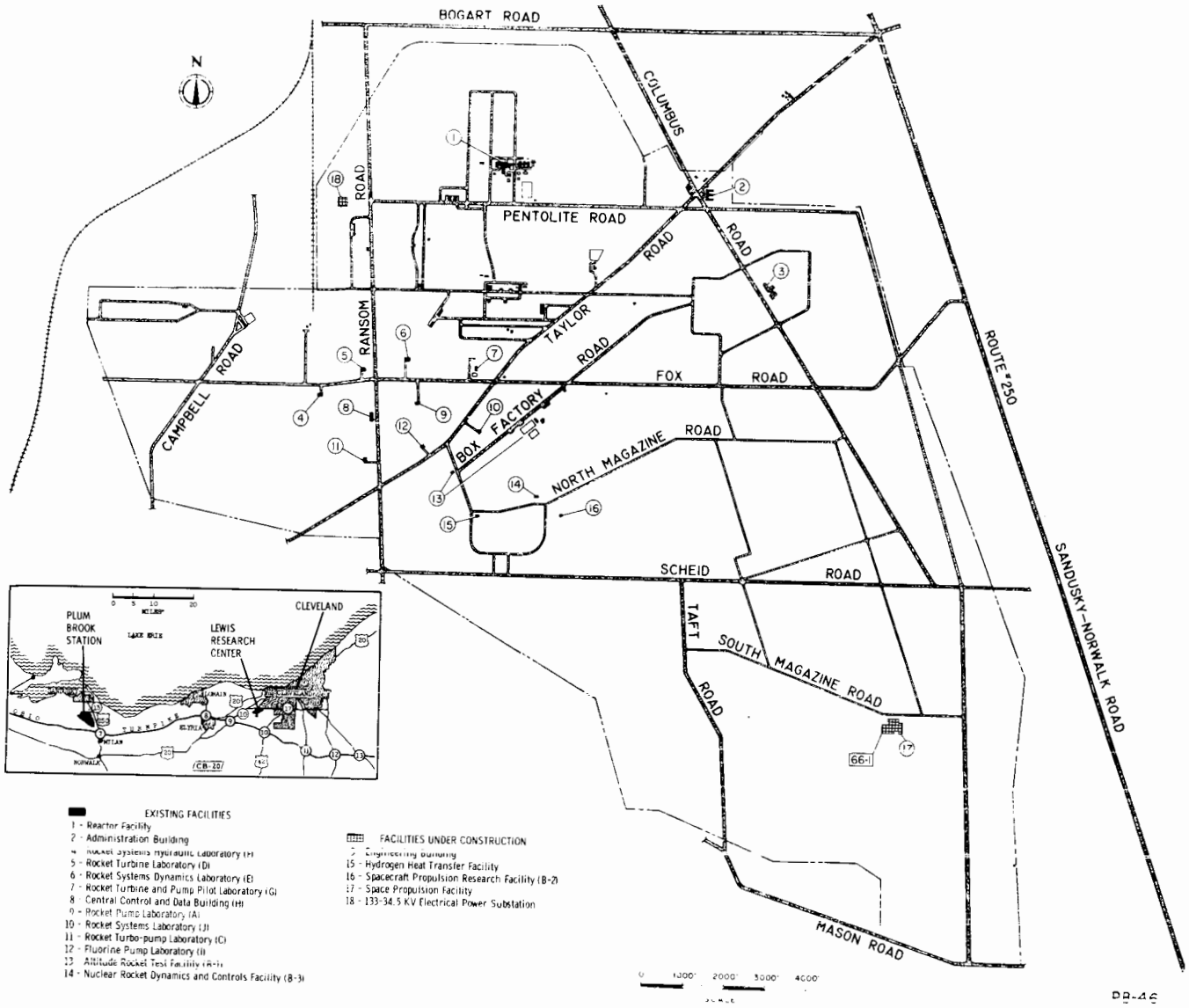
LEWIS RESEARCH CENTER
FISCAL YEAR 1966 ESTIMATES

LOCATION PLAN



LEWIS RESEARCH CENTER
PLUM BROOK STATION
FISCAL YEAR 1966 ESTIMATES

LOCATION PLAN



DR-46

CF 6-2

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1966 BUDGET ESTIMATES

(Dollars in thousands)

NASA INSTALLATION	COGNIZANT PROGRAM OFFICE FOR INSTALLATION	LOCATION OF INSTALLATION	COUNTY	NEAREST CITY
Lewis Research Center 1/	Advanced Research & Technology	Cleveland, Ohio	Cuyahoga	Cleveland, Ohio

INSTALLATION MISSION

Research and development in the areas of advanced propulsion and space power generation. In-house projects include: materials and metallurgy; bearings, seals and heat transfer problems at cryogenic and liquid-metal temperatures; combustion and direct-energy conversion processes; chemical, nuclear and electric rockets and their accessories; system control dynamics; plasmas and magnetohydrodynamics; and zero-gravity effects. The Center maintains technical management of many NASA contracts, including the Centaur, Agena, M-1 and large solid propellant rockets.

PERSONNEL STRENGTH	FY 1964	FY 1965	FY 1966
NASA PERSONNEL *(End of Year)*	4859	4847	4847
CONTRACTOR AND OTHER PERSONNEL	300	340	365
TOTAL ALL PERSONNEL	5159	5187	5212

LAND	NO. ACRES
NASA-OWNED	6,380
OTHER GOVERNMENT AGENCY-OWNED	-
NON-FEDERAL *(Leases, easements)*	15
TOTAL LAND	6,395
TOTAL CAPITAL INVESTMENT *(Including NASA-Owned Land) (as of June 30, 1964)*	$ 239,998.0

PROJECT LINE ITEM	COGNIZANT OFFICE	FY 1959 THRU CURRENT YEAR	FY 1966 *(Estimated)*	FUTURE YEARS *(Estimated)*	TOTAL ALL YEARS *(Estimated)*
Building Addition to 10 x 10-foot Supersonic Wind Tunnel for Data Processing	OART	23.0	407.0	-0-	430.0
Space Power Research Laboratory	OART	27.0	460.0	-0-	487.0
ALL OTHER PROJECTS		93,663.0			
TOTALS		93,713.0	1/ 867.0		

NASA FORM 1029 (REV. NOV 64) PREVIOUS EDITIONS ARE OBSOLETE.

1/ Includes Plum Brook Station

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1966 ESTIMATES

BUILDING ADDITION TO THE 10 x 10 FOOT SWT
FOR DATA PROCESSING

AUTHORIZATION LINE ITEM: Lewis Research Center

PROGRAM OFFICE FOR THE PROJECT: Office of Advanced Research and Technology

LOCATION OF PROJECT: Cleveland, Cuyahoga County, Ohio

COGNIZANT NASA INSTALLATION: Lewis Research Center

TYPE OF CONSTRUCTION PROJECT: New

FUNDING:

FY 1965 and Prior Years	$23,000
FY 1966 Estimate	407,000
Total Funding Through FY 1966	$430,000

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$383,700
Building	Sq. Ft.	14,480	$25.85	374,300
Site preparation	LS	---	1,300	1,300
Roads and parking	LS	---	---	---
Utilities	LS	---	8,100	8,100
Equipment				$23,300
Card and table cabinets	LS	---	15,100	15,100
Office furniture	LS	---	8,200	8,200
Design	---	---	---	---
Fallout Shelter	---	---	---	-0-
			TOTAL	$407,000

PROJECT PURPOSE:

This project will provide an acceptable location for data processing equipment that is presently on order and required to process the increased data load.

PROJECT DESCRIPTION:

This project consists of a three-story and basement addition to the 10 x 10 Supersonic Wind Tunnel Building. The structure will be a steel frame with masonry curtain walls. The first floor and basement will be reinforced concrete. Exterior dimensions will be approximately 73 feet by 47 feet.

The basement will be used for mechanical and electrical equipment; the first floor for office space, conference area and toilet facilities; the second and third floors for the new computer and data processing equipment and office area.

The wall between the new and existing buildings will be removed on the second and third floors so that one large computer area will be obtained.

Special air-conditioning equipment will be used for the equipment with comfort conditioning being supplied for the building. A raised floor system will be used in the computer and data processing areas.

PROJECT JUSTIFICATION:

Present data collection systems are incapable of processing the increased data load that is being generated in support of such research programs as the supersonic transport compressor and turbine components, injection tests, combustion instability, and simulated power system loop tests. To meet this requirement, additions to the present data system are being purchased. They include a 30,000 sample-per-second data system and telemetry data reduction system that will be used to process raw data tapes of Centaur and Agena shots.

The additional data processing equipment being delivered in the next twelve months cannot be housed in the present area. A survey of the buildings indicates no area of adequate size to accept the complete computing installation in an efficient, coordinated arrangement. A new computer building would greatly exceed the cost of the proposed addition.

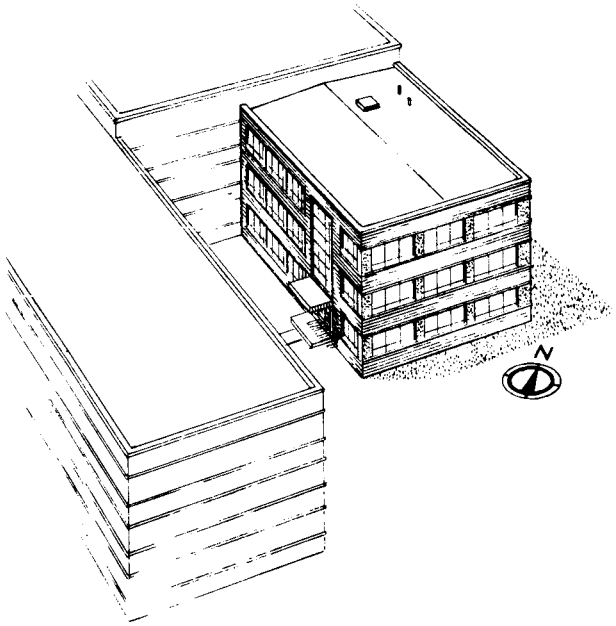
The large digital computers are a modified 1103 and 7094 Mod. - II. These, with their peripheral equipment, and all of the digital and analog data systems, are presently housed in two rooms of the 10 x 10 Supersonic Wind Tunnel office building. This area is already so overcrowded that peripheral equipment for those systems is located in adjoining offices. Without the proposed building addition, the telemetry system will have to be remotely located and additional people will be required to operate the new

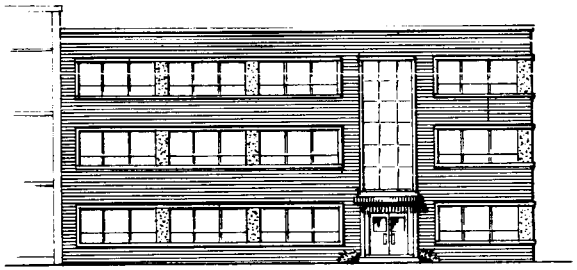
data systems because the equipment could not be centrally located. The output of all digital data systems is accepted by a single computer and is formated for further data processing. The proposed building addition will reduce the scattering of the systems and thereby reduce the possible need for a new computer.

ESTIMATED FUTURE YEAR FUNDING FOR THIS PROJECT: None

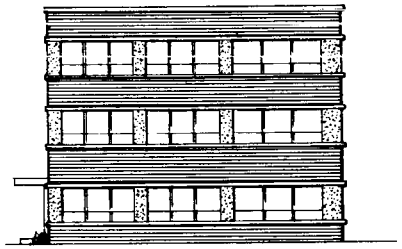
LEWIS RESEARCH CENTER
FISCAL YEAR 1966 ESTIMATES

BUILDING ADDITION TO THE 10 X 10 FOOT SUPERSONIC WIND TUNNEL FOR DATA PROCESSING



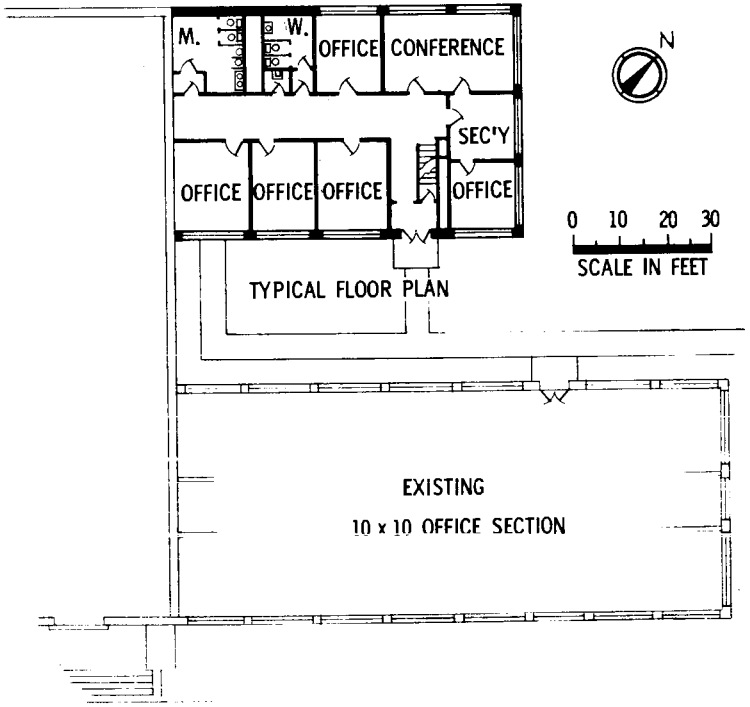


SOUTH ELEVATION

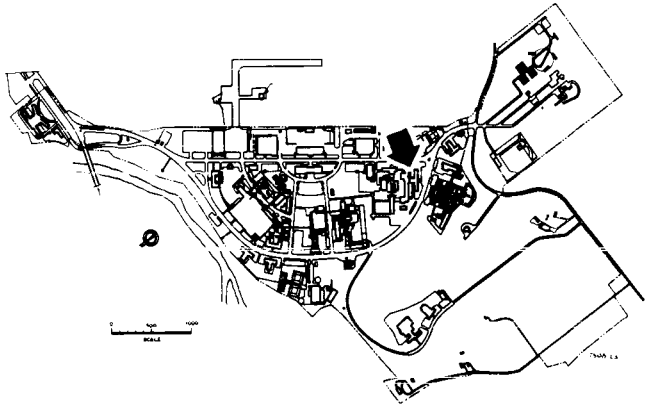


EAST ELEVATION

0 10 20 30
SCALE IN FEET



TYPICAL FLOOR PLAN



CB-37

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1966 ESTIMATES

SPACE POWER RESEARCH LABORATORY

AUTHORIZATION LINE ITEM: Lewis Research Center

PROGRAM OFFICE FOR THE PROJECT: Office of Advanced Research and Technology

LOCATION OF PROJECT: Cleveland, Cuyahoga County, Ohio

COGNIZANT NASA INSTALLATION: Lewis Research Center

TYPE OF CONSTRUCTION PROJECT: New

FUNDING:

FY 1965 and Prior Years	$27,000
FY 1966 Estimate	460,000
Total Funding Through FY 1966	$487,000

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$333,500
Building	Sq. Ft.	13,300	$ 21.21	282,100
Site development and utilities	LS	---	51,400	51,400
Equipment				$126,500
Laboratory furniture	LS	---	47,250	47,250
Mechanical support services	LS	---	48,550	48,550
Electrical support services	LS	---	30,700	30,700
Design	---	---	---	---
Fallout Shelter (Not feasible)	---	---	---	None
		TOTAL		$460,000

PROJECT PURPOSE:

This project will expand research capabilities in electrochemistry, fuel cells, fused salt chemistry, secondary battery characteristics and thin-film photovoltaic cells as related to fundamentals and development of space electric power systems.

PROJECT DESCRIPTION:

This project provides a new building to be attached to the existing Energy Conversion Laboratory in the west area. It will be a two-story building, without basement, of about 13,000 square feet. The first floor will provide four laboratory areas and housing for central heating and air conditioning equipment; the second floor will provide six laboratory areas, an electrical equipment room and two small offices.

PROJECT JUSTIFICATION:

Continued improvement in chemical rocket capability generates an ever increasing need for improved auxiliary electric power systems. Since satellites and space probes require about one-fourth to one-half watts of electricity for each pound of space vehicle weight, power systems developing 1-10 kilowatts will soon be needed to match the launch capabilities of Saturn class boosters. Advanced solar cell systems, possibly of the thin-film type, and electrochemical power systems will play an important part in filling this need for auxiliary power.

The Lewis Research Center is actively engaged in in-house research aimed at the fundamentals of many potential space electric power systems. Largely missing from this Center's research and development effort is the intermediate phase of developing and debugging prototype or bread-board devices and studies, at bench scale, of the unit processes required for future, high power systems. Also missing is a significant effort on the fundamentals of electrochemistry. This facility will fill these gaps.

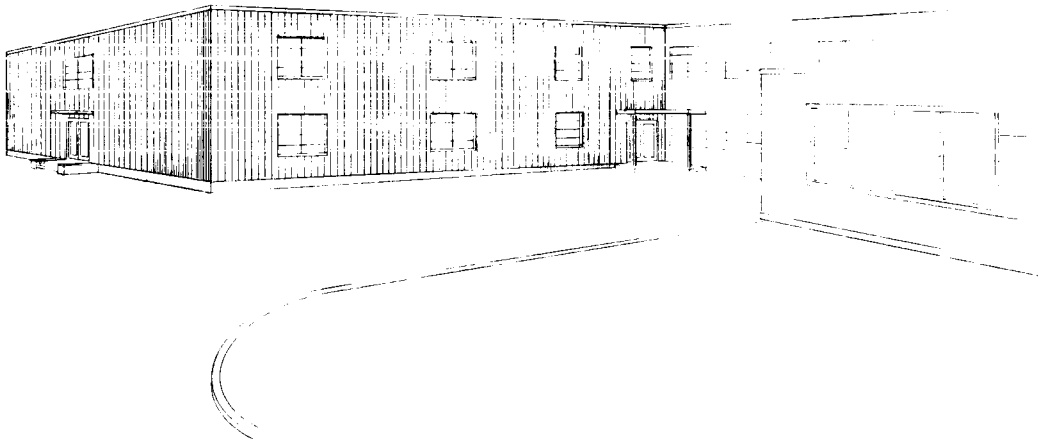
The facility will provide the capability for:

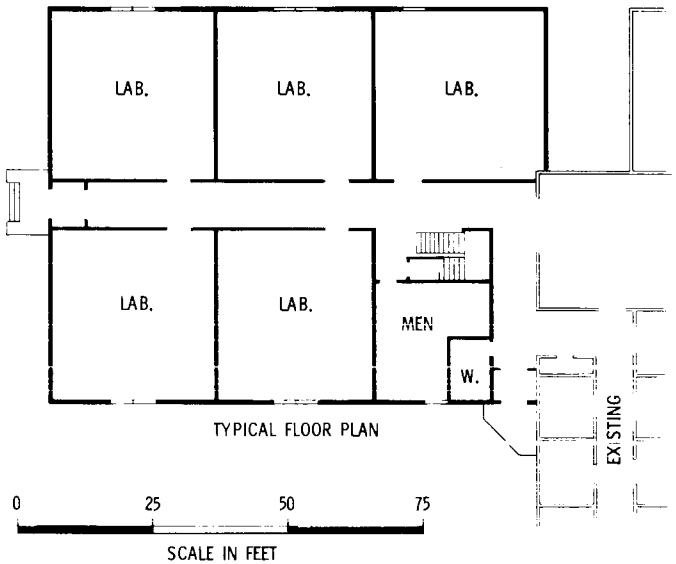
1. An increased research and development effort on the fabrication and evaluation of thin-film solar cells.
2. Increased work on improving the performance of conventional solar cells, especially in regards to lowering specific weights and increasing resistance to radiation damage.
3. Research on new types of high energy-density batteries.
4. The development and evaluation of fuel cell components.
5. Research on fused-salt electrochemical systems.

ESTIMATED FUTURE YEAR FUNDING FOR THIS PROJECT: None

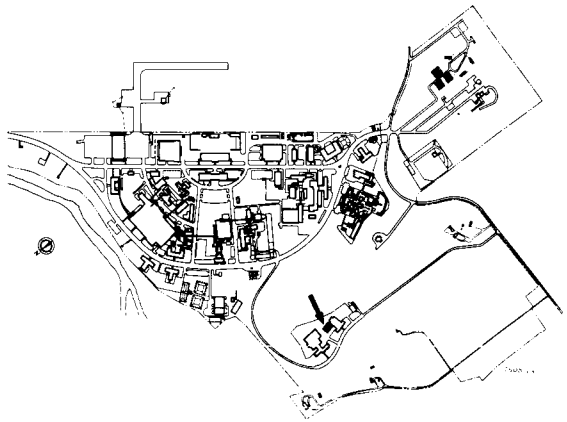
LEWIS RESEARCH CENTER
FISCAL YEAR 1966 ESTIMATES

SPACE POWER RESEARCH LABORATORY





TYPICAL FLOOR PLAN



PLOT PLAN

CB-45

7612-047 O - 65 - 22

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1966 ESTIMATES

VARIOUS LOCATIONS

Page No.

Summary..... CF 11-1

Office of Manned Space Flight Projects:

Facilities for F-1 engine program..... CF 11-2

Facilities for J-2 engine program..... CF 11-8

Facilities for S-II stage program..... CF 11-13

Office of Tracking and Data Acquisition Projects:

Deep space antenna facility, Madrid, Spain..... CF 11-18

Deep space antenna facility, Canberra, Australia..... CF 11-22

STADAN facility, Fairbanks, Alaska..... CF 11-27

Apollo network ground station, Antigua, W. I.
(facility for unified "S" band system)..... CF 11-34

Apollo network ground station, Antigua, W. I.
(community support facilities)..... CF 11-37

Apollo network ground station, Grand Canary Islands..... CF 11-42

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1966 BUDGET ESTIMATES
(Dollars in Thousands)

NASA INSTALLATION	COGNIZANT PROGRAM OFFICE FOR INSTALLATION	LOCATION OF INSTALLATION	COUNTY	NEAREST CITY
Various Locations	Manned Space Flight	Not applicable	Not applicable	Not applicable

INSTALLATION MISSION

PERSONNEL STRENGTH	FY 1964	FY 1965	FY 1966
NASA PERSONNEL *(End of Year)*			
CONTRACTOR AND OTHER PERSONNEL			
TOTAL ALL PERSONNEL			

LAND	NO. ACRES
NASA-OWNED	
OTHER GOVERNMENT AGENCY-OWNED	
NON-FEDERAL *(Leases, easements)*	
TOTAL LAND	
TOTAL CAPITAL INVESTMENT *(Including NASA-Owned Land) (as of June 30, 1964)*	$ ---

PROJECT LINE ITEM	COGNIZANT OFFICE	FY 1962 THRU CURRENT YEAR	FY 1966 *(Estimated)*	FUTURE YEARS *(Estimated)*	TOTAL ALL YEARS *(Estimated)*
Facilities for F-1 Engine Program	MSF	62,196.0	2,007.0	-0-	64,203.0
Facilities for J-2 Engine Program	MSF	29,502.8	2,436.0	-0-	31,938.8
Facilities for S-II Stage Program	MSF	2,863.7	1,690.0	-0-	4,553.7
Deep Space Antenna Facility, Madrid, Spain	TDA	36.0	472.0	-0-	508.0
Deep Space Antenna Facility, Canberra, Australia	TDA	38.0	510.0	-0-	548.0
STADAN Facility, Fairbanks, Alaska	TDA	83.0	1,115.0	-0-	1,198.0
Apollo Network Ground Station - Antigua (Fac. for Unified "S" - Band System)	TDA	162.0	2,700.0	-0-	2,862.0
Apollo Network Ground Station - Antigua (Community Support Facilities)	TDA	210.0	3,090.0	-0-	3,300.0
Apollo Network Ground Station - Canary Islands	TDA	120.0	7,674.0	-0-	7,794.0
ALL OTHER PROJECTS		390,672.5			
TOTALS		485,884.0	21,694.0		

NASA FORM 1029 (REV. NOV 64) PREVIOUS EDITIONS ARE OBSOLETE.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1966 ESTIMATES

APOLLO WING, MADRID DEEP SPACE FACILITY

AUTHORIZATION LINE ITEM: Various Locations

PROGRAM OFFICE FOR THE PROJECT: Office of Tracking and Data Acquisition

LOCATION OF PROJECT: Madrid, Spain

COGNIZANT NASA INSTALLATION: Jet Propulsion Laboratory

TYPE OF CONSTRUCTION PROJECT: New

FUNDING:

FY 1965 and Prior Years	$36,000
FY 1966 Estimate	472,000
Total Funding Through FY 1966	$508,000

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$472,000
New wing (first floor)	Sq. Ft.	4,600	$40.00	184,000
(basement)	Sq. Ft.	4,000	17.50	70,000
Utilities	LS	---	5,900	5,900
Engine generator	LS	---	94,000	94,000
Tunnel	LS	---	29,400	29,400
Site development	LS	---	4,500	4,500
Air conditioning	LS	---	84,200	84,200
Equipment	---	---	---	---
Design	---	---	---	---
Fallout Shelter (Not feasible)	---	---	---	None
		TOTAL		$472,000

PROJECT PURPOSE:

This project provides for the construction of a Manned Space Flight Net (MSFN) wing addition to the existing Control Building at the Deep Space Station, Madrid, Spain which will house electronic equipments to permit this antenna system to serve as essential backup to the prime Apollo station at Madrid.

PROJECT DESCRIPTION:

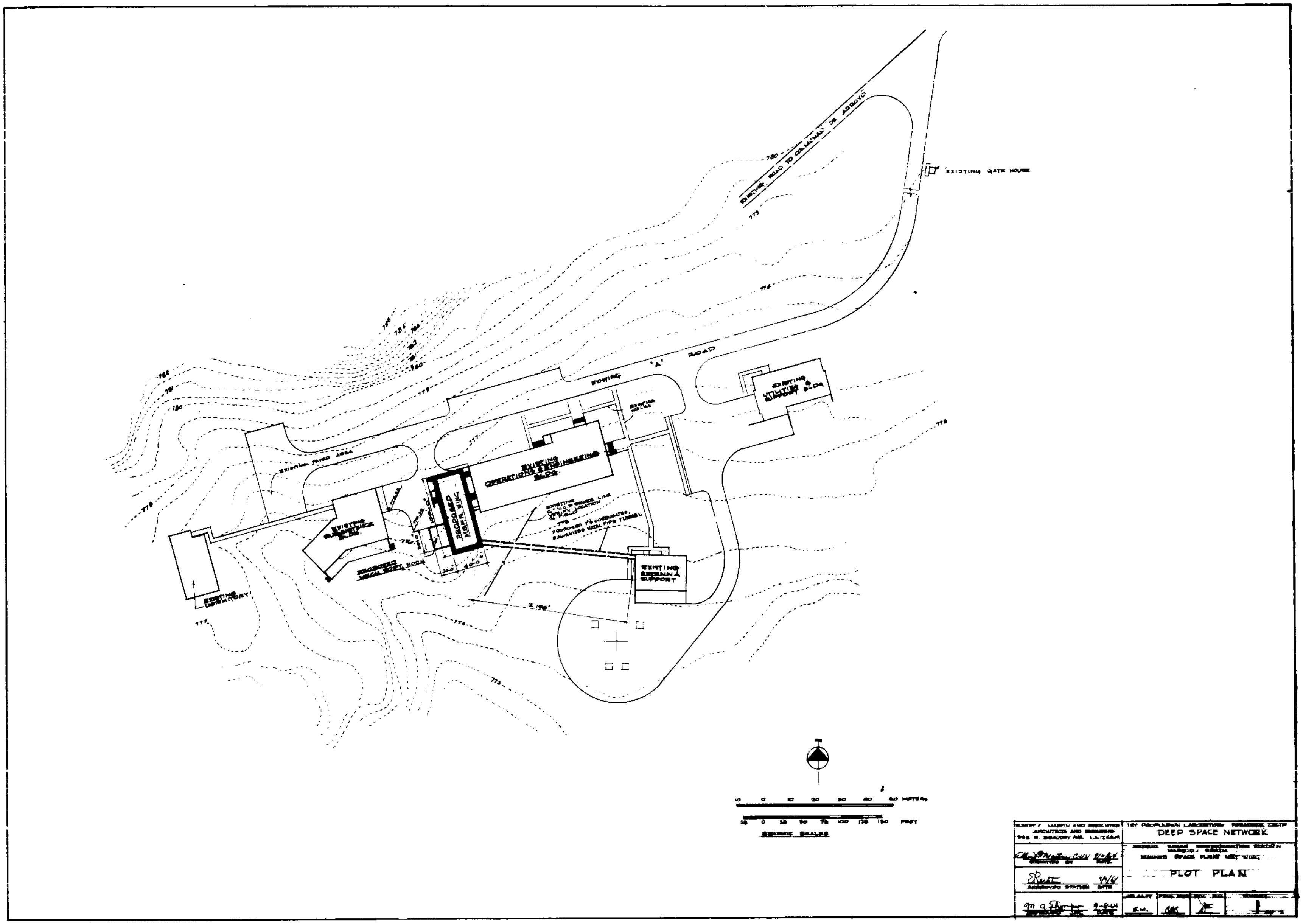
Exterior dimensions of the new wing are approximately 40 feet wide by 100 feet long. The building will consist of a basement area to serve as a raceway for equipment wiring and the air conditioning system plenum, and a floor space of 4,000 square feet to contain the technical equipment. In addition, there will be a mechanical utility structure of approximately 600 square feet to house the required heating and air conditioning equipment for this wing.

Architecturally, the addition will match the existing building.

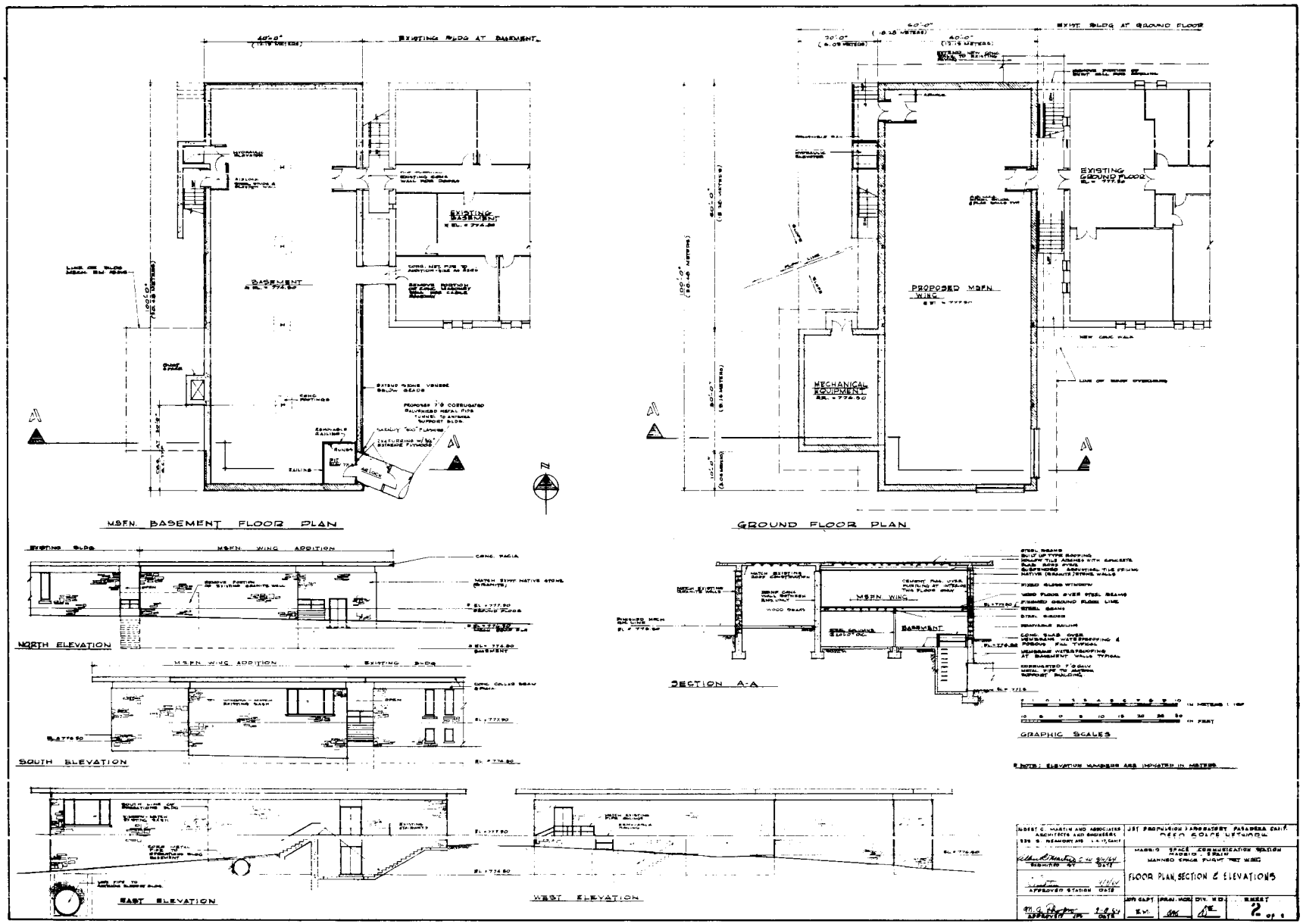
PROJECT JUSTIFICATION:

To support the lunar phases of the Apollo missions, three single prime 85 foot antenna stations are required at locations around the world, separated by approximately 120° of longitude, in order to provide continual spatial coverage. These prime Apollo antennas have been co-located with the Deep Space facilities to achieve maximum costs savings and to provide, in the near vicinity, a backup capability essential for Apollo missions in the event of a failure or malfunction of the single manned flight facility. To provide the deep space antenna with this capability, certain basic electronic equipment peculiar to Apollo support must be added to the station instrumentation. This equipment permits the transmission of data to the Apollo station for the major data handling and processing functions. The wing addition to the control building is required to house this equipment.

ESTIMATED FUTURE YEAR FUNDING FOR THIS PROJECT: None


EXISTING GATE HOUSE
EXISTING "A" ROAD
EXISTING OPERATIONS & ENGINEERING BLDG.
PROPOSED MSFN WING
EXISTING ANTENNA SUPPORT
EXISTING UTILITIES & SUPPORT BLDG.
EXISTING DORMITORY
METRIC SCALES
DEEP SPACE NETWORK
PLOT PLAN

CF 11-20


EXISTING BLDG AT BASEMENT
EXISTING BASEMENT
BASEMENT
M.S.F.N. BASEMENT FLOOR PLAN
EXIST. BLDG AT GROUND FLOOR
EXISTING GROUND FLOOR
PROPOSED M.S.F.N. WING
MECHANICAL EQUIPMENT
GROUND FLOOR PLAN
M.S.F.N. WING ADDITION
NORTH ELEVATION
SOUTH ELEVATION
SECTION A-A
GRAPHIC SCALES
EAST ELEVATION
WEST ELEVATION
FLOOR PLAN, SECTION & ELEVATIONS

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1966 ESTIMATES

APOLLO WING, CANBERRA DEEP SPACE FACILITY

AUTHORIZATION LINE ITEM: Various Locations

PROGRAM OFFICE FOR THE PROJECT: Office of Tracking and Data Acquisition

LOCATION OF PROJECT: Canberra, Australia

COGNIZANT NASA INSTALLATION: Jet Propulsion Laboratory

TYPE OF CONSTRUCTION PROJECT: New

FUNDING:

FY 1965 and Prior Years	$38,000
FY 1966 Estimate	510,000
Total Funding Through FY 1966	$548,000

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$510,000
New wing (first floor)	Sq. Ft.	4,600	$45.00	207,000
(basement)	Sq. Ft.	4,000	21.23	84,900
Utilities	LS	---	7,000	7,000
Engine generator	LS	---	91,700	91,700
Tunnel	LS	---	12,800	12,800
Site development	LS	---	3,200	3,200
Air conditioning	LS	---	103,400	103,400
Equipment	---	---	---	---
Design	---	---	---	---
Fallout Shelter (Not feasible)	---	---	---	None
		TOTAL		$510,000

PROJECT PURPOSE:

This project provides for the construction of a Manned Space Flight Network (MSFN) wing addition to the existing Control Building at the Deep Space Station, Canberra, Australia which will house electronic equipments to permit this antenna system to serve as the essential backup to the prime Apollo station at Canberra.

PROJECT DESCRIPTION:

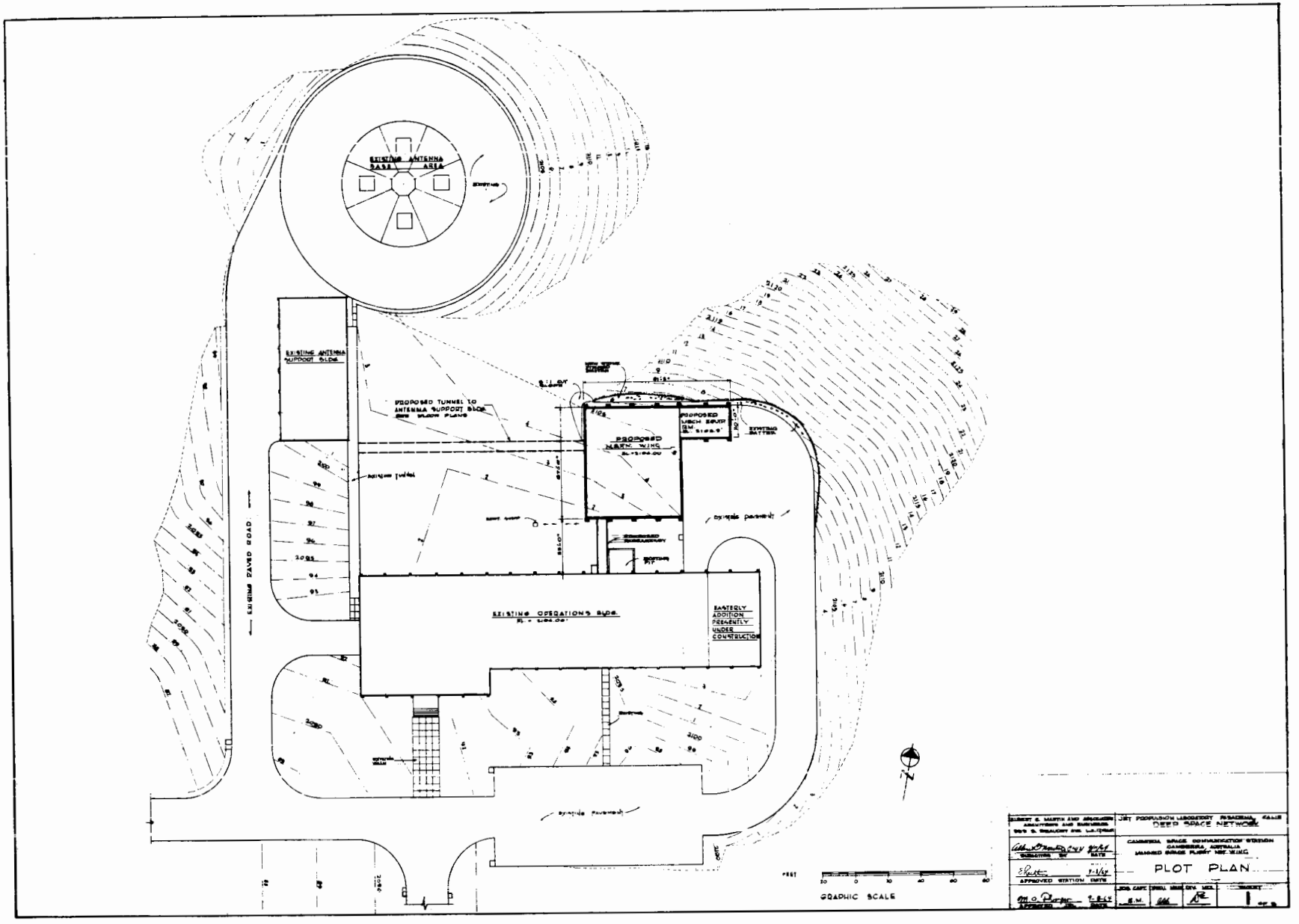
Exterior dimensions of the new wing are approximately 60 feet wide by 67 feet long. The building will consist of a basement area to serve as a raceway for equipment wiring and the air conditioning system plenum and a floor space of 4,000 square feet to contain the technical equipment. In addition, there will be a mechanical utility structure of approximately 600 square feet to house the required heating and air conditioning equipment for this wing.

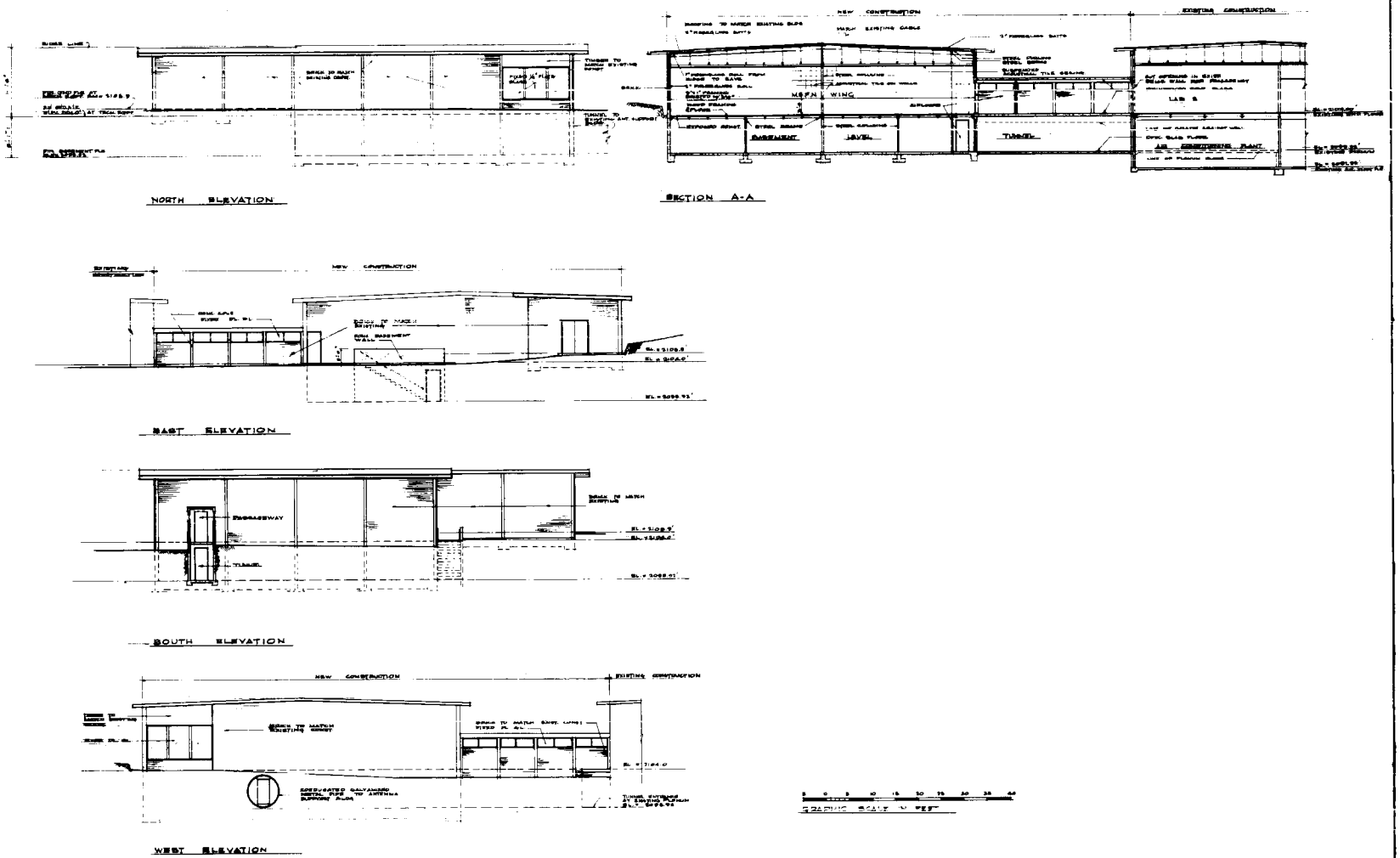
Architecturally, the addition will match the existing building.

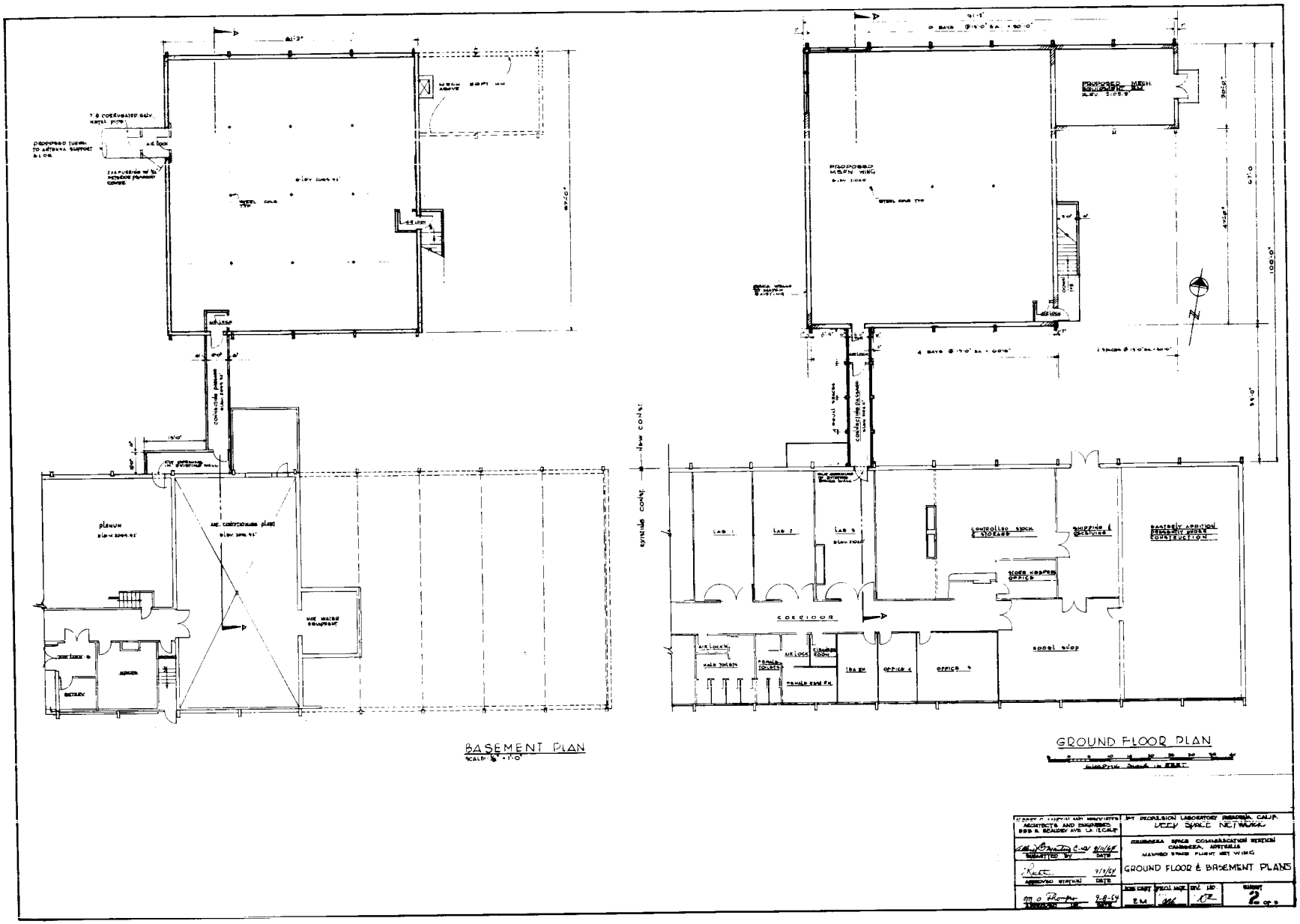
PROJECT JUSTIFICATION:

To support the lunar phases of the Apollo missions, three single , prime 85-foot antenna stations are required at locations around the world, separated by approximately 120° of longitude, in order to provide continual spatial coverage. These prime Apollo antennas have been co-located with the Deep Space facilities to achieve maximum cost savings and to provide, in the near vicinity, a backup capability essential for Apollo missions in the event of a failure or malfunction of the manned flight facility. To provide the deep space antenna with this capability, certain basic electronic equipment peculiar to Apollo support must be added to the station instrumentation. This equipment permits the transmission of data to the Apollo station for the major data handling and processing functions. The wing addition to the control building is required to house this equipment.

ESTIMATED FUTURE YEAR FUNDING FOR THIS PROJECT: None


EXISTING ANTENNA BASE AREA
EXISTING ANTENNA SUPPORT BLDG.
PROPOSED TUNNEL TO ANTENNA SUPPORT BLDG.
PROPOSED NEW WING
PROPOSED LIBCH SUPP BLDG
EXISTING BATTERY
EXISTING PAVED ROAD
EXISTING OPERATIONS BLDG.
EASTERLY ADDITION PRESENTLY UNDER CONSTRUCTION
GRAPHIC SCALE
FEET
20 0 20 40 60 80
GILBERT E. MARTIN AND ASSOCIATES
ARCHITECTS AND ENGINEERS
JET PROPULSION LABORATORY PASADENA, CALIF.
DEEP SPACE NETWORK
CANBERRA SPACE COMMUNICATION STATION
CANBERRA, AUSTRALIA
MANNED SPACE FLIGHT NEW WING
PLOT PLAN
DIRECTING BY
DATE
APPROVED STATION DATE
APPROVED DATE
JOB CAPT.
DRAWN
DIV.
SHEET 1 OF 9


NORTH ELEVATION
SECTION A-A
NEW CONSTRUCTION
EXISTING CONSTRUCTION
MAIN WING
BASEMENT
LEVEL
TUNNEL
LAB. 5
AIR CONDITIONING PLANT
EAST ELEVATION
SOUTH ELEVATION
FOOTBRIDGE WAY
WEST ELEVATION
GRAPHIC SCALE IN FEET
ARCHITECTS AND ENGINEERS
DEEP SPACE NETWORK
CANBERRA SPACE COMMUNICATION STATION
CANBERRA, AUSTRALIA
MANNED SPACE FLIGHT NET. WING
SECTION & ELEVATIONS
SUBMITTED BY
APPROVED STATION
APPROVED JPL
DATE
JOB CAPT.
DRW. NO.
REV. NO.
SHEET 3 OF 13


BASEMENT PLAN
GROUND FLOOR PLAN
PLENUM
AIR CONDITIONING PLANT
CORRIDOR
SHOP
OFFICE
LAB 1
LAB 2
LAB 3
CONTROLLED STORAGE
SHIPPING & RECEIVING
EASTERLY ADDITION
MANNED SPACE FLIGHT NET WING
GROUND FLOOR & BASEMENT PLANS
JET PROPULSION LABORATORY PASADENA, CALIF.
DEEP SPACE NETWORK
CANBERRA SPACE COMMUNICATION SECTION
CANBERRA, AUSTRALIA
ARCHITECTS AND ENGINEERS
2

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1966 ESTIMATES

STADAN FACILITY EXPANSION

AUTHORIZATION LINE ITEM: Various Locations

PROGRAM OFFICE FOR THE PROJECT: Office of Tracking and Data Acquisition

LOCATION OF PROJECT: Fairbanks, Alaska

COGNIZANT NASA INSTALLATION: Goddard Space Flight Center

TYPE OF CONSTRUCTION PROJECT: Extension and New

FUNDING:

FY 1965 and Prior Years	$83,000
FY 1966 Estimate	1,115,000
Total Funding Through FY 1966	$1,198,000

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$1,115,000
Operations building addition	Sq. Ft.	6,000	$64.00	384,000
Utility and storage building - new	Sq. Ft.	7,900	56.33	445,000
Special air conditioning for high heat loss equipment	LS	---	85,000	85,000
Switchgear and transformers	LS	---	57,000	57,000
Utilities	LS	---	44,000	44,000
Site preparation, paving and landscaping	LS	---	36,000	36,000
Electrical distribution	LS	---	64,000	64,000

	Unit of Measure	Quantity	Unit Cost	Total Cost
Equipment	---	---	---	---
Design	---	---	---	---
Fallout Shelter (Not feasible)	---	---	---	None
		TOTAL		$1,115,000

PROJECT PURPOSE:

This project provides for additional technical operations area, maintenance area, and high-quality magnetic tape storage area at the STADAN Alaska Station. The expansion of technical and support facilities at this station is required to permit the NASA 85-foot Data Acquisition Facility (DAF) to effectively support and accommodate major scientific and application satellite program equipment.

PROJECT DESCRIPTION:

This project provides the construction of a new Utility and Storage Building of approximately 7,900 square feet and an addition to the Operations and Telemetry Building of approximately 6,000 square feet of technical area. The building construction will conform to the architectural appearance of the existing structures. Air-conditioning and humidity-temperature controls will be installed to provide the environment necessary for efficient operation of electronic equipment in all required areas. An elevated floor system will be installed in areas where electronic equipment cableways are necessary. The materials used in construction of the buildings shall be of the sub-arctic type especially suited to the extreme temperature ranges of the locale.

PROJECT JUSTIFICATION:

The Alaska 85-foot station was the first major Data Acquisition Facility (DAF) constructed by NASA and was completed prior to the full growth of the flight programs it is now required to support. Equipment installations necessary to properly support major scientific observatory programs have not only fully utilized the limited technical area, but have extended beyond this area, at the expense of needed maintenance and storage space. Additional spacecraft control and command consoles and wideband data transmission equipments have been and will be required at this facility in support of the meteorological and scientific observatory programs. These equipments are essential to the control, monitoring, and performance evaluation of the spacecraft in addition to the spacecraft experiments.

The Utility and Storage Building is necessary to house and adequately accommodate a combined electronic and hydraulic maintenance, vehicle maintenance, and related storage areas in support of the Alaska Facility complex. This area is especially critical for mass storage of high quality magnetic telemetry and computer tapes. Extreme weather conditions in the area restrict maintenance operations during a great part of the year. It is necessary that proper facilities be available to permit minimum maintenance under any weather condition. Space is also provided to install the electronics of the Minitrack interferometer system which will be moved to the DAF location from College, Alaska, to further consolidate operations and maintenance.

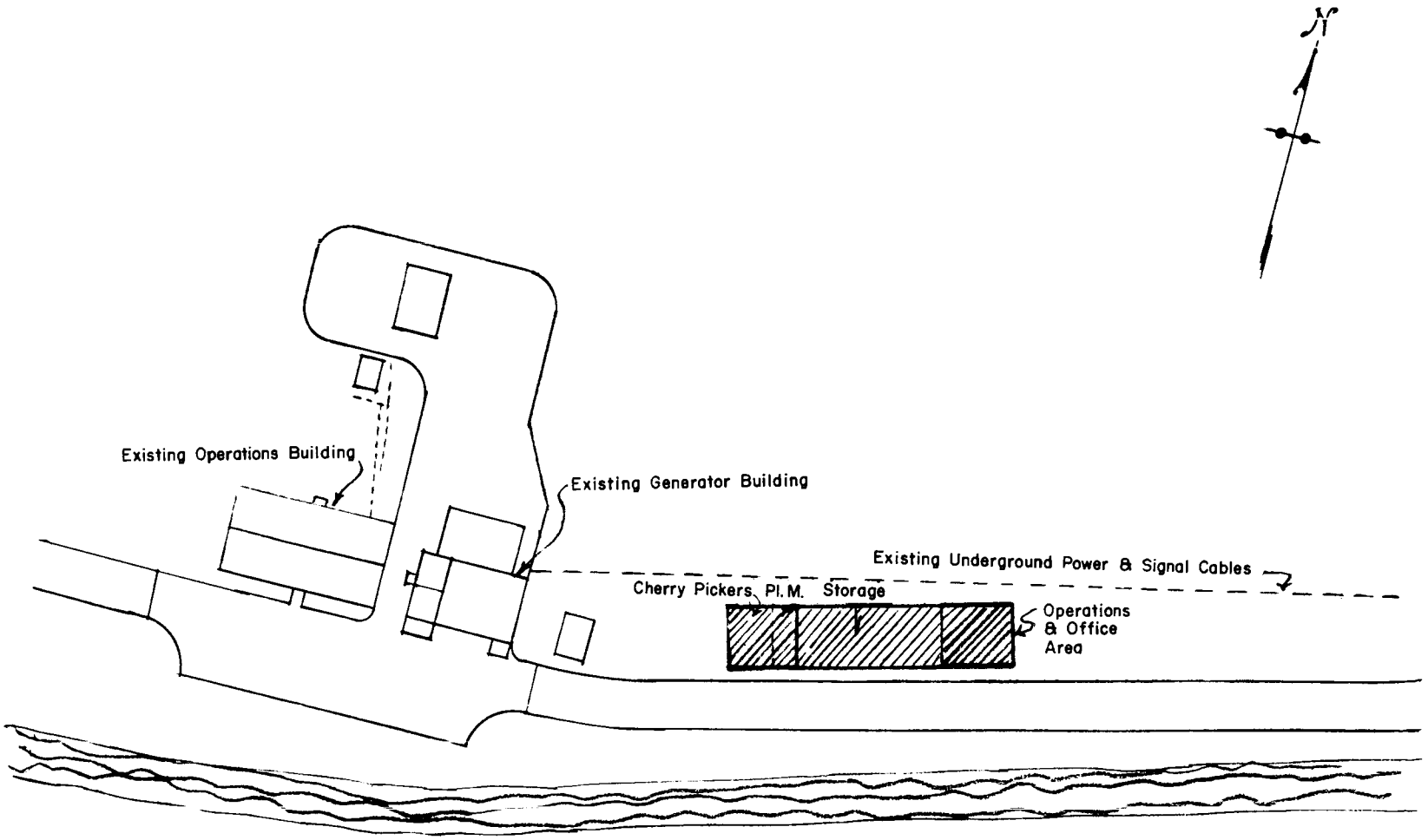
ESTIMATED FUTURE YEAR FUNDING FOR THIS PROJECT: None

VARIOUS LOCATIONS

FISCAL YEAR 1966 ESTIMATES

STADAN FACILITY, FAIRBANKS, ALASKA

STORAGE BUILDING



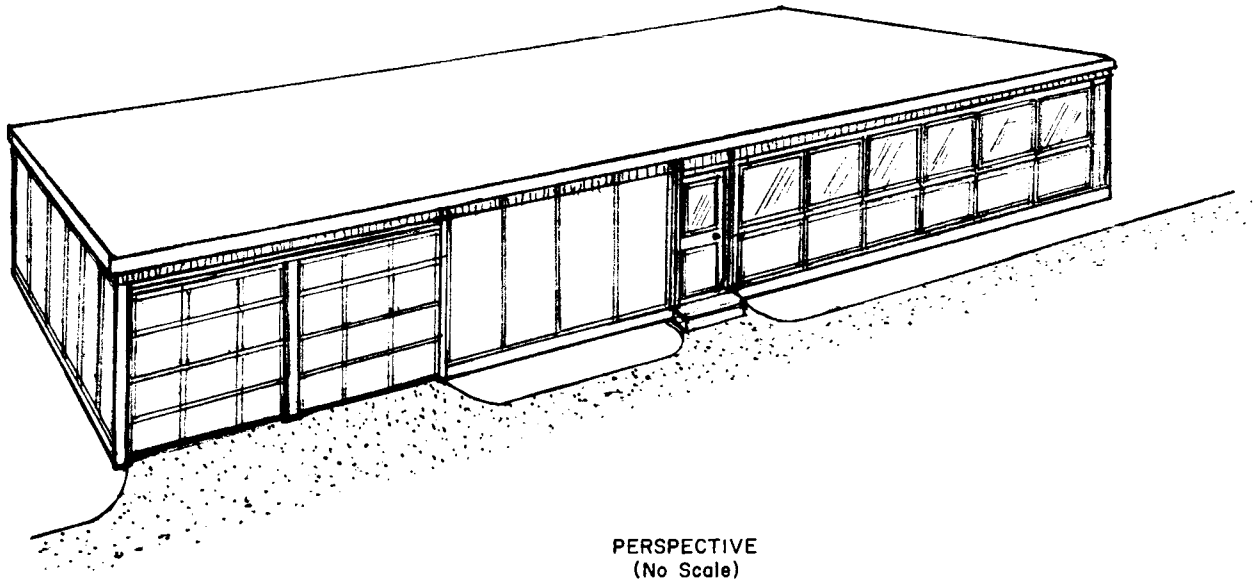
SITE PLAN
(No Scale)

VARIOUS LOCATIONS

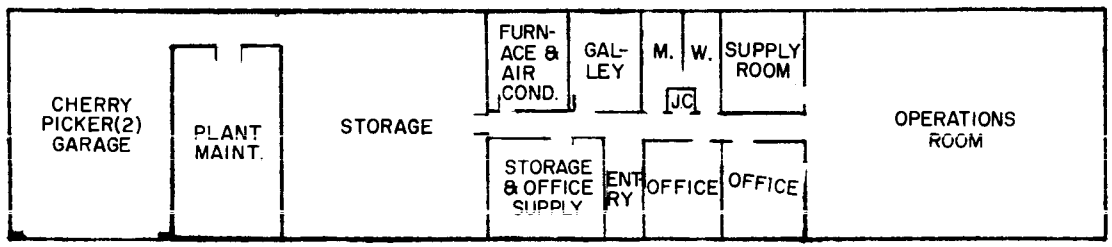
FISCAL YEAR 1966 ESTIMATES

STADAN FACILITY, FAIRBANKS, ALASKA

STORAGE BUILDING



PERSPECTIVE
(No Scale)



PLAN
Scale: 1" = 30'-0"

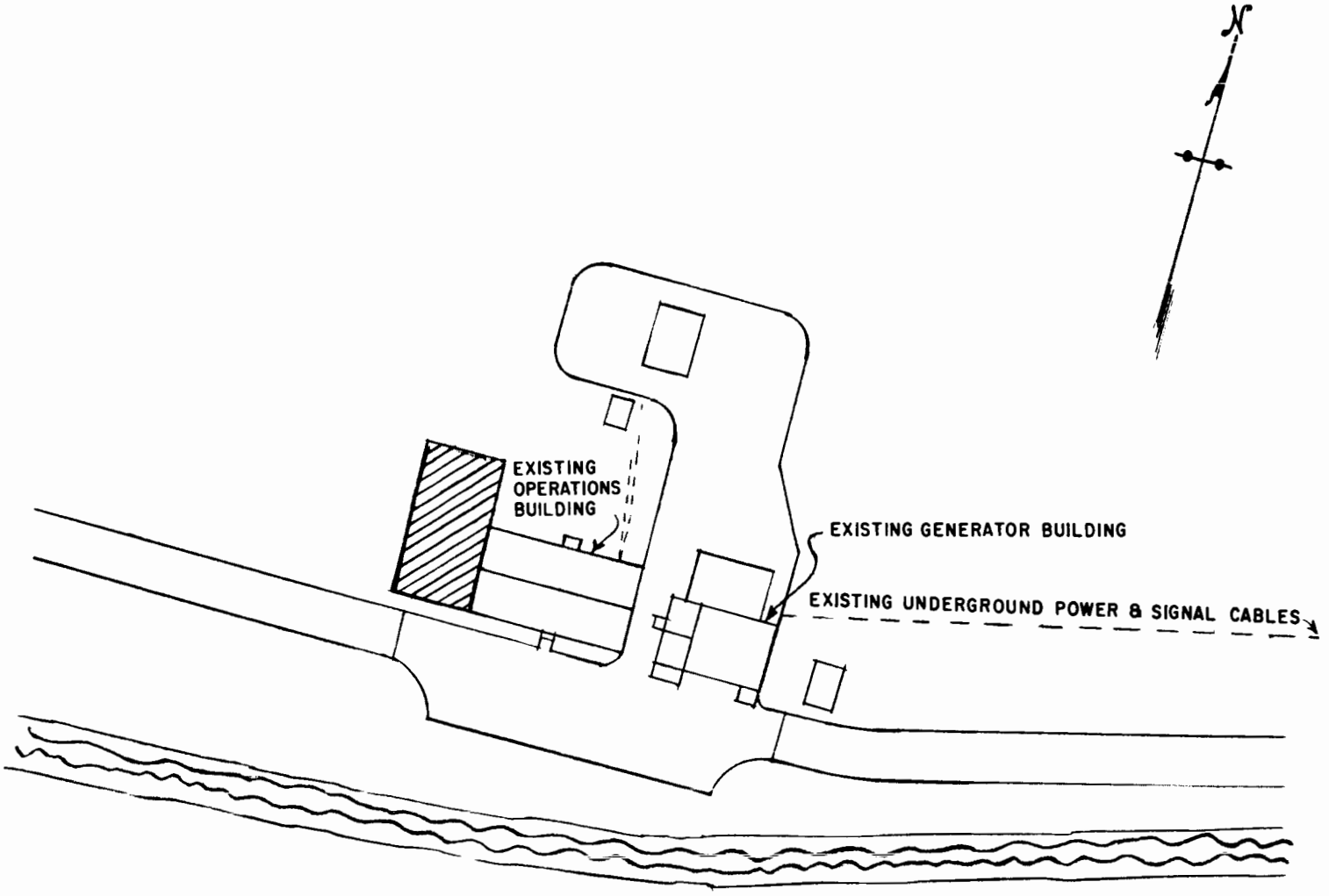
712-047 O - 65 - 2-4

VARIOUS LOCATIONS

FISCAL YEAR 1966 ESTIMATES

STADAN FACILITY, FAIRBANKS, ALASKA

ADDITION TO TELEMETRY BUILDING



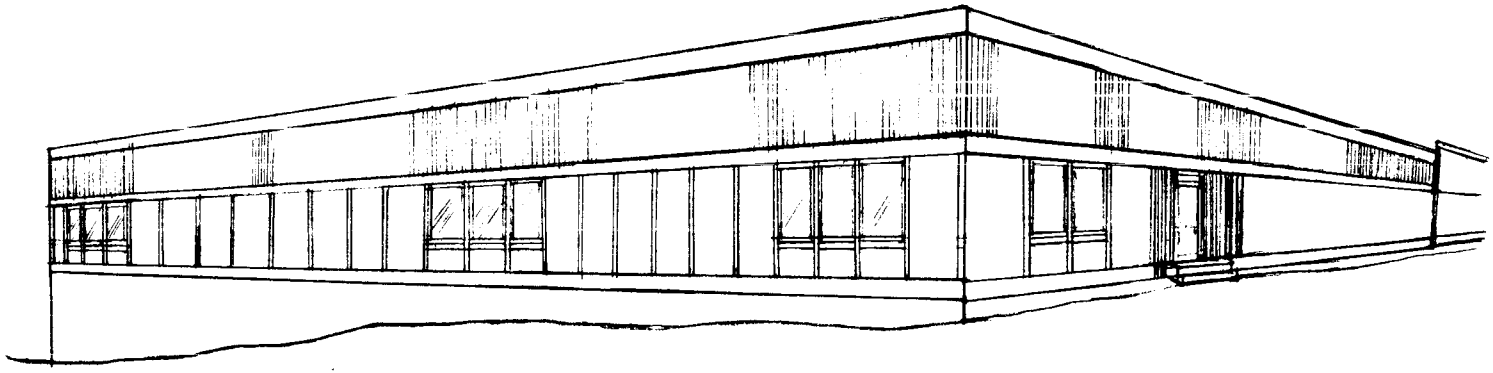
SITE PLAN
(No Scale)

VARIOUS LOCATIONS

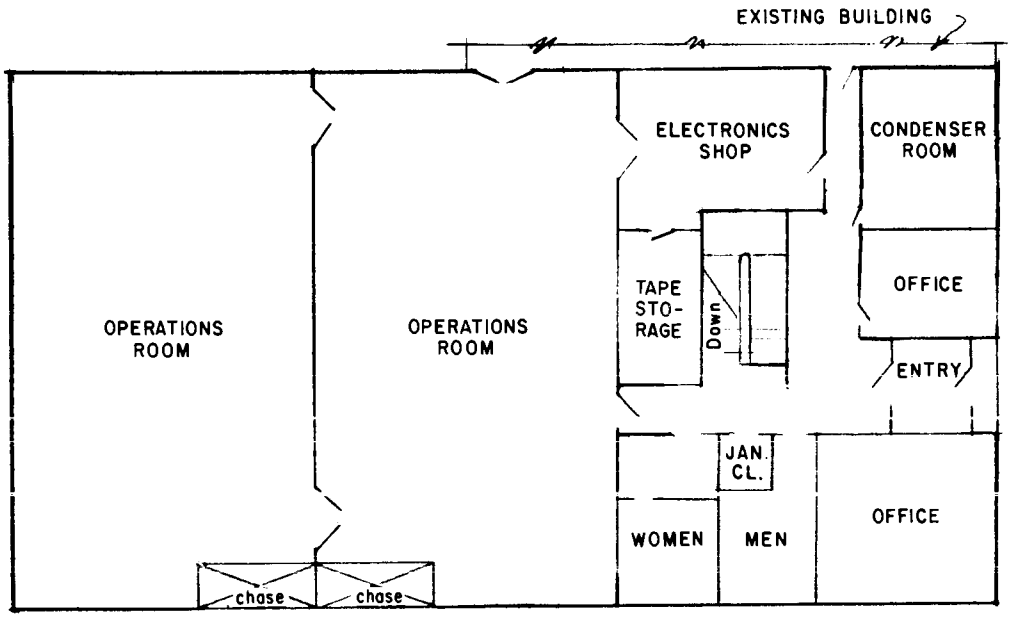
FISCAL YEAR 1966 ESTIMATES

STADAN FACILITY, FAIRBANKS, ALASKA

ADDITION TO TELEMETRY BUILDING



PERSPECTIVE
(No Scale)



PLAN
Scale: 1/16"=1'-0"

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1966 ESTIMATES

APOLLO NETWORK GROUND STATION

AUTHORIZATION LINE ITEM: Various Locations

PROGRAM OFFICE FOR THE PROJECT: Office of Tracking and Data Acquisition

LOCATION OF PROJECT: Antigua, West Indies

COGNIZANT NASA INSTALLATION: Goddard Space Flight Center

TYPE OF CONSTRUCTION PROJECT: New

FUNDING:

FY 1965 and Prior Years	$162,000
FY 1966 Estimate	2,700,000
Total Funding Through FY 1966	$2,862,000

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	Acre	40	$5,000	$200,000
Construction				$2,500,000
Instrumentation and operations building	Sq. Ft.	12,000	60	720,000
Generator building	Sq. Ft.	4,000	40	160,000
Collimation tower enclosure	LS	---	20,000	20,000
Generators, switchgear and transformers	LS	---	540,000	540,000
Utilities	LS	---	200,000	200,000
Fencing, roads, grading and landscaping	LS	---	125,000	125,000
Hydro-mechanical services	LS	---	40,000	40,000
Antenna and collimation tower foundations	LS	---	65,000	65,000
Collimation tower site grading and access roads	LS	---	100,000	100,000
Intra-site cable	LS	---	110,000	110,000

	Unit of Measure	Quantity	Unit Cost	Total Cost
Underground power and signal cables and electrical distribution	LS	---	$120,000	$120,000
Communications	LS	---	300,000	300,000
Equipment	---	---	---	---
Design	---	---	---	---
Fallout Shelter (Not feasible)	---	---	---	None
		TOTAL		$2,700,000

PROJECT PURPOSE:

This project provides for the construction of facilities required to install the Apollo S-Band System equipment at Antigua, West Indies, to support the orbital and lunar phases of the Apollo missions.

PROJECT DESCRIPTION:

The construction of an Operations Building and Generator Building (including generators, switchgear and transformers) is required. To support these structures and the antenna, site improvements including roads and grading, utility systems, and antenna and collimation tower foundations will be provided. Included in this project are funds for the acquisition of approximately 40 acres of land.

The Unified S-Band System, antenna and associated equipment for the Antigua Station, is being procured under prior year funding due to development and fabrication lead time involved.

PROJECT JUSTIFICATION:

The Apollo flight program requires continuous coverage during the launch and insertion phases into orbit and during orbital checkout prior to the injection phase of a lunar mission. In order to provide network support to these orbital and lunar missions, in the launch azimuths of 90 to 108 degrees, this station at Antigua, West Indies, is considered mandatory. This project provides the facilities for the installation of the necessary S-Band tracking, telemetry reception, updata transmission and air-to-ground voice communication equipment.

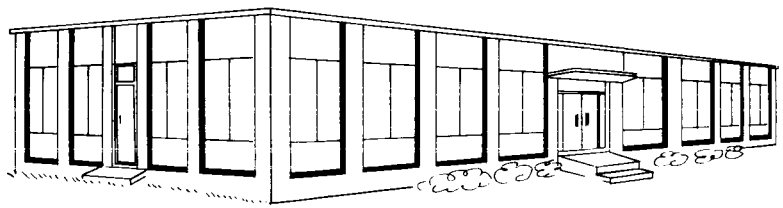
ESTIMATED FUTURE YEAR FUNDING FOR THIS PROJECT: None

VARIOUS LOCATIONS

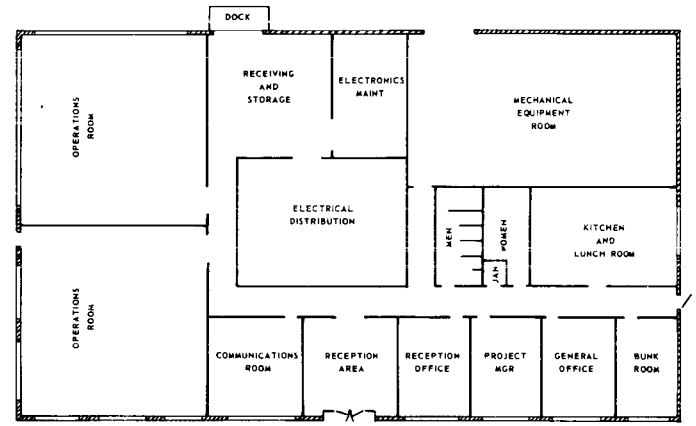
FISCAL YEAR 1966 ESTIMATES

APOLLO NETWORK GROUND STATION – ANTIGUA, W.I.

INSTRUMENTATION AND OPERATIONS BUILDING

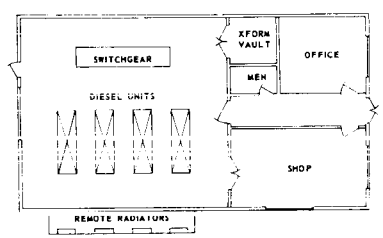


PERSPECTIVE

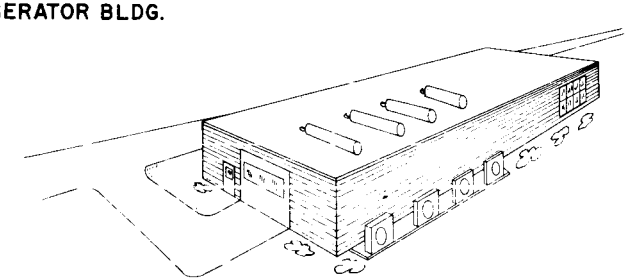


PLAN

DIESEL-GENERATOR BLDG.



PLAN



PERSPECTIVE

SCALE 0 10 50 FEET

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1966 ESTIMATES

COMMUNITY SUPPORT FACILITIES

AUTHORIZATION LINE ITEM: Various Locations

PROGRAM OFFICE FOR THE PROJECT: Office of Tracking and Data Acquisition

LOCATION OF PROJECT: Antigua, West Indies

COGNIZANT NASA INSTALLATION: Goddard Space Flight Center

TYPE OF CONSTRUCTION PROJECT: New

FUNDING:

FY 1965 and Prior Years	$210,000
FY 1966 Estimate	3,090,000
Total Funding Through FY 1966	$3,300,000

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction *				$3,090,000
Three (3) personnel buildings (officer-type quarters)	Sq. Ft.	18,000	$55.56	1,000,000
One (1) personnel building (quonset-type building)	Sq. Ft.	4,000	30.00	120,000
Modifications to existing mess facility	Sq. Ft.	3,000	40.00	120,000
Cafeteria equipment	LS	---	80,000	80,000
Dry and cold storage addition (mess hall)	Sq. Ft.	2,500	36.00	90,000
Refrigeration equipment	LS	---	40,000	40,000
Laundry building addition	Sq. Ft.	4,000	35.00	140,000
Laundry equipment	LS	---	60,000	60,000
Power building addition	Sq. Ft.	4,000	55.00	220,000
Diesel generator	LS	---	70,000	70,000

	Unit of Measure	Quantity	Unit Cost	Total Cost
Diesel storage tank (150,000 gallon) including sitework, fencing, piping	LS	---	100,000	100,000
Water storage tanks, pumping stations and associated piping	LS	---	60,000	60,000
Sanitary and storm sewers	LS	---	70,000	70,000
General storage building	Sq. Ft.	4,800	37.50	180,000
Vehicle maintenance bldg. modifications	Sq. Ft.	1,600	31.25	50,000
Vehicle maintenance equipment	LS	---	25,000	25,000
Dispensary addition	Sq. Ft.	1,500	40.00	60,000
Dispensary equipment	LS	---	40,000	40,000
Recreation facilities addition	LS	---	150,000	150,000
Electrical distribution	LS	---	250,000	250,000
Site preparation and roads	LS	---	165,000	165,000
Equipment	---	---	---	---
*Design	---	---	---	---
Fallout Shelter (Not feasible)	---	---	---	None
		TOTAL		$3,090,000

*The square foot and other construction costs are in conformance with previous construction agency (Navy) experience of construction on Antigua, West Indies.

PROJECT PURPOSE:

This project will provide for the construction of adequate community support facilities on the Island of Antigua to house and support the personnel of the Apollo Network Ground Station. These facilities augment the existing Air Force community.

PROJECT DESCRIPTION:

Community support facilities to be constructed consist of three (3) officer-type Barracks, a General Storage Building, additional Mess facilities, a Power Building addition, Water Storage tanks, Dispensary addition, and additional recreational facilities. Construction will be similar to the existing Air Base community facilities.

PROJECT JUSTIFICATION:

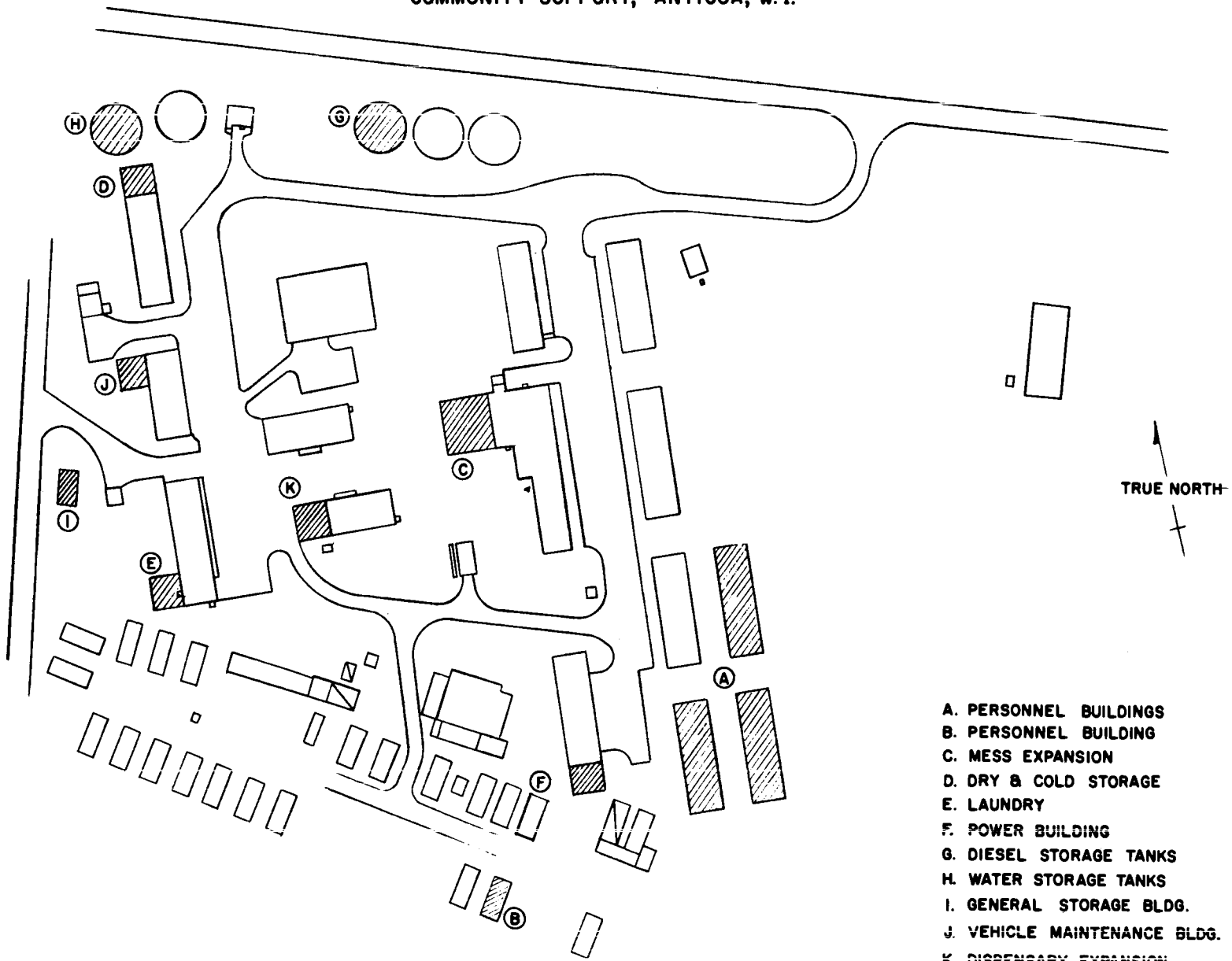
The Island of Antigua does not contain a population center adequate to house and support the Manned Space Flight Station personnel. The existing facilities located on the leased Coolidge Air Force Base are not adequate to support additional personnel. The construction of community support facilities is therefore required to support both the permanent and temporary duty personnel who will operate the Manned Space Flight Station.

ESTIMATED FUTURE YEAR FUNDING FOR THIS PROJECT: None

VARIOUS LOCATIONS

FISCAL YEAR 1966 ESTIMATES

COMMUNITY SUPPORT, ANTIGUA, W. I.

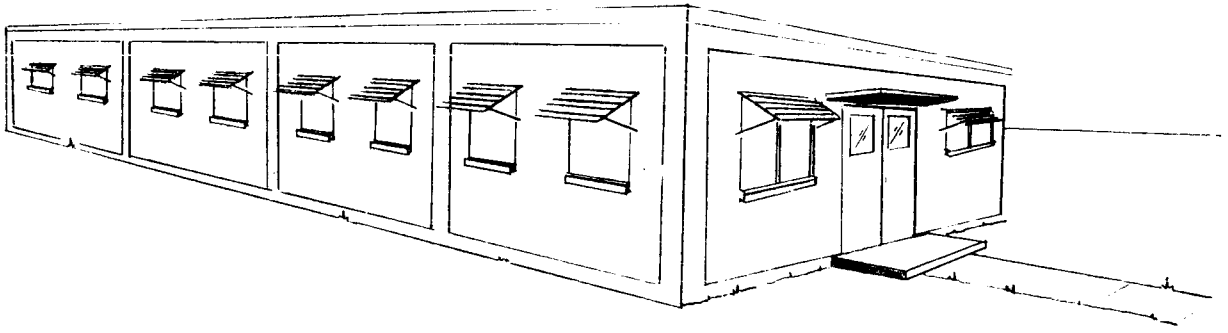


A. PERSONNEL BUILDINGS
B. PERSONNEL BUILDING
C. MESS EXPANSION
D. DRY & COLD STORAGE
E. LAUNDRY
F. POWER BUILDING
G. DIESEL STORAGE TANKS
H. WATER STORAGE TANKS
I. GENERAL STORAGE BLDG.
J. VEHICLE MAINTENANCE BLDG.
K. DISPENSARY EXPANSION

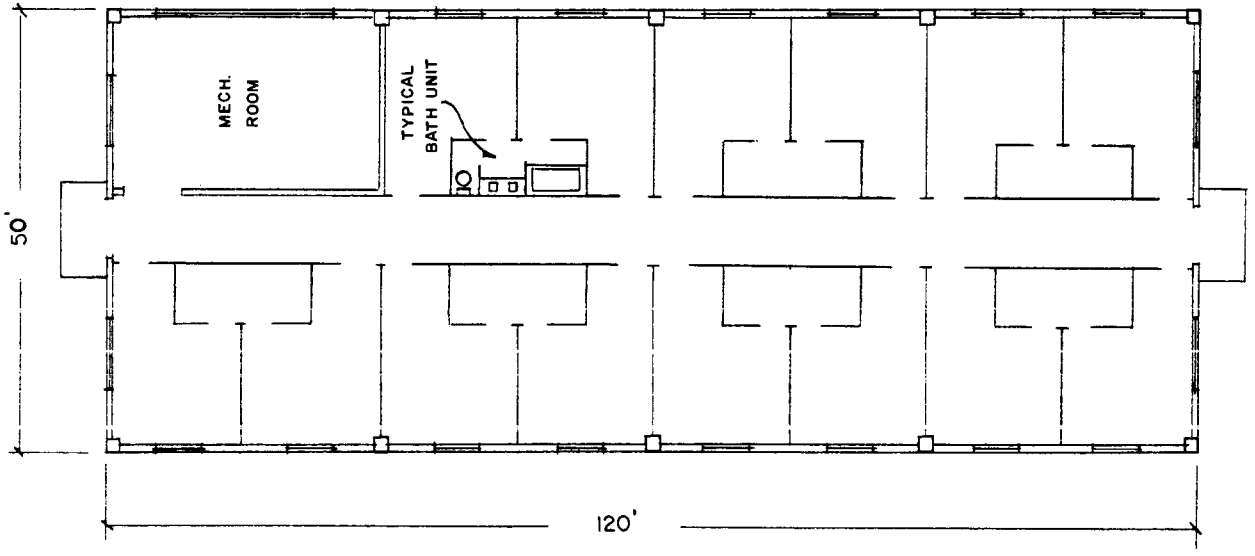
VARIOUS LOCATIONS
FISCAL YEAR 1966 ESTIMATES

COMMUNITY SUPPORT, ANTIGUA, W. I.

PERSONNEL QUARTERS



PERSPECTIVE



PLAN

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1966 ESTIMATES

APOLLO NETWORK GROUND STATION

AUTHORIZATION LINE ITEM: Various Locations

PROGRAM OFFICE FOR THE PROJECT: Office of Tracking and Data Acquisition

LOCATION OF PROJECT: Grand Canary Island

COGNIZANT NASA INSTALLATION: Goddard Space Flight Center

TYPE OF CONSTRUCTION PROJECT: New and Extension

FUNDING:

FY 1965 and Prior Years	$120,000
FY 1966 Estimate	7,674,000
Total Funding Through FY 1966	$7,794,000

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$1,474,000
Unified S-band antenna operations building	Sq. Ft.	5,600	$33.04	185,000
Addition to existing telemetry building	Sq. Ft.	3,000	33.00	99,000
Raised floor system	Sq. Ft.	6,100	10.00	61,000
Generator building	Sq. Ft.	5,100	26.08	133,000
Hydro-mechanical building	Sq. Ft.	500	26.00	13,000
Generators, switchgear and transformers	LS	---	367,000	367,000
Utilities	LS	---	18,000	18,000
Site preparation, roads and fencing	LS	---	203,000	203,000
Electrical distribution and signal cabling	LS	---	350,000	350,000
Antenna foundations	LS	---	45,000	45,000

	Unit of Measure	Quantity	Unit Cost	Total Cost
Equipment				$6,200,000
Unified S-band 30 ft. antenna	Each	1	$1,250,000	1,250,000
Unified S-band Apollo unique electronics	LS	---	255,000	255,000
Optical package	LS	---	30,000	30,000
Frequency standard	Each	1	50,000	50,000
TLM data processor	Each	1	400,000	400,000
TV monitor	Each	1	8,000	8,000
DCS data processor/encoder/ modulator	LS	---	600,000	600,000
Systems consoles	Each	7	114,200	800,000
Group display	Each	1	100,000	100,000
Recorders	Each	3	84,300	253,000
Receiver and transmitter subsystems	LS	---	730,000	730,000
Ranging subsystem	LS	---	100,000	100,000
Test transponders	Each	2	50,000	100,000
Communications	LS	---	370,000	370,000
Spare parts	LS	---	454,000	454,000
Shipping, installation, integration and checkout	LS	---	700,000	700,000
Design	---	---	---	---
Fallout Shelter (Not feasible)	---	---	---	None
		TOTAL		$7,674,000

PROJECT PURPOSE:

This project provides for the facility construction and the electronic equipment necessary to provide the Grand Canary Island manned flight station (now configured to support Gemini) with the full Apollo S-band capability for supporting the Apollo missions beginning in the third Quarter of Calendar Year 1967.

PROJECT DESCRIPTION:

The project provides the Apollo S-band system to fulfull the requirements of the Apollo orbital missions, and the facilities to accommodate the antenna and associated electronics.

Facilities required include an Antenna Operations Building, Power Building (with generators and switchgear), Hydro-Mechanical Building, and an expansion to the existing Telemetry Building. Also included are Antenna and

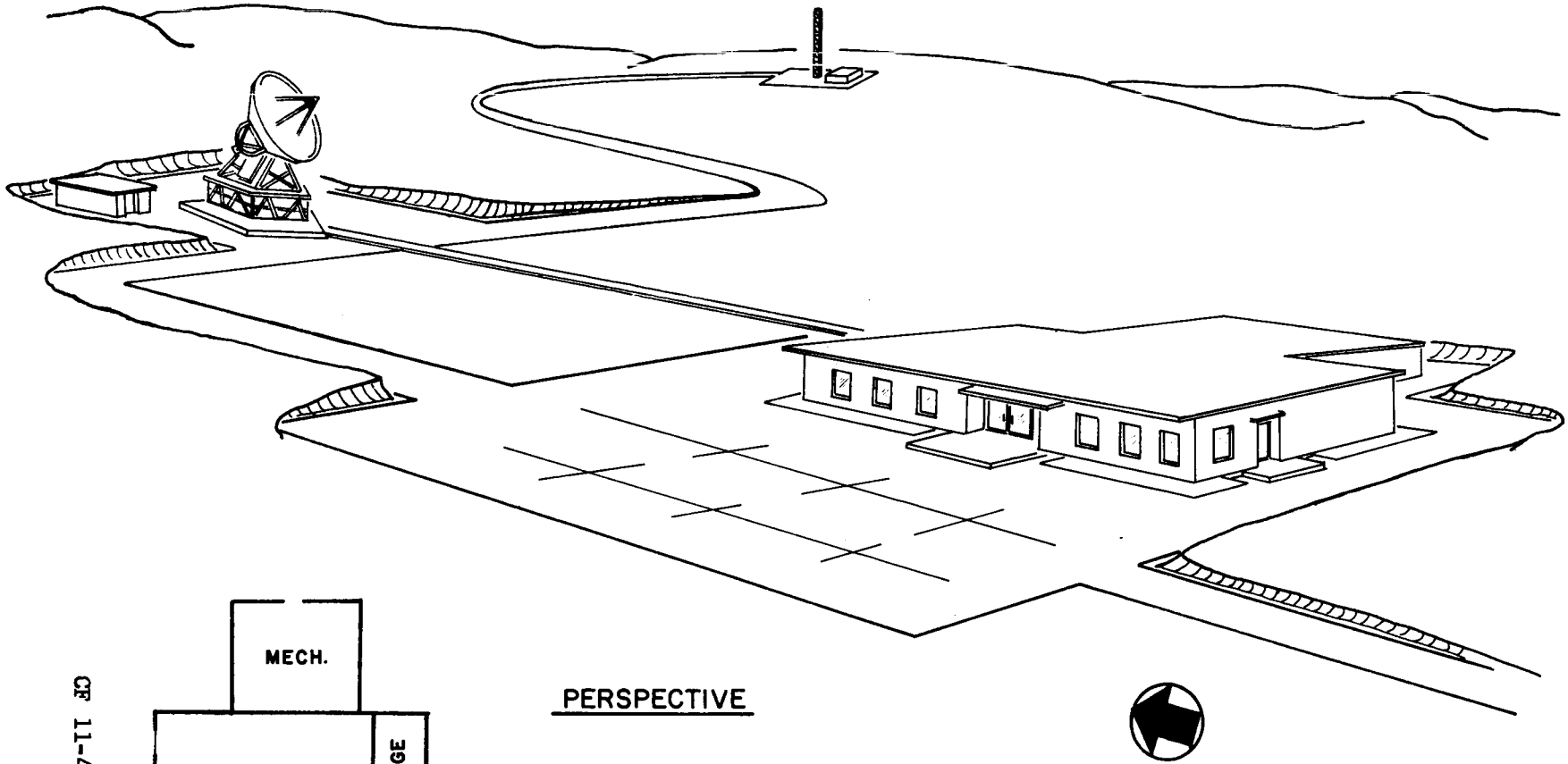
Collimation Tower foundations, sitework, roads and necessary utilities.

PROJECT JUSTIFICATION:

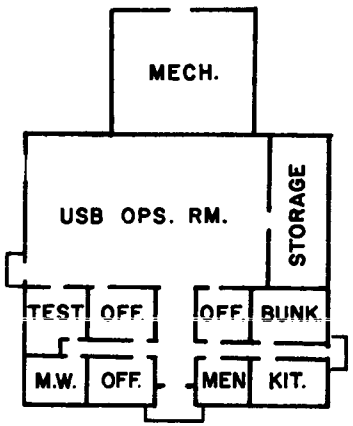
As a result of the normal and progressive refinement of Apollo flight program definition, the requirements on either an individual station or on network coverage may be altered. As a recent result of this process, it has been determined that ground support to the spacecraft for verification of orbital injection parameters on launch azimuths of 72 to 80 degrees and landing information for a sub-orbital abort, must be provided. In order to support these requirements, full Apollo S-band coverage from Grand Canary is necessary. The present station is configured solely for Gemini support. This limited capability is not adequate to meet the new Apollo requirements. Consequently, additional facilities and equipments are required to provide tracking, telemetry, updata transmission and air-to-ground voice communications to and from the Apollo spacecraft.

ESTIMATED FUTURE YEAR FUNDING FOR THIS PROJECT: None

VARIOUS LOCATIONS,
FISCAL YEAR 1966 ESTIMATES.
APOLLO NETWORK GROUND STATION,
GRAND CANARY ISLANDS



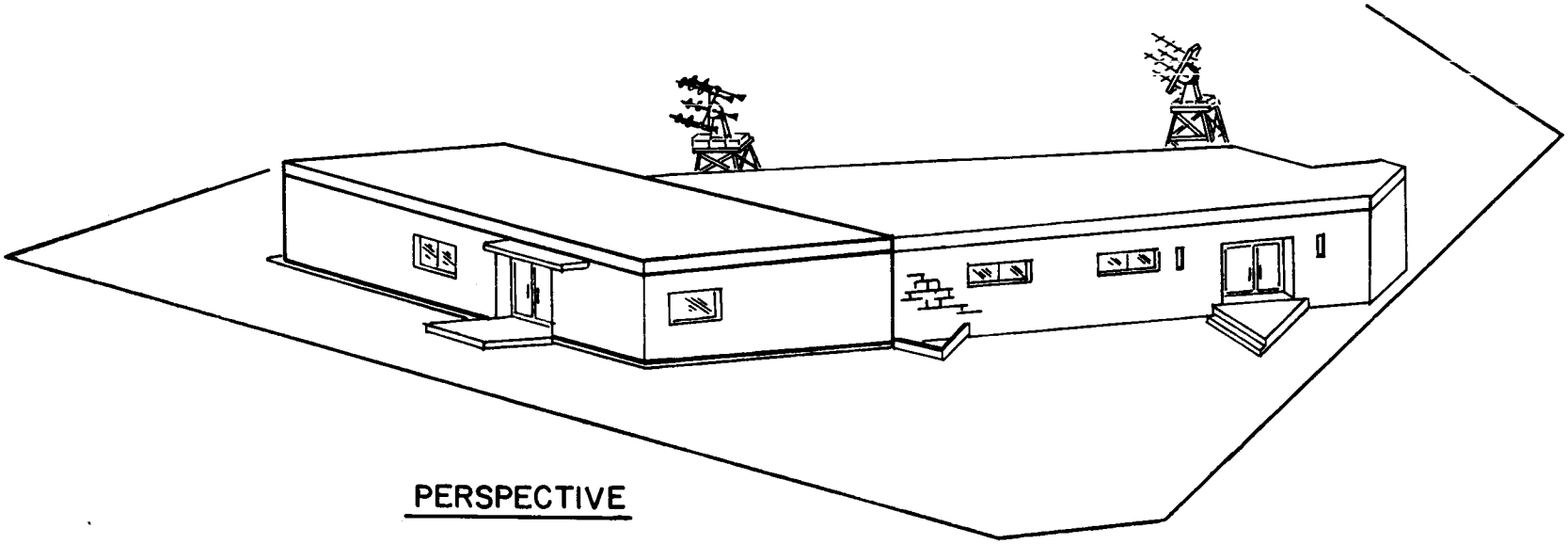
PERSPECTIVE



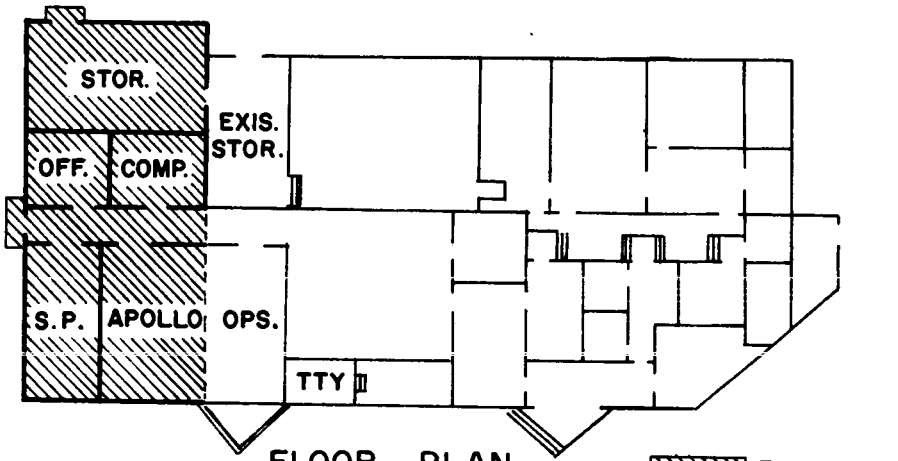
FLOOR PLAN
SCALE: 1" = 40'

APOLLO - UNIFIED S-BAND FACILITY

VARIOUS LOCATIONS,
FISCAL YEAR 1966 ESTIMATES.
APOLLO NETWORK GROUND STATION,
GRAND CANARY ISLANDS



PERSPECTIVE



FLOOR PLAN
SCALE: 1" = 40'

EXPANSION

T & C BUILDING EXPANSION

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1966 ESTIMATES

FACILITY PLANNING AND DESIGN

	Page No.
Summary	CF 13-1
Office of the Associate Administrator (NASA General)	
Facility planning and design	CF 13-2

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 19 66 BUDGET ESTIMATES

(Dollars in thousands)

NASA INSTALLATION	COGNIZANT PROGRAM OFFICE FOR INSTALLATION	LOCATION OF INSTALLATION	COUNTY	NEAREST CITY
All	Office of Associate Administrator	---	---	---

INSTALLATION MISSION

See Justification.

PERSONNEL STRENGTH	FY 19	FY 19	FY 19
NASA PERSONNEL *(End of Year)*			
CONTRACTOR AND OTHER PERSONNEL			
TOTAL ALL PERSONNEL	Not Applicable		

LAND	NO. ACRES
NASA-OWNED	
OTHER GOVERNMENT AGENCY-OWNED	
NON-FEDERAL *(Leases, easements)*	
TOTAL LAND	
TOTAL CAPITAL INVESTMENT *(Including NASA-Owned Land) (as of June 30, 19)*	$

PROJECT LINE ITEM	COGNIZANT OFFICE	FY 19 62 THRU CURRENT YEAR	FY 19 *(Estimated)*	FUTURE YEARS *(Estimated)*	TOTAL ALL YEARS *(Estimated)*
Facility Planning and Design	AA	$43,937.0	$7,500.0	Not Applicable	Not Applicable
ALL OTHER PROJECTS					
TOTALS		1/ ($43,937.0)	$7,500.0		

NASA FORM 1029 (REV. NOV 64) PREVIOUS EDITIONS ARE OBSOLETE.

1/ This amount is "non-add"; has been distributed in the appropriate installation summary sheets.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1966 ESTIMATES

FACILITY PLANNING AND DESIGN

AUTHORIZATION LINE ITEM: **Facility Planning and Design**

PROGRAM OFFICE: Office of the Associate Administrator (NASA General)

FUNDING:

FY 1965 and Prior Years	$43,937,000
FY 1966 Estimate	7,500,000
Total Funding Through FY 1966	$51,437,000

DESCRIPTION:

The funds requested under this item are required for advanced facility planning and design on projects for which construction funds may be requested in subsequent budgets.

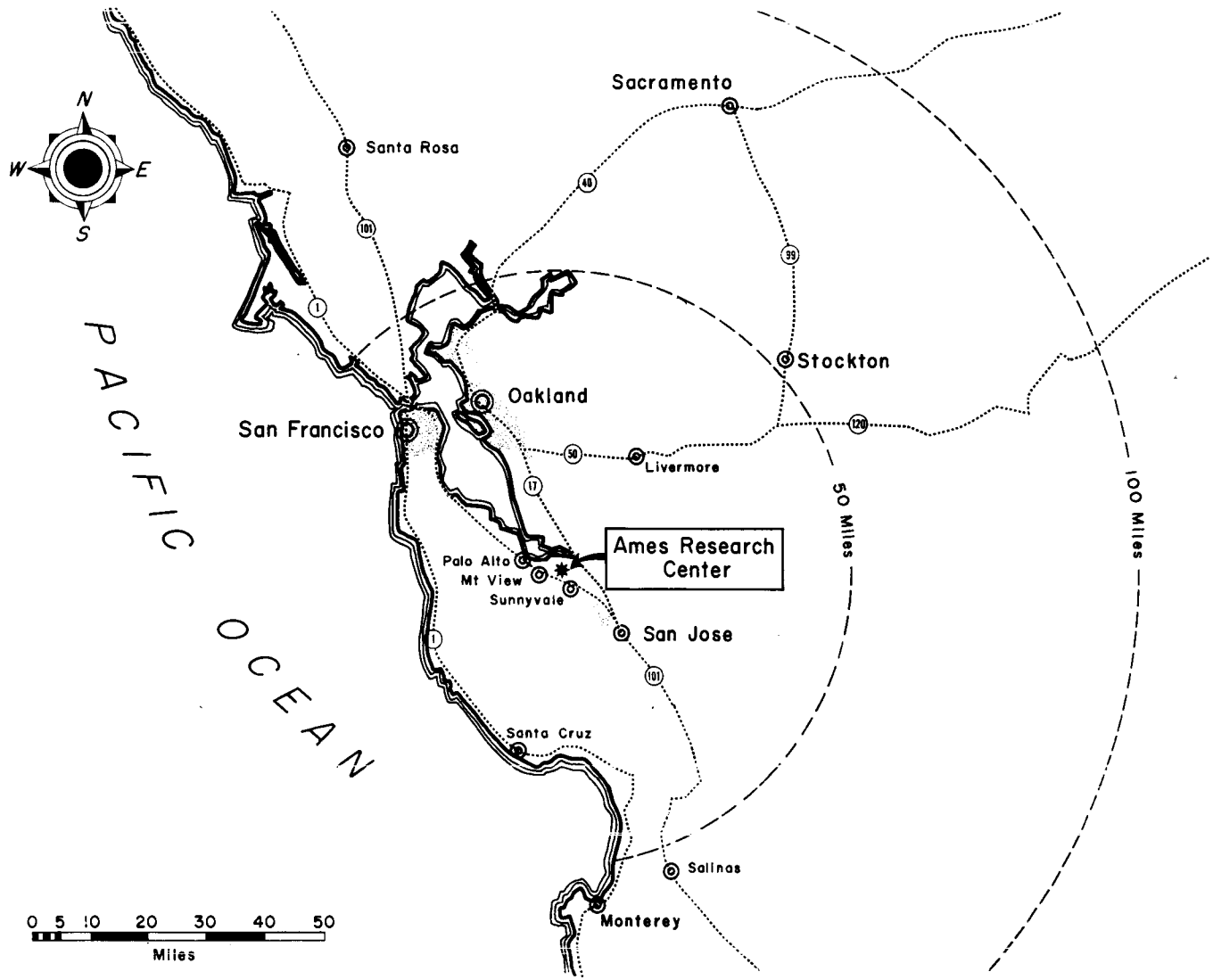
JUSTIFICATION:

Long-range plans in several program areas must anticipate the need for the construction of facilities beyond the budget year for which estimates are being submitted. A considerable saving in time and an increase in the accuracy of construction cost estimates is possible with the availability of a facility planning and design fund which can be used to initiate the design of high-priority facilities prior to the enactment of project authorization and the appropriation of funds.

With these funds, NASA will continue as an on-going and continuing activity the general activity of facility planning and design of future construction projects which have not as yet been authorized or for which appropriations have not been made. NASA will also continue to make special project studies, feasibility studies, and other studies necessary to develop and improve overall criteria and standards for the design and construction of facilities.

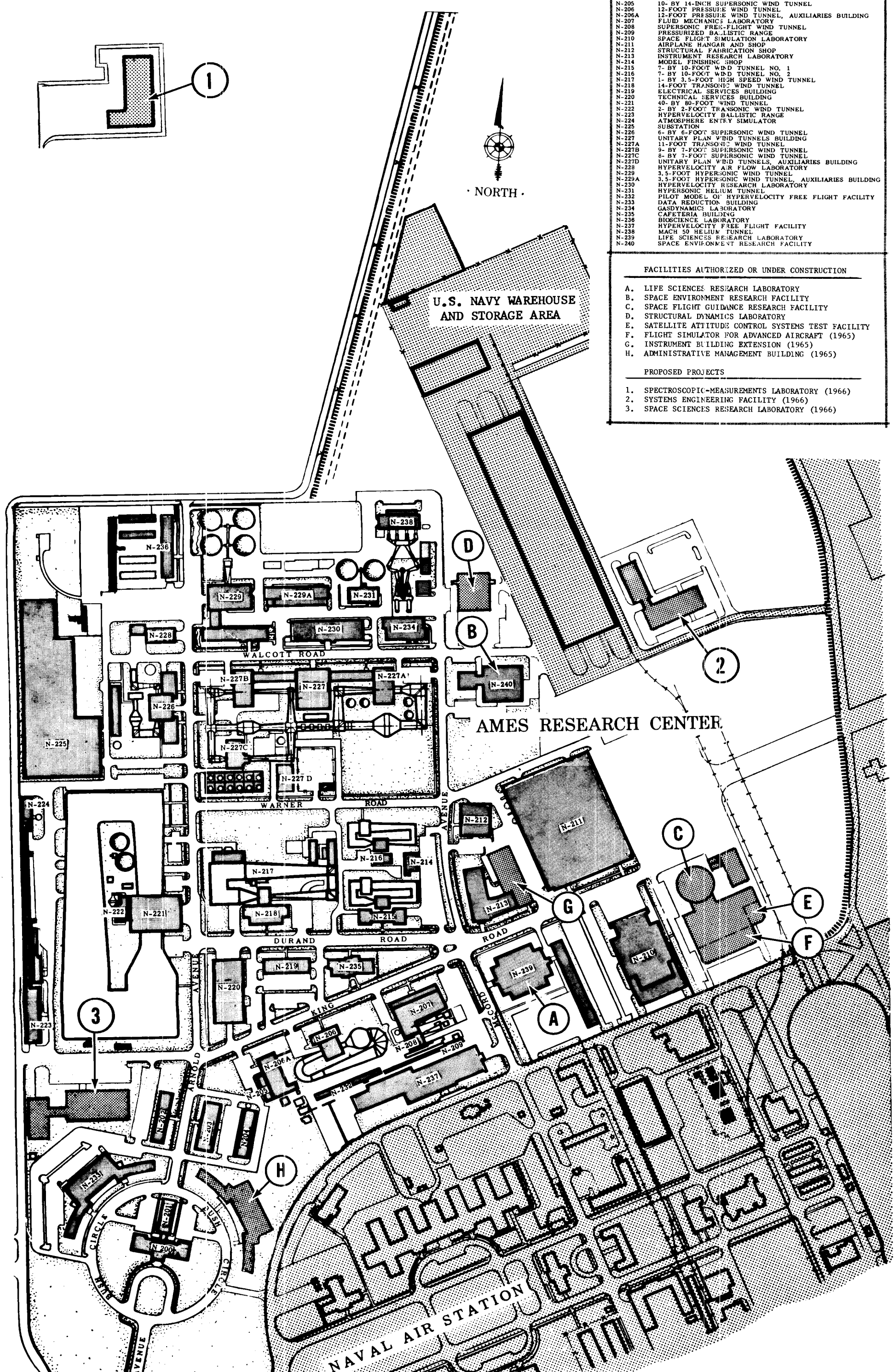
AMES RESEARCH CENTER
FISCAL YEAR 1966 ESTIMATES

VICINITY MAP



AMES RESEARCH CENTER
FISCAL YEAR 1966 ESTIMATES

LOCATION PLAN



LEGEND

N-200	ADMINISTRATION BUILDING
N-201	AUDITORIUM
N-202	ADMINISTRATION BUILDING ANNEX
N-203	ENGINEERING SERVICES BUILDING
N-204	SPACE TECHNOLOGY BUILDING
N-205	10- BY 14-INCH SUPERSONIC WIND TUNNEL
N-206	12-FOOT PRESSURE WIND TUNNEL
N-206A	12-FOOT PRESSURE WIND TUNNEL, AUXILIARIES BUILDING
N-207	FLUID MECHANICS LABORATORY
N-208	SUPERSONIC FREE-FLIGHT WIND TUNNEL
N-209	PRESSURIZED BALLISTIC RANGE
N-210	SPACE FLIGHT SIMULATION LABORATORY
N-211	AIRPLANE HANGAR AND SHOP
N-212	STRUCTURAL FABRICATION SHOP
N-213	INSTRUMENT RESEARCH LABORATORY
N-214	MODEL FINISHING SHOP
N-215	7- BY 10-FOOT WIND TUNNEL NO. 1
N-216	7- BY 10-FOOT WIND TUNNEL NO. 2
N-217	1- BY 3.5-FOOT HIGH SPEED WIND TUNNEL
N-218	14-FOOT TRANSONIC WIND TUNNEL
N-219	ELECTRICAL SERVICES BUILDING
N-220	TECHNICAL SERVICES BUILDING
N-221	40- BY 80-FOOT WIND TUNNEL
N-222	2- BY 2-FOOT TRANSONIC WIND TUNNEL
N-223	HYPERVELOCITY BALLISTIC RANGE
N-224	ATMOSPHERE ENTRY SIMULATOR
N-225	SUBSTATION
N-226	6- BY 6-FOOT SUPERSONIC WIND TUNNEL
N-227	UNITARY PLAN WIND TUNNELS BUILDING
N-227A	11-FOOT TRANSONIC WIND TUNNEL
N-227B	9- BY 7-FOOT SUPERSONIC WIND TUNNEL
N-227C	8- BY 7-FOOT SUPERSONIC WIND TUNNEL
N-227D	UNITARY PLAN WIND TUNNELS, AUXILIARIES BUILDING
N-228	HYPERVELOCITY AIR FLOW LABORATORY
N-229	3.5-FOOT HYPERSONIC WIND TUNNEL
N-229A	3.5-FOOT HYPERSONIC WIND TUNNEL, AUXILIARIES BUILDING
N-230	HYPERVELOCITY RESEARCH LABORATORY
N-231	HYPERSONIC HELIUM TUNNEL
N-232	PILOT MODEL OF HYPERVELOCITY FREE FLIGHT FACILITY
N-233	DATA REDUCTION BUILDING
N-234	GASDYNAMICS LABORATORY
N-235	CAFETERIA BUILDING
N-236	BIOSCIENCE LABORATORY
N-237	HYPERVELOCITY FREE FLIGHT FACILITY
N-238	MACH 50 HELIUM TUNNEL
N-239	LIFE SCIENCES RESEARCH LABORATORY
N-240	SPACE ENVIRONMENT RESEARCH FACILITY

FACILITIES AUTHORIZED OR UNDER CONSTRUCTION

A. LIFE SCIENCES RESEARCH LABORATORY
B. SPACE ENVIRONMENT RESEARCH FACILITY
C. SPACE FLIGHT GUIDANCE RESEARCH FACILITY
D. STRUCTURAL DYNAMICS LABORATORY
E. SATELLITE ATTITUDE CONTROL SYSTEMS TEST FACILITY
F. FLIGHT SIMULATOR FOR ADVANCED AIRCRAFT (1965)
G. INSTRUMENT BUILDING EXTENSION (1965)
H. ADMINISTRATIVE MANAGEMENT BUILDING (1965)

PROPOSED PROJECTS

1. SPECTROSCOPIC-MEASUREMENTS LABORATORY (1966)
2. SYSTEMS ENGINEERING FACILITY (1966)
3. SPACE SCIENCES RESEARCH LABORATORY (1966)

AMES RESEARCH CENTER
FISCAL YEAR 1966 ESTIMATES

LOCATION PLAN

LEGEND	
N-200	ADMINISTRATION BUILDING
N-201	AUDITORIUM
N-202	ADMINISTRATION BUILDING ANNEX
N-203	ENGINEERING SERVICES BUILDING
N-204	SPACE TECHNOLOGY BUILDING
N-205	10- BY 14-INCH SUPERSONIC WIND TUNNEL
N-206	12-FOOT PRESSURE WIND TUNNEL
N-206A	12-FOOT PRESSURE WIND TUNNEL, AUXILIARIES BUILDING
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N-208	SUPERSONIC FREE-FLIGHT WIND TUNNEL
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N-213	INSTRUMENT RESEARCH LABORATORY
N-214	MODEL FINISHING SHOP
N-215	7- BY 10-FOOT WIND TUNNEL NO. 1
N-216	7- BY 10-FOOT WIND TUNNEL NO. 2
N-217	1- BY 3.5-FOOT HIGH SPEED WIND TUNNEL
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N-220	TECHNICAL SERVICES BUILDING
N-221	40- BY 80-FOOT WIND TUNNEL
N-222	2- BY 2-FOOT TRANSONIC WIND TUNNEL
N-223	HYPERVELOCITY BALLISTIC RANGE
N-224	ATMOSPHERE ENTRY SIMULATOR
N-225	SUBSTATION
N-226	6- BY 6-FOOT SUPERSONIC WIND TUNNEL
N-227	UNITARY PLAN WIND TUNNELS BUILDING
N-227A	11-FOOT TRANSONIC WIND TUNNEL
N-227B	9- BY 7-FOOT SUPERSONIC WIND TUNNEL
N-227C	8- BY 7-FOOT SUPERSONIC WIND TUNNEL
N-227D	UNITARY PLAN WIND TUNNELS, AUXILIARIES BUILDING
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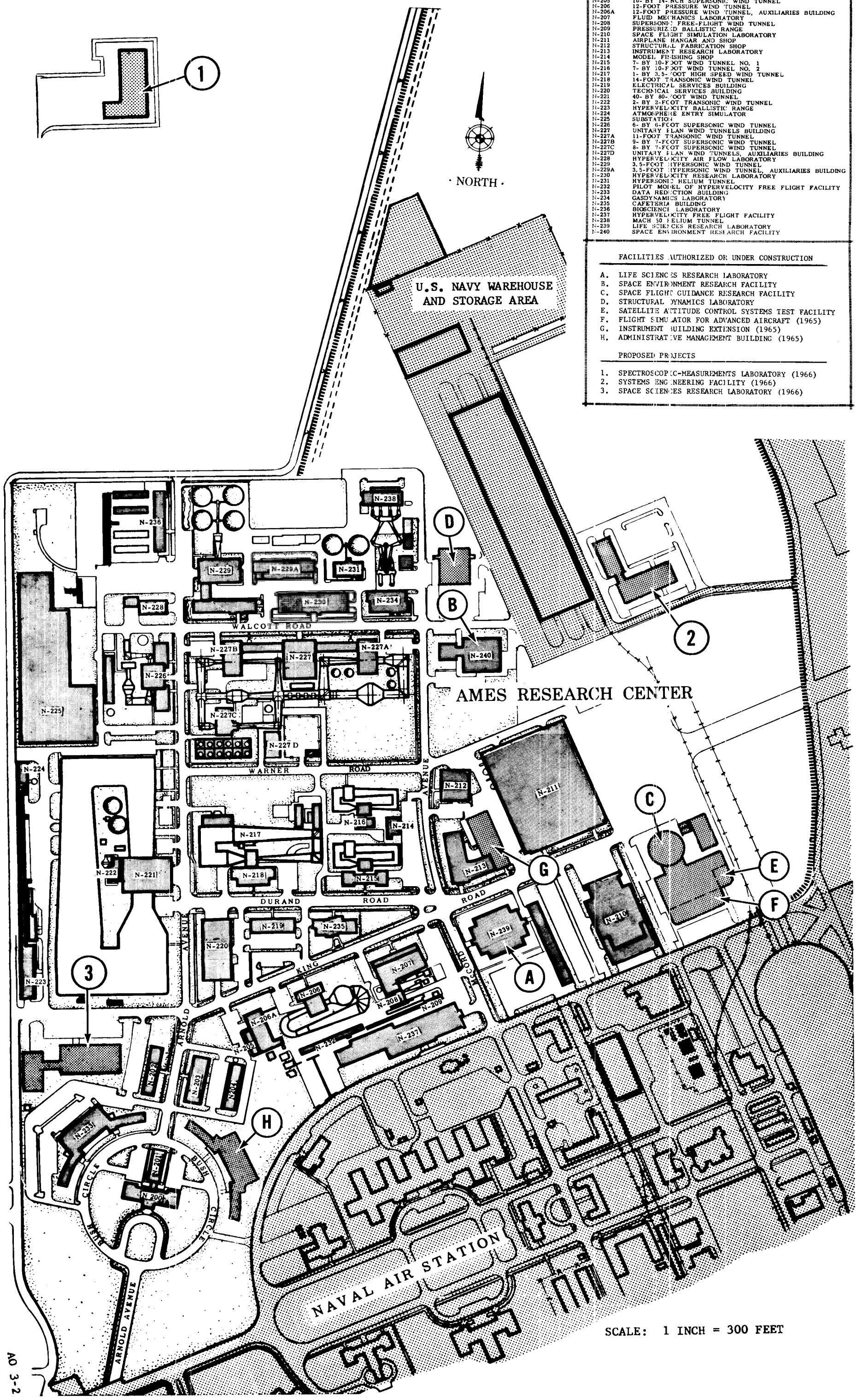
N-234	GASDYNAMICS LABORATORY
N-235	CAFETERIA BUILDING
N-236	BIOSCIENCE LABORATORY
N-237	HYPERVELOCITY FREE FLIGHT FACILITY
N-238	MACH 50 HELIUM TUNNEL
N-239	LIFE SCIENCES RESEARCH LABORATORY
N-240	SPACE ENVIRONMENT RESEARCH FACILITY

FACILITIES AUTHORIZED OR UNDER CONSTRUCTION

A. LIFE SCIENCES RESEARCH LABORATORY
B. SPACE ENVIRONMENT RESEARCH FACILITY
C. SPACE FLIGHT GUIDANCE RESEARCH FACILITY
D. STRUCTURAL DYNAMICS LABORATORY
E. SATELLITE ATTITUDE CONTROL SYSTEMS TEST FACILITY
F. FLIGHT SIMULATOR FOR ADVANCED AIRCRAFT (1965)
G. INSTRUMENT BUILDING EXTENSION (1965)
H. ADMINISTRATIVE MANAGEMENT BUILDING (1965)

PROPOSED PROJECTS

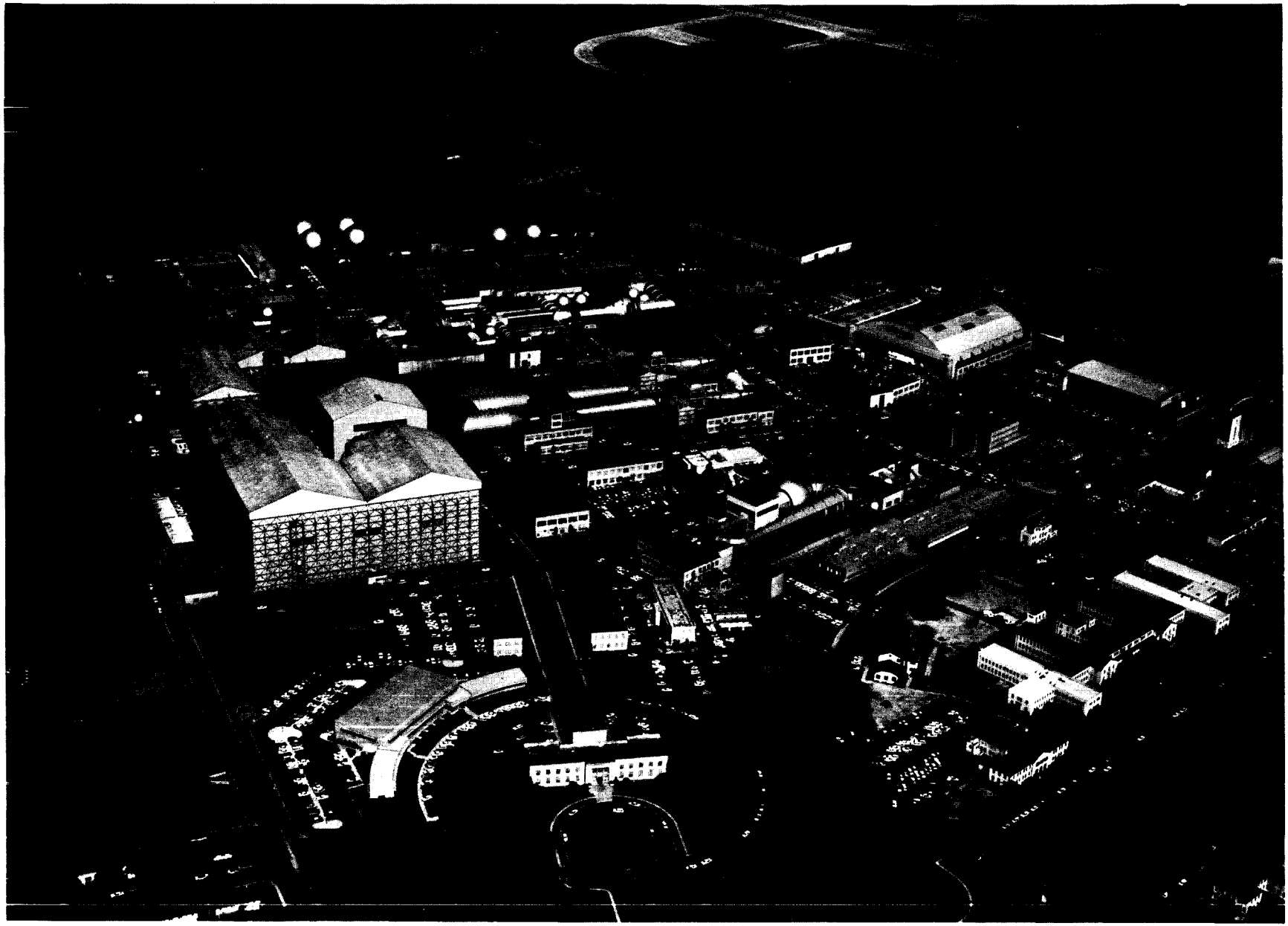
1. SPECTROSCOPIC-MEASUREMENTS LABORATORY (1966)
2. SYSTEMS ENGINEERING FACILITY (1966)
3. SPACE SCIENCES RESEARCH LABORATORY (1966)



SCALE: 1 INCH = 300 FEET

AO 3-2

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
AMES RESEARCH CENTER, MOFFETT FIELD, CALIFORNIA



AO 3-3

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ORGANIZATION AND STAFFING CHART

AMES RESEARCH CENTER

STAFFING SUMMARY

	65	66
Excepted	29	29
GS-16	17	17
GS-15	97	97
GS-14	150	150
All other GS	1,102	1,102
Wage Board	790	790
Total Permanent	2,185	2,185
Temporary	20	20
Total Positions	2,205	2,205

DIRECTOR

	65	66
Excepted	2	2
GS-16	-	-
GS-15	1	1
GS-14		
All other GS	5	5
Wage Board		
Total	8	8

RESOURCES MANAGEMENT OFFICE

	65	66
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	1	1
All other GS	1	1
Wage Board	-	-
Total	3	3

TECHNOLOGY UTILIZATION OFFICE

	65	66
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	1	1
All other GS	2	2
Wage Board	-	-
Total	4	4

PUBLIC INFORMATION OFFICE

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	1	1
All other GS	4	4
Wage Board	-	-
Total	5	5

ASSISTANT DIRECTOR AERONAUTICS AND FLIGHT MECHANICS

	65	66
Excepted	1	1
GS-16	-	-
GS-15	-	-
GS-14	1	1
All other GS	1	1
Wage Board	-	-
Total	3	3

AERONAUTICS DIVISION

	65	66
Excepted	1	1
GS-16	2	2
GS-15	6	6
GS-14	11	11
All other GS	68	68
Wage Board	58	58
Total	146	146

FULL SCALE AND SYSTEMS RESEARCH DIVISION

	65	66
Excepted	2	2
GS-16	1	1
GS-15	16	16
GS-14	19	19
All other GS	90	90
Wage Board	22	22
Total	150	150

INSTRUMENTATION DIVISION

	65	66
Excepted	2	2
GS-16	1	1
GS-15	6	6
GS-14	10	10
All other GS	109	109
Wage Board	129	129
Total	257	257

ASSISTANT DIRECTOR ASTRONAUTICS

	65	66
Excepted	1	1
GS-16	-	-
GS-15	1	1
GS-14	-	-
All other GS	1	1
Wage Board	-	-
Total	3	3

THERMO AND GAS DYNAMICS DIVISION

	65	66
Excepted	4	4
GS-16	1	1
GS-15	14	14
GS-14	19	19
All other GS	88	88
Wage Board	46	46
Total	172	172

VEHICLE ENVIRONMENT DIVISION

	65	66
Excepted	1	1
GS-16	4	4
GS-15	10	10
GS-14	17	12
All other GS	95	95
Wage Board	36	36
Total	158	158

SPACE SCIENCES DIVISION

	65	66
Excepted	1	1
GS-16	2	2
GS-15	7	7
GS-14	12	12
All other GS	32	32
Wage Board	17	17
Total	71	71

ASSISTANT DIRECTOR LIFE SCIENCES

	65	66
Excepted	1	1
GS-16	-	-
GS-15	-	-
GS-14	-	-
All other GS	6	6
Wage Board	-	-
Total	7	7

EXOBIOLOGY DIVISION

	65	66
Excepted	1	1
GS-16	1	1
GS-15	3	3
GS-14	5	5
All other GS	38	38
Wage Board	-	-
Total	48	48

ENVIRONMENTAL BIOLOGY DIVISION

	65	66
Excepted	2	2
GS-16	1	1
GS-15	3	3
GS-14	5	5
All other GS	44	44
Wage Board	7	7
Total	61	61

BIOTECHNOLOGY DIVISION

	65	66
Excepted	1	1
GS-16	1	1
GS-15	2	2
GS-14	7	7
All other GS	37	37
Wage Board	-	-
Total	48	48

ASSISTANT DIRECTOR DEVELOPMENT

	65	66
Excepted	1	1
GS-16	1	1
GS-15	-	-
GS-14	-	-
All other GS	1	1
Wage Board	-	-
Total	3	3

SYSTEMS ENGINEERING DIVISION

	65	66
Excepted	-	-
GS-16	1	1
GS-15	3	3
GS-14	8	8
All other GS	14	14
Wage Board	-	-
Total	26	26

PROJECT PIONEER

	65	66
Excepted	1	1
GS-16	-	-
GS-15	5	5
GS-14	10	10
All other GS	25	25
Wage Board	-	-
Total	41	41

PROJECT BIOSATELLITE

	65	66
Excepted	2	2
GS-16	-	-
GS-15	4	4
GS-14	7	7
All other GS	53	53
Wage Board	7	7
Total	73	73

ASSISTANT DIRECTOR R AND D ANALYSIS AND PLANNING

	65	66
Excepted	1	1
GS-16	-	-
GS-15	1	1
GS-14	-	-
All other GS	1	1
Wage Board	-	-
Total	3	3

MISSION ANALYSIS DIVISION

	65	66
Excepted	1	1
GS-16	1	1
GS-15	2	2
GS-14	5	5
All other GS	15	15
Wage Board	-	-
Total	24	24

TECHNICAL PLANNING DIVISION

	65	66
Excepted	1	1
GS-16	-	-
GS-15	3	3
GS-14	2	2
All other GS	2	2
Wage Board	-	-
Total	8	8

TECHNICAL INFORMATION DIVISION

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	-	-
All other GS	35	35
Wage Board	14	14
Total	49	49

ASSISTANT DIRECTOR ADMINISTRATION

	65	66
Excepted	1	1
GS-16	-	-
GS-15	-	-
GS-14	1	1
All other GS	1	1
Wage Board	-	-
Total	3	3

ADMINISTRATIVE SERVICES DIVISION

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	-	-
All other GS	25	25
Wage Board	10	10
Total	35	35

FISCAL DIVISION

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	1	1
All other GS	74	74
Wage Board	-	-
Total	75	75

PERSONNEL DIVISION

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	1	1
All other GS	55	55
Wage Board	-	-
Total	56	56

LEGAL OFFICE

	65	66
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	1	1
All other GS	1	1
Wage Board	-	-
Total	3	3

RESEARCH FACILITIES AND EQUIPMENT DIVISION

	65	66
Excepted	1	1
GS-16	-	-
GS-15	5	5
GS-14	8	8
All other GS	105	105
Wage Board	65	65
Total	184	184

TECHNICAL SERVICES DIVISION

	65	66
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	1	1
All other GS	1	1
Wage Board	360	360
Total	363	363

PROCUREMENT AND SUPPLY DIVISION

	65	66
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	1	1
All other GS	73	73
Wage Board	20	20
Total	95	95

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ADMINISTRATIVE OPERATIONS

FISCAL YEAR 1966 ESTIMATES

AMES RESEARCH CENTER

MISSION AND CAPABILITIES:

In addition to the traditional research mission in the physical sciences, the Ames Research Center mission includes research in the life sciences, flight project management, and spacecraft experimentation in the space sciences. The Center has flight-project management responsibility for Pioneer and Biosatellite projects. The Pioneer project will provide scientific observations of phenomena in interplanetary space from an unmanned spacecraft and the Biosatellite project will explore the biological effects of the space environment on primates and other earth organisms.

Physical sciences research includes studies in atmosphere entry and environmental physics, guidance and control systems, and aeronautics. Research in entry and environmental physics includes basic studies of the physics and chemistry of high-temperature gases; the stability, control, and performance of a wide range of spacecraft configurations; and of materials and structures for spacecraft. In the area of gas physics, particular emphasis is placed on problems associated with flight into earth and other planetary atmospheres. Through this effort, significant contributions have been made to the design of the Mercury, Gemini, and Apollo spacecraft, the design of Mars entry vehicles, and the design of ballistic missiles. Research in the environmental physics is directed toward the physics and chemistry of materials exposed to environmental conditions encountered by spacecraft and entry vehicles and includes the effects of micrometeoric particles and meteoric impact on structures as well as on materials. The work in guidance and control systems is broad in nature and is applicable to manned and unmanned spacecraft, as well as aircraft. Current emphasis in guidance systems is directed mainly at manned vehicles and in particular Apollo and follow-on manned missions. This includes an intensive effort in the area of midcourse navigation and terminal guidance with a smaller effort directed at examining various techniques applicable to satellite attitude stabilization and techniques applicable to vertical and short take-off (V/STOL) aircraft, the supersonic transport, and the Apollo spacecraft. The research program in aeronautics is directed toward studies of problems associated with supersonic aircraft with particular emphasis on the supersonic transport, a wide variety of V/STOL vehicles and with hypersonic research aircraft. This includes studies of piloting problems with numerous fixed-base, moving-base, and flight simulators.

Space sciences research includes studies in the fields of solar physics, planetary environments, and geophysics. This includes ground-based theoretical and experimental research, sounding rocket experimentation, as well

as experimentation requiring specialized instruments aboard satellites and space probes. The work covers studies pertaining to magnetic fields plasma, micrometeoroids in space, and studies to determine the composition and structure of planets and of planetary and stellar atmospheres.

Life sciences research is conducted in three major areas: basic research in the physiological and behavioral sciences concerned with obtaining a basic understanding of the effects of terrestrial and extraterrestrial environments and of space flight stresses upon living organisms; studies in exobiology oriented towards the prediction, detection, and study of extraterrestrial life forms; and research in the human factors aspects of the relationships between man and the machines which will transport him into space and support him during lunar and planetary exploration.

SUMMARY OF RESOURCES REQUIREMENTS:

	1964	1965	1966
Number of Positions, end of year...	2,204	2,205	2,205
Average Number of All Employees....	2,173	2,195	2,195
Administrative Operations.....	$29,886,000	$31,698,000	$32,300,000

INSTALLATION DESCRIPTION:

The Ames Research Center was established in 1940 and is located at the southern end of San Francisco Bay on land contiguous to the U.S. Naval Air Station, Moffett Field, California. Its physical plant comprises many specialized facilities for aerospace research in the traditional physical sciences as well as the space sciences and life sciences, all of which are included in the mission of the Center. These include conventional wind tunnels, entry-heating simulators, and free-flight ballistic test facilities capable of conducting tests at speeds up to and above earth escape speed as well as laboratories equipped to study solar and geophysical phenomena, life synthesis, life detection, and life environmental factors. The Center occupies about 235 acres of land of which 115 acres are owned by NASA and the remainder is made available through a use permit with the Department of the Navy. Certain other facilities, such as the utilities and airfield runways, are used jointly by NASA and the Navy. The total capital investment as of June 30, 1964, was $155,427,000.

ANALYSIS OF RESOURCES REQUIREMENTS BY OBJECT CLASSIFICATION:

	1964	1965	1966
11. Personnel Compensation.....	$19,042,000	$20,700,000	$20,729,000
12. Personnel Benefits.....	1,389,000	1,500,000	1,503,000
Total, personnel costs.....	$20,431,000	$22,200,000	$22,232,000

	1964	1965	1966
21. Travel and Transportation of Persons	$508,000	$610,000	$600,000
22. Transportation of Things	59,000	58,000	58,000
23. Rents, Communications, and Utilities	4,605,000	4,725,000	5,205,000
24. Printing and Reproduction	37,000	35,000	35,000
25. Other Services	1,644,000	1,355,000	1,488,000
Services of other agencies	112,000	105,000	112,000
26. Supplies and Materials	1,045,000	1,234,000	1,234,000
31. Equipment	614,000	1,076,000	1,036,000
32. Lands and Structures	831,000	300,000	300,000
42. Insurance Claims and Indemnities	---	---	---
Total	$29,886,000	$31,698,000	$32,300,000

JUSTIFICATION BY OBJECT CLASSIFICATION:

Personnel Distribution

	1964	1965	1966
Direct Personnel by Program			
Manned Space Flight			
Gemini	6	6	-
Apollo	13	13	-
Space Science and Applications			
Physics and astronomy	40	42	42
Lunar and planetary exploration	106	118	116
Bioscience	214	207	210
Advanced Research and Technology			
Solar and chemical power	8	11	12
Space vehicle systems	193	204	206
Electronics systems	193	196	200
Aeronautics	292	285	284
Human factor systems	117	102	110
Basic research	352	347	344
Technology Utilization	4	4	4
Sub-total, direct positions	1,538	1,535	1,528

	1964	1965	1966
Support personnel			
Director and Staff.....	48	49	49
Administration.....	304	310	310
Research and development support...	311	291	298
Sub-total, support personnel.....	663	650	657
Total, permanent positions.....	2,201	2,185	2,185
Other positions:			
Positions under cooperative training agreements.....	1	1	1
Other positions.....	2	19	19
Total, all positions.....	2,204	2,205	2,205

Personnel Requirements

Substantial effort in FY 1966 will continue to be devoted to the management of the Biosatellite and Pioneer Projects. Considerable effort will also be expended on research in aeronautics, space vehicles, and life sciences. Fluctuating workload requirements will involve minor reassignments of personnel between programs as changing program priorities dictate. Support for the FY 1966 personnel program will require a nominal increase to compensate for that portion of specific salary adjustments which cannot be absorbed through personnel turnover.

Personnel Costs

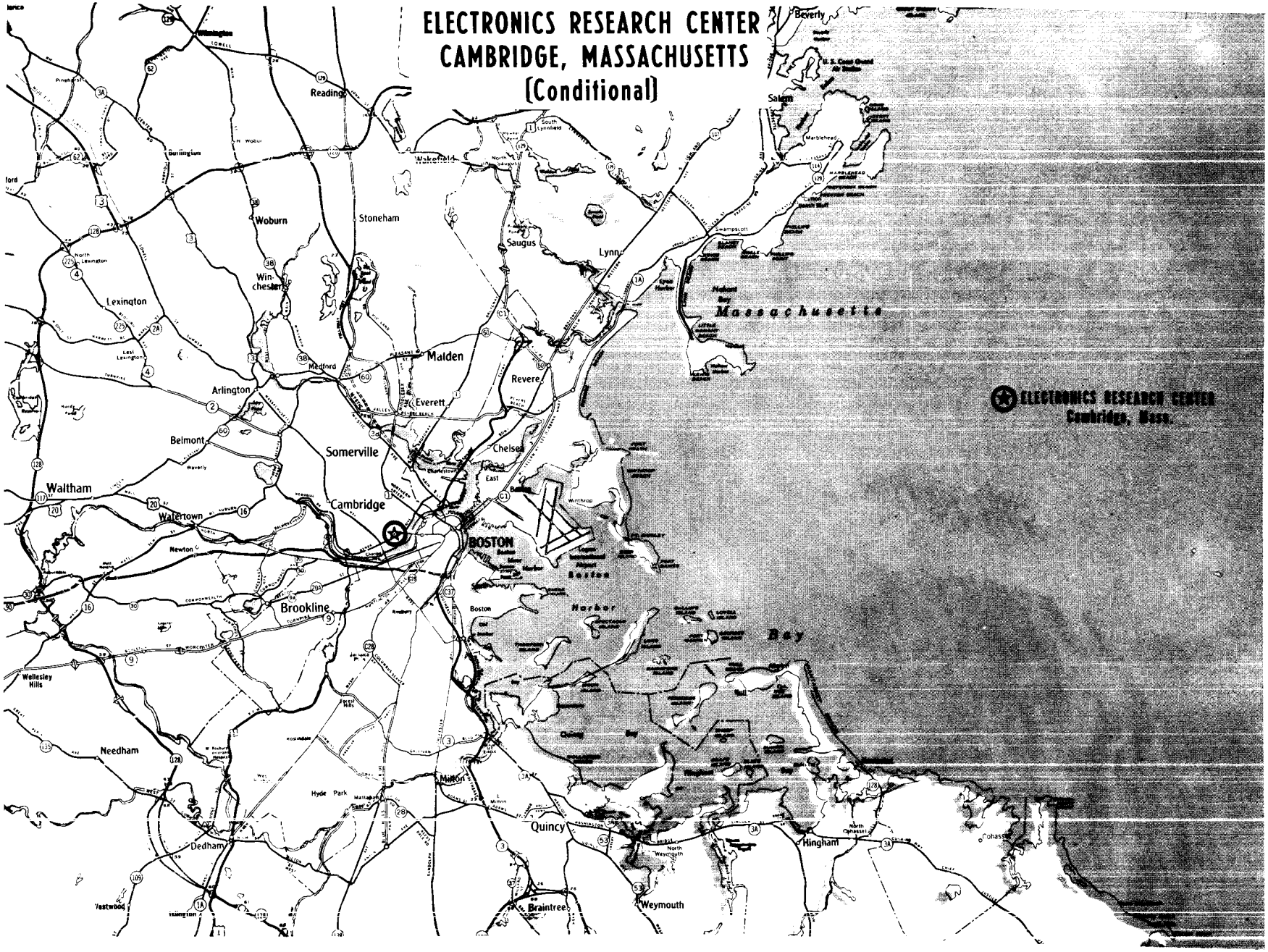
	1964	1965	1966
Total Positions.....	2,204	2,205	2,205
Permanent.....	2,201	2,185	2,185
Other.....	3	20	20
Personnel Compensation:			
Annual cost of permanent positions.....	$19,528,000	$20,220,000	$20,220,000
Pay above the stated annual rate.....	164,000	78,000	78,000
Lapses (deduct).....	-1,045,000	-39,000	-10,000
Cost of net permanent positions	18,647,000	20,259,000	20,288,000
Other personnel compensation...	395,000	441,000	441,000
Total compensation.....	19,042,000	20,700,000	20,729,000
NASA funded	19,042,000	20,700,000	20,729,000
Reimbursable.....	---	---	---

	1964	1965	1966
Personnel benefits	$1,389,000	$1,500,000	$1,503,000
NASA funded	1,389,000	1,500,000	1,503,000
Reimbursable	---	---	---
Total personnel costs	20,431,000	22,200,000	22,232,000
NASA funded	20,431,000	22,200,000	22,232,000
Reimbursable	---	---	---
Average Number of All Employees (Man Years)	2,173	2,195	2,195

Requirements for all other objects for FY 1966 reflect an increase of $570,000 over the amount estimated to be required for FY 1965, essentially in the following areas: (1) rental of electronic computing equipment; (2) electric power requirements; and (3) other contractual services.

The scheduled launchings under the Pioneer Project will necessitate the rental of auxiliary items of computer equipment to facilitate the increased workload resulting from the processing of flight data. This requirement will reflect an increase of $441,000. An increase in electric power consumption relating to scheduled wind tunnel tests will require additional funding in the amount of approximately $44,000. These increases are offset by a net decrease of $5,000 in other requirements for rents, communications and utilities. Other contractual services will require a nominal increase to cover additional maintenance costs for these facilities coming into initial operation in FY 1966.

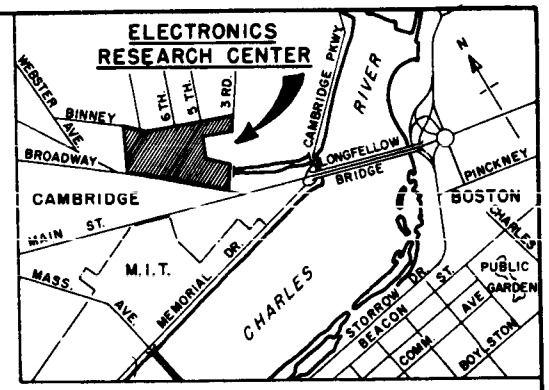
ELECTRONICS RESEARCH CENTER
CAMBRIDGE, MASSACHUSETTS
(Conditional)



ELECTRONICS RESEARCH CENTER
FISCAL YEAR 1966 ESTIMATES

LOCATION PLAN

CAMBRIDGE, MASS.
(CONDITIONAL)



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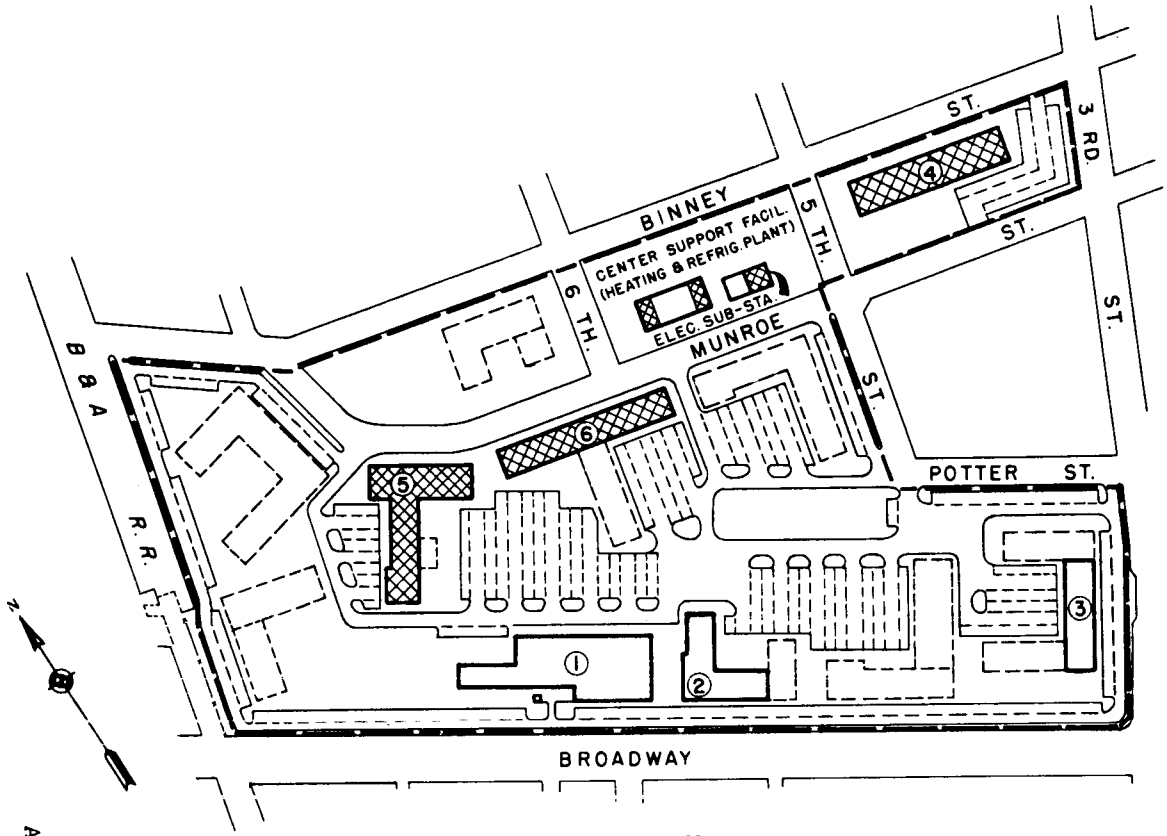
SCALE IN MILES



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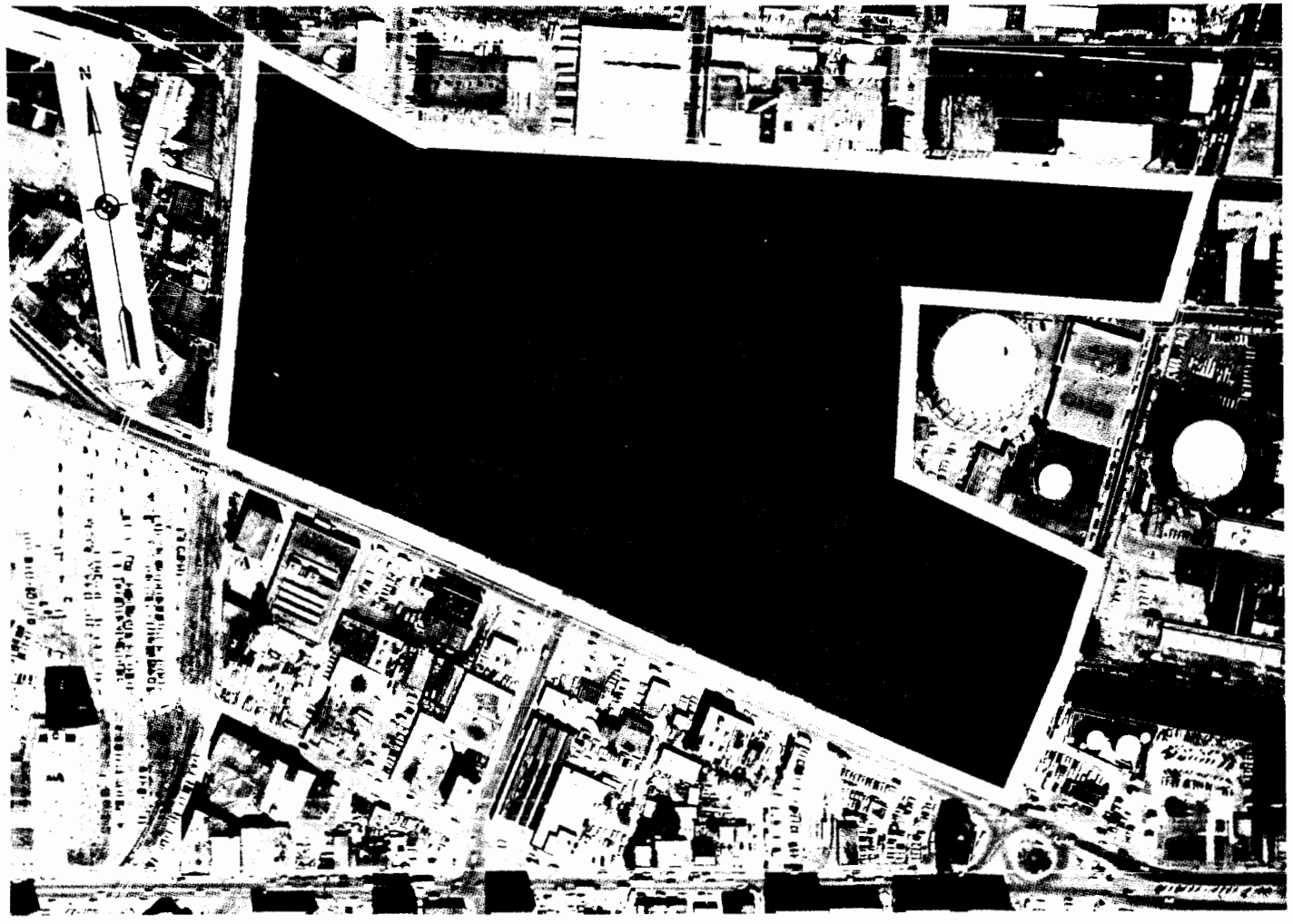
SCALE IN FEET

1. ENGINEERING & ADMINISTRATION BUILDING
2. ELECTRONIC COMPONENTS LABORATORY
3. QUALIFICATIONS & STANDARDS LABORATORY
4. MICROWAVE RADIATION LABORATORY
5. SPACE GUIDANCE LABORATORY
6. OPTICAL COMMUNICATIONS LABORATORY

LEGEND

- FY-65 FACILITIES
- FACILITIES PROPOSED IN 1966 ESTIMATES
- FUTURE FACILITIES
- PROJECT BOUNDARY

ELECTRONICS RESEARCH CENTER
CAMBRIDGE, MASS.
(Conditional)



AERIAL VIEW

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ORGANIZATION AND STAFFING CHART

ELECTRONICS RESEARCH CENTER

OFFICE OF THE DIRECTOR

	65	66
Excepted	2	3
GS-16	-	-
GS-15	2	4
GS-14	4	8
All other GS	12	10
Wage Board	-	-
Total	20	25

STAFFING SUMMARY

	65	66
Excepted	10	11
GS-16	-	-
GS-15	16	46
GS-14	50	110
All other GS	174	383
Wage Board	-	-
Total Permanent	250	550
Temporary	-	-
Total Positions	250	550

PROGRAMS AND RESOURCES

	65	66
Excepted	1	1
GS-16	-	-
GS-15	2	3
GS-14	3	6
All other GS	13	40
Wage Board	-	-
Total	19	50

ADMINISTRATION

	65	66
Excepted	1	1
GS-16	-	-
GS-15	-	1
GS-14	5	12
All other GS	49	81
Wage Board	-	-
Total	55	95

FACILITIES AND ENGINEERING

	65	66
Excepted	1	1
GS-16	-	-
GS-15	2	4
GS-14	6	15
All other GS	24	40
Wage Board	-	-
Total	33	60

SYSTEMS RESEARCH

	65	66
Excepted	1	1
GS-16	-	-
GS-15	2	7
GS-14	5	11
All other GS	8	28
Wage Board	-	-
Total	16	47

ELECTRONIC COMPONENTS RESEARCH

	65	66
Excepted	1	1
GS-16	-	-
GS-15	2	8
GS-14	8	17
All other GS	27	73
Wage Board	-	-
Total	38	99

GUIDANCE AND CONTROL RESEARCH

	65	66
Excepted	1	1
GS-16	-	-
GS-15	2	7
GS-14	7	14
All other GS	12	38
Wage Board	-	-
Total	22	60

INSTRUMENTATION AND DATA PROCESSING RESEARCH

	65	66
Excepted	1	1
GS-16	-	-
GS-15	2	6
GS-14	5	13
All other GS	14	38
Wage Board	-	-
Total	22	58

ELECTRO-MAGNETIC RESEARCH

	65	66
Excepted	1	1
GS-16	-	-
GS-15	2	6
GS-14	7	14
All other GS	15	35
Wage Board	-	-
Total	25	56

ADMINISTRATIVE OPERATIONS

FISCAL YEAR 1966 ESTIMATES

ELECTRONICS RESEARCH CENTER

MISSION AND CAPABILITIES:

The Electronics Research Center will increase NASA's capability in space electronics by providing the groundwork of knowledge and advanced technology needed to overcome present deficiencies.

The Center will conduct comprehensive programs of basic and applied research in areas of space electronics now inadequately covered. The research will include performance characteristics, test procedures, and specifications for space electronic components, and investigate new concepts for making space electronics equipment more reliable. The Center will investigate techniques and lay the fundamental technological groundwork for space electronics equipment of reduced weight, size, power drain, and complexity, capable of withstanding the harsh conditions found in space. The Center will devise new concepts and techniques and prove their feasibility both analytically and experimentally for space electronic equipment capable of achieving levels of performance beyond those of today.

SUMMARY OF RESOURCES REQUIREMENTS:

	1964	1965	1966
Number of Positions, end of year.	25	250	550
Average Number of All Employees..	12	119	405
Administrative Operations.....	$730,000	$3,600,000	$7,622,000

INSTALLATION DESCRIPTION:

The Electronics Research Center will be located in Cambridge, Massachusetts. The initial phase of construction, on a 29-acre tract of land will commence in the spring of 1965, with partial occupancy scheduled by the end of 1966. The master planning for the Center contemplates the acquisition of an auxiliary site (presently unselected) for the construction of additional research facilities and the development of field test areas. There was no capital investment as of June 30, 1964.

ANALYSIS OF RESOURCES REQUIREMENTS BY OBJECT CLASSIFICATION:

	1964	1965	1966
11. Personnel Compensation.....	$137,000	$1,470,000	$4,368,000
12. Personnel Benefits.....	10,000	110,000	332,000
Total, personnel costs.....	$147,000	$1,580,000	$4,700,000
21. Travel and Transportation of Persons.....	18,000	240,000	270,000
22. Transportation of Things.....	---	121,000	141,000
23. Rents, Communications, and Utilities.....	---	389,000	784,000
24. Printing and Reproduction....	---	35,000	65,000
25. Other Services.....	486,000	394,000	762,000
Services of other agencies.	37,000	110,000	153,000
26. Supplies and Materials.....	13,000	154,000	376,000
31. Equipment.....	29,000	453,000	261,000
32. Lands and Structures.....	---	124,000	110,000
42. Insurance Claims and Indemnities.....	---	---	---
Total.....	$730,000	$3,600,000	$7,622,000

JUSTIFICATION BY OBJECT CLASSIFICATION:

Personnel Distribution

	1964	1965	1966
Direct Personnel by Program			
Advanced Research and Technology			
Electronic systems.....	8	129	410
Technology Utilization.....	-	1	1
Support personnel			
Director and Staff.....	8	36	39
Administration.....	4	39	50
Research and development support.	5	45	50
Sub-total, support positions...	17	120	139
Total, permanent positions.....	25	250	550

Personnel Requirements

The personnel level proposed for FY 1966 includes a request for 300 additional employees. This accession is in conformity with the phased growth originally conceived in the long-range development of the Electronics Research Center. The increase will permit the staffing of those essential technical functions necessary for the effective direction and management of the most important program objectives relating to the elctronics endeavor.

The increase in personnel costs, amounting to $3,120,000, is required to (1) cover the full year costs of personnel added in FY 1965, and (2) for the cost of the additional staffing requested in FY 1966. The cost of the additional employees has been included in the estimates at a lapsed rate of approximately 47 per cent.

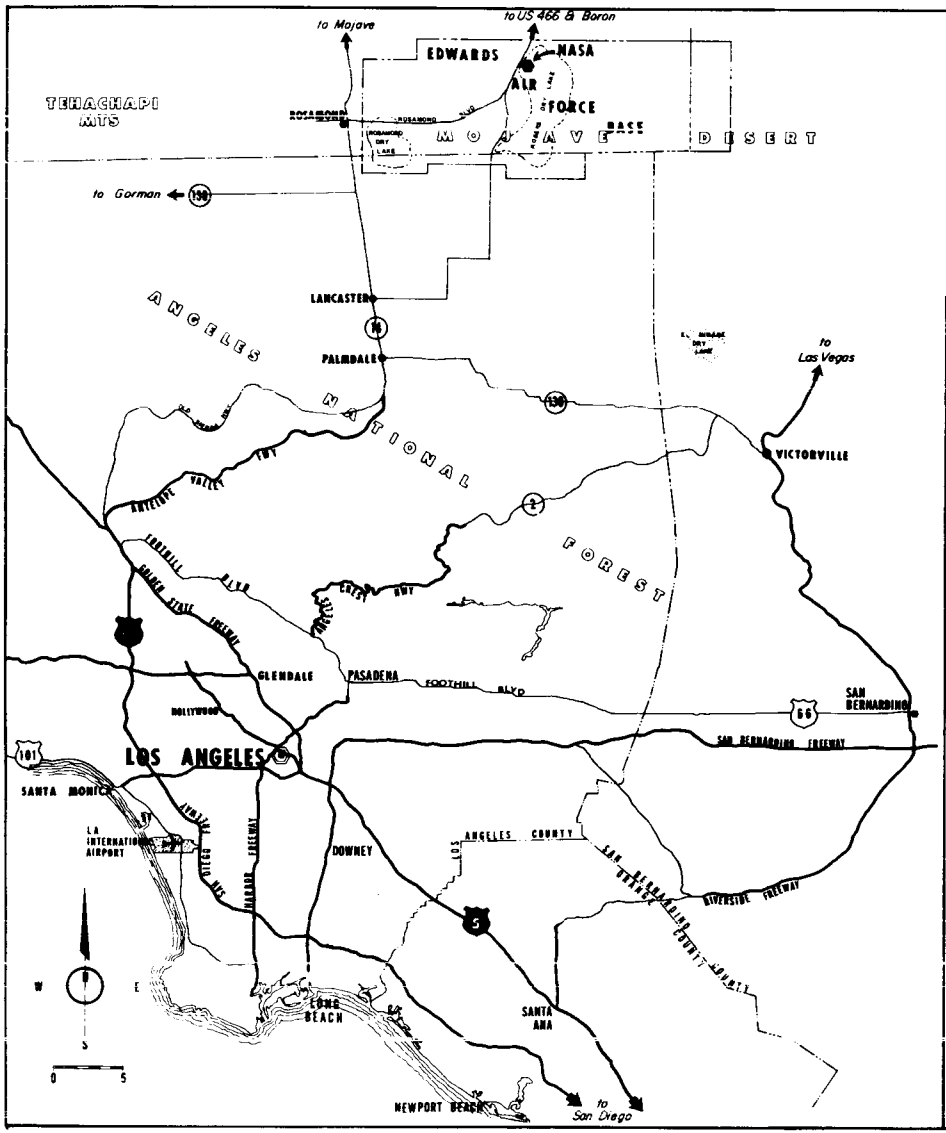
Personnel Costs

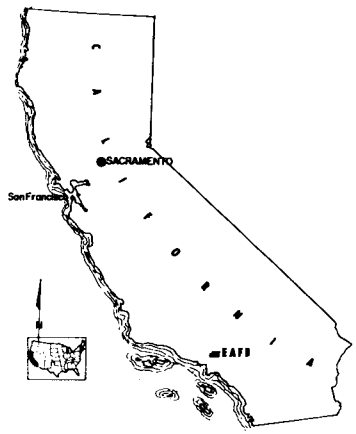
	1964	1965	1966
Total Positions	25	250	550
Permanent	25	250	550
Other	--	---	---
Personnel Compensation:			
Annual cost of permanent positions	$277,000	$2,799,000	$5,716,000
Pay above the stated annual rate	2,000	10,000	22,000
Lapses (deduct)	-143,000	-1,411,000	-1,527,000
Net cost of permanent positions	136,000	1,398,000	4,211,000
Other personnel compensation	1,000	72,000	157,000
Total compensation	137,000	1,470,000	4,368,000
NASA funded	137,000	1,470,000	4,368,000
Reimbursable	---	---	---
Personnel benefits	10,000	110,000	332,000
NASA funded	10,000	110,000	332,000
Reimbursable	---	---	---
Total personnel costs	147,000	1,580,000	4,700,000
NASA funded	147,000	1,580,000	4,700,000
Reimbursable	---	---	---
Average Number of All Employees (Man Years)	12	119	405

Requirements for all other objects reflect an increase of $902,000 over the amount estimated for FY 1965. To a considerable extent, the increase reflects the continuation of commitments and requirements established in FY 1965 although partly funded during that period.

Included in the increase is the requirement for additional contractual services. This is primarily due to the lack of in-house capability for administrative and housekeeping functions essential to efficient operation. Until such time as the in-house support functions are adequately staffed, the services of outside contractors must be utilized to augment the limited capability of employees already employed as well as those planned for the budget year.

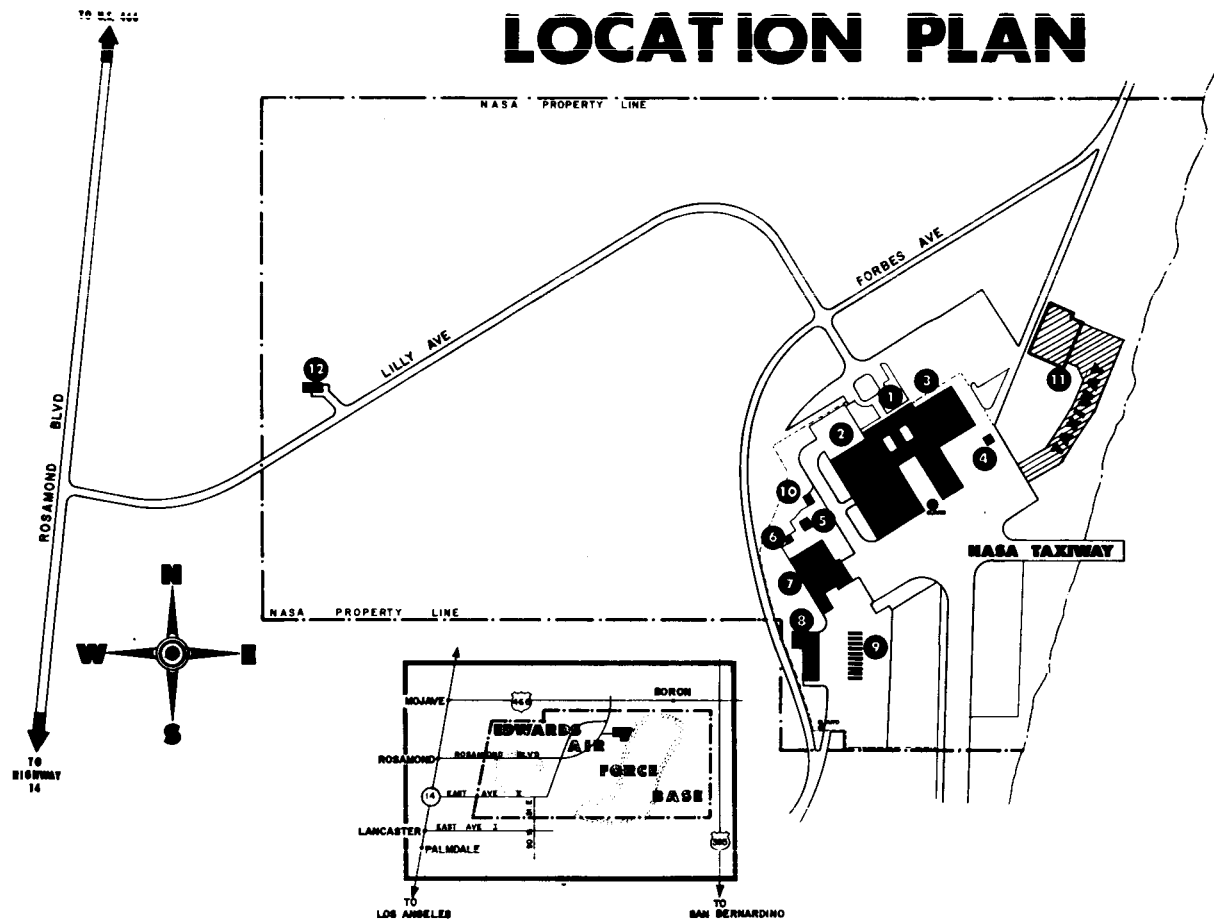
FLIGHT RESEARCH CENTER
FISCAL YEAR 1966 ESTIMATES
VICINITY MAP





KEY PLAN

FLIGHT RESEARCH CENTER
FISCAL YEAR 1966 ESTIMATES
LOCATION PLAN

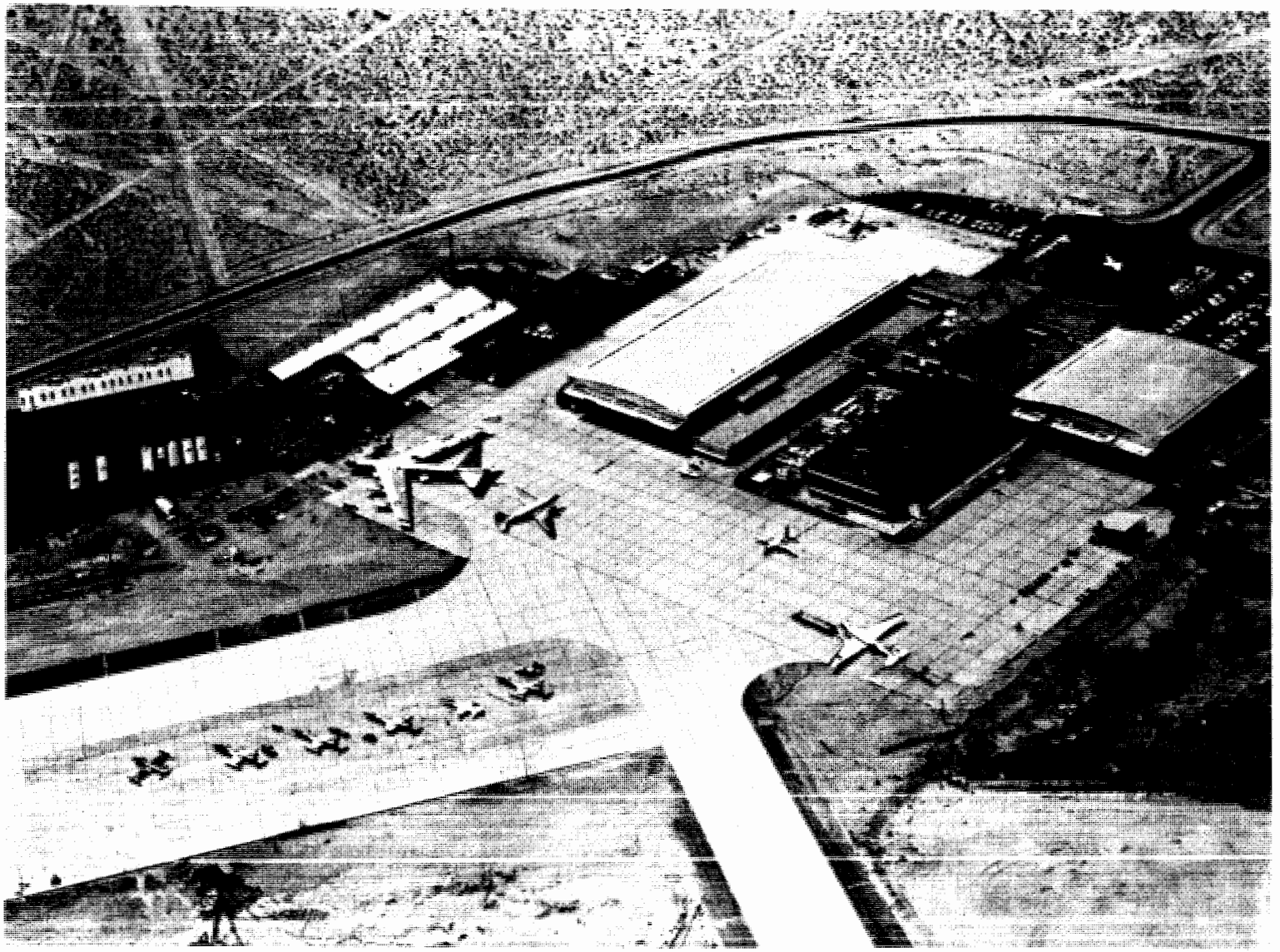


1. LABORATORY
2. MAIN HANGAR
3. CALIBRATION HANGAR
4. AUXILIARY POWER UNIT BUILDING X-15
5. BOILER HOUSE BUILDING
6. PAINT STORAGE BUILDING
7. WAREHOUSE Nº 1-Nº 2 & A.G.E.
8. WAREHOUSE Nº 3
9. TRAILER PARK
10. PAINT SPRAY BUILDING
11. HIGH TEMPERATURE LOADS CALIBRATION FACILITY F.Y. 1964
12. COMMUNICATION BUILDING

EXISTING FACILITIES
AUTHORIZED FACILITY

0 500 1000

FLIGHT RESEARCH CENTER
FISCAL YEAR 1966 ESTIMATES



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ORGANIZATION AND STAFFING CHART

FLIGHT RESEARCH CENTER

STAFFING SUMMARY

	65	66
Excepted	6	6
GS-16	3	3
GS-15	13	13
GS-14	31	31
All other GS	289	289
Wage Board	263	263
Total Permanent	605	605
Temporary	14	14
Total Positions	619	619

OFFICE OF THE DIRECTOR

	65	66
Excepted	3	3
GS-16	1	1
GS-15	1	1
GS-14	1	1
All other GS	6	6
Wage Board	26	26
Total	38	38

RESEARCH DIVISION

	65	66
Excepted	2	2
GS-16	1	1
GS-15	4	4
GS-14	12	12
All other GS	96	96
Wage Board	1	1
Total	116	116

OPERATIONS DIVISION

	65	66
Excepted	1	1
GS-16	-	-
GS-15	5	5
GS-14	6	6
All other GS	20	20
Wage Board	130	130
Total	162	162

DATA SYSTEMS DIVISION

	65	66
Excepted	-	-
GS-16	1	1
GS-15	2	2
GS-14	9	9
All other GS	91	91
Wage Board	79	79
Total	182	182

ADMINISTRATIVE DIVISION

	65	66
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	3	3
All other GS	76	76
Wage Board	27	27
Total	107	107

ADMINISTRATIVE OPERATIONS

FISCAL YEAR 1966 ESTIMATES

FLIGHT RESEARCH CENTER

MISSION AND CAPABILITIES:

The Flight Research Center, established in 1947, conducts research and evaluates problems of manned flight, both within and outside the atmosphere. The Center's mission includes effort on problems of takeoff and landing, low-speed flight, supersonic and hypersonic flight, and reentry to verify predicted characteristics and to identify unexpected problems in actual flight.

Projects currently underway or projected include aeronautics projects such as the X-15, B-70, supersonic transport, and hypersonic research; space vehicle systems projects in which the flight behavior of advanced reentry vehicles is studied; and electronic systems projects such as display, guidance and control in advanced flight missions and improvements on systems and sensors used in bio-medical monitoring, tracking, and data acquisition. Research of interest to the manned space flight program concerning projects Gemini and Apollo is provided through paraglider development and lunar landing research.

The major research tools for conducting these programs are the aircraft. They range from lightweight civil aircraft for handling qualities investigations to century series fighters for pilot proficiency and general investigations, and to X-15 rocket aircraft used for hypersonic research and reentry investigations. Special purpose vehicles such as paragliders, lifting bodies, lunar landing research vehicles and variable stability aircraft or airborne simulators are contractor procured or developed in-house. Specialized laboratory facilities are available to complement the flight activities with proper preliminary research and testing. Simulation equipment is used to guide and assist in the performance of productive flight activities. A three-station radar for tracking and data acquisition is operated to support the flight activity.

SUMMARY OF RESOURCES REQUIREMENTS:

	1964	1965	1966
Number of Positions, end of year..	619	619	619
Average Number of All Employees...	621	622	619
Administrative Operations.....	$9,514,000	$9,750,000	$9,600,000

INSTALLATION DESCRIPTION:

The Flight Research Center, Edwards, California, is approximately 65 miles northeast of Los Angeles. The Center is located along the northern

boundary of Edwards Air Force Base on 171 acres of land leased from the Air Force. The Center is adjacent to Rogers Dry Lake, a 55 square mile area with a complex of runways varying in length from 5 to 11 miles.

The physical plant consists of an office-laboratory building with adjoining shops, a flight maintenance hangar and a calibration hangar. Auxiliary buildings include warehouses, an auxiliary power systems building, and a communications building. The main station of the 3-station radar range operated by the Center is located on the third floor of the office-laboratory building. The total capital investment as of June 30, 1964, was $27,116,000.

ANALYSIS OF RESOURCES REQUIREMENTS BY OBJECT CLASSIFICATION:

		1964	1965	1966
11.	Personnel Compensation.....	$5,659,000	$6,218,000	$6,265,000
12.	Personnel Benefits.....	410,000	432,000	435,000
	Total, personnel costs....	$6,069,000	$6,650,000	$6,700,000
21.	Travel and Transportation of Persons.....	234,000	260,000	260,000
22.	Transportation of Things....	31,000	40,000	40,000
23.	Rents, Communications, and Utilities.....	362,000	337,000	331,000
24.	Printing and Reproduction...	6,000	10,000	10,000
25.	Other Services.....	1,029,000	985,000	1,044,000
	Services of other agencies	78,000	---	---
26.	Supplies and Materials.....	600,000	540,000	540,000
31.	Equipment.....	1,007,000	762,000	524,000
32.	Lands and Structures.....	98,000	165,000	150,000
42.	Insurance Claims and Indemnities.....	---	1,000	1,000
	Total.....	$9,514,000	$9,750,000	$9,600,000

JUSTIFICATION BY OBJECT CLASSIFICATION:

Personnel Distribution

	1964	1965	1966
Direct Personnel by Program			
Manned Space Flight			
Apollo.....	50	39	37
Space Science and Applications			
Physics and astronomy.....	3	3	3

	1964	1965	1966
Advanced Research and Technology			
Space vehicle systems	24	26	40
Electronics systems	17	17	8
Aeronautics	344	351	350
Human factor systems	10	10	10
Basic research	-	1	1
Tracking and Data Acquisition	39	39	37
Technology Utilization	-	1	1
Sub-total, direct positions	487	487	487
Support personnel			
Director and Staff	10	11	11
Administration	108	107	107
Sub-total, support positions	118	118	118
Total, permanent positions	605	605	605
Other positions:			
Positions under cooperative training agreements	14	14	14
Total, all positions	619	619	619

Personnel Requirements

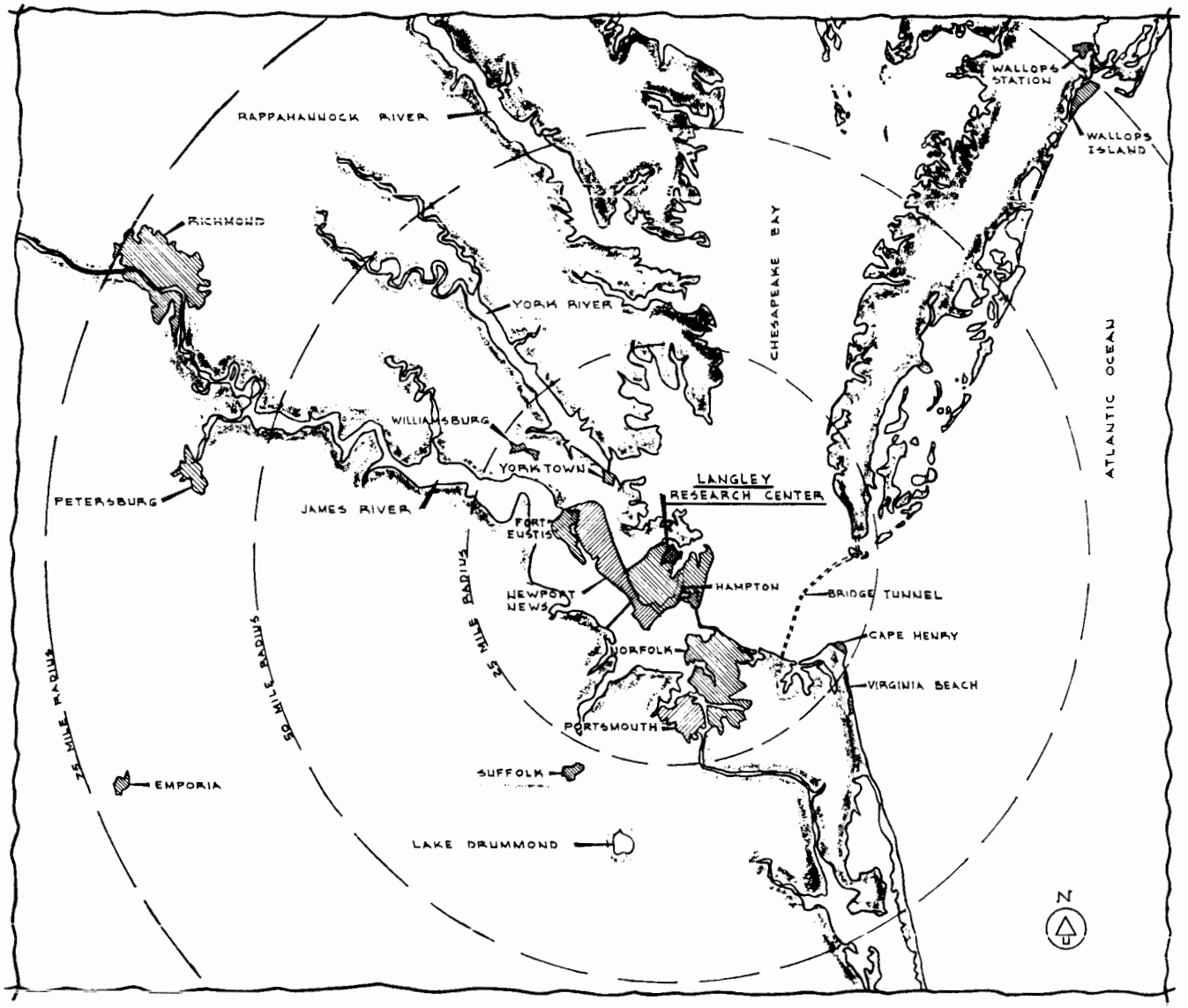
Current and projected research effort will be devoted essentially to the X-15, B-70, the supersonic transport, and the M-2 lifting body reentry vehicle. Except for minor personnel reassignments, the present manpower levels will remain constant in FY 1966.

The nominal increase in personnel costs requested for FY 1966 will compensate for those personnel salary adjustments not absorbed through personnel turnover. The limited staff at the Flight Research Center requires funding for these purposes in order to maintain a constant man-year effort to facilitate the accomplishment of program objectives.

Personnel Costs

	1964	1965	1966
Total Positions	619	619	619
Permanent	605	605	605
Other	14	14	14
Personnel Compensation:			
Annual cost of permanent positions	$5,320,000	$5,671,000	$5,744,000
Pay above the stated annual rate	42,000	22,000	22,000
Lapses (deduct)	-205,000	-122,000	-44,000
Net cost of permanent positions	5,157,000	5,571,000	5,722,000
Other personnel compensation	502,000	647,000	543,000
Total compensation	5,659,000	6,218,000	6,265,000
NASA funded	5,659,000	6,218,000	6,265,000
Reimbursable	---	---	---
Personnel benefits	410,000	432,000	435,000
NASA funded	410,000	432,000	435,000
Reimbursable	---	---	---
Total personnel costs	$6,069,000	$6,650,000	$6,700,000
NASA funded	6,069,000	6,650,000	6,700,000
Reimbursable	---	---	---
Average Number of All Employees (Man Years)	621	622	619

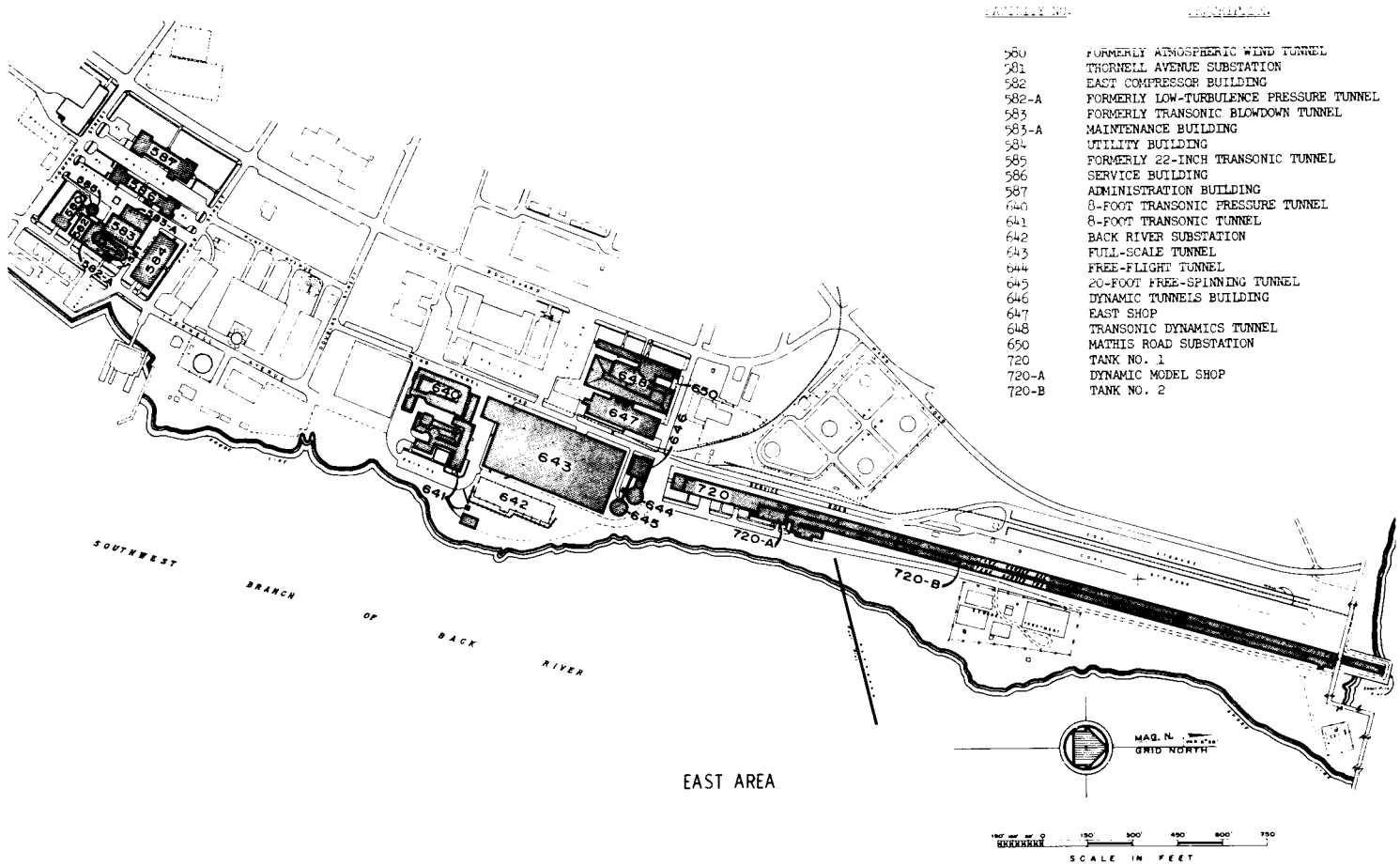
Offsetting the small increase of $59,000 requested for contractual services, required essentially for equipment and plant maintenance, lower estimates in other areas effect a decrease of $150,000 in the overall requirements for FY 1966.



LANGLEY RESEARCH CENTER AND VICINITY

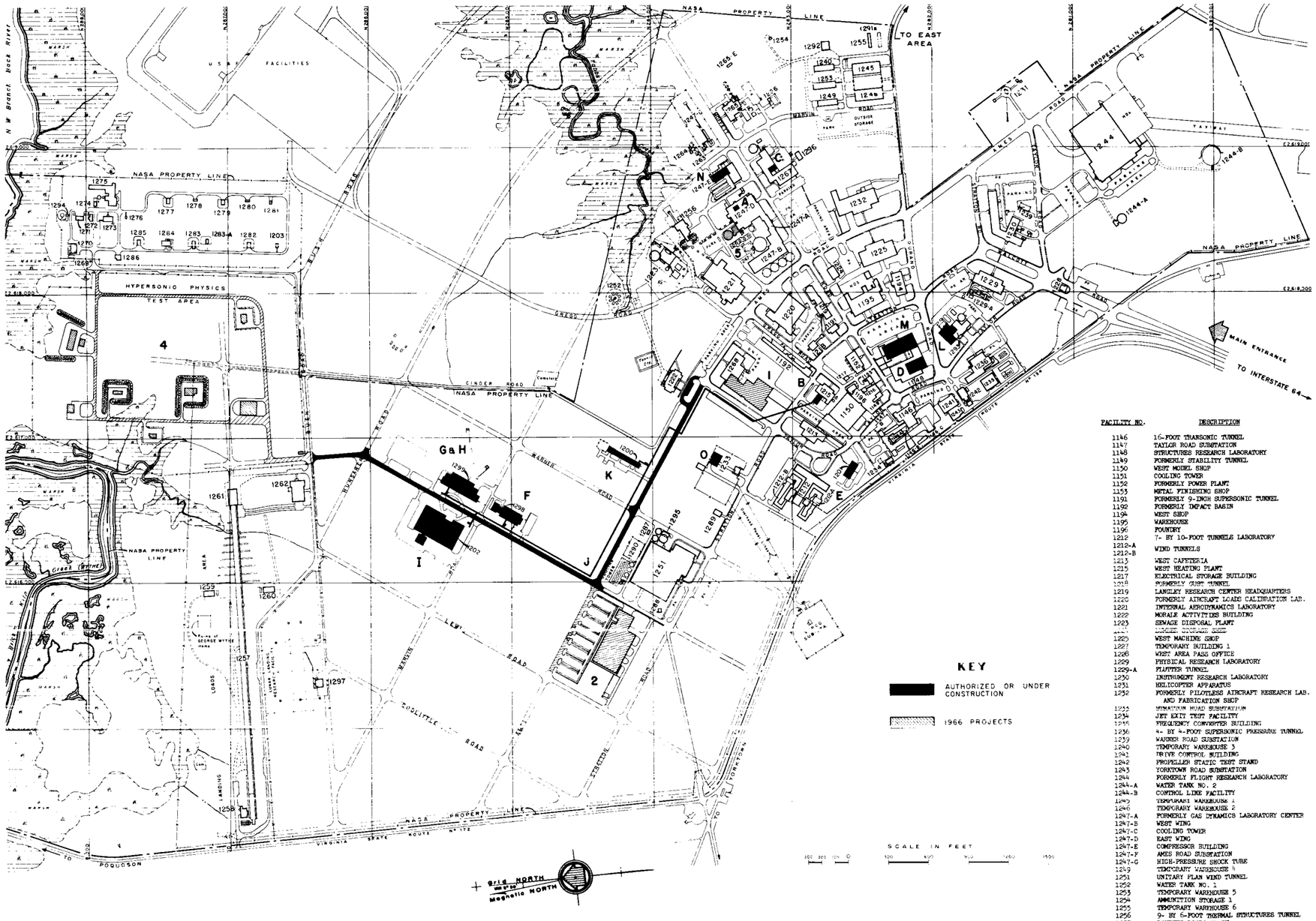
LANGLEY RESEARCH CENTER
FISCAL YEAR 1966 ESTIMATES

LOCATION PLAN



LANGLEY RESEARCH CENTER
FISCAL YEAR 1966 ESTIMATES

LOCATION PLAN



PROPOSED FISCAL YEAR 1966 PROJECTS

1. FLIGHT CONTROL RESEARCH FACILITY
2. LIFE SUPPORT TECHNOLOGY LABORATORY
4. MAGAZINE AND TEST AREA FOR HIGHLY REACTIVE CHEMICAL MATERIALS
5. INCREASE RESEARCH CAPABILITY M = 6 AND 8.5 TUNNELS

FACILITY NO.	DESCRIPTION
1146	16-FOOT TRANSONIC TUNNEL
1147	TAYLOR ROAD SUBSTATION
1148	STRUCTURES RESEARCH LABORATORY
1149	FORMERLY STABILITY TUNNEL
1150	WEST MODEL SHOP
1151	COOLING TOWER
1152	FORMERLY POWER PLANT
1153	METAL FINISHING SHOP
1191	FORMERLY 9-INCH SUPERSONIC TUNNEL
1192	FORMERLY IMPACT BASIN
1194	WEST SHOP
1195	WAREHOUSE
1196	FOUNDRY
1212	7- BY 10-FOOT TUNNELS LABORATORY
1212-A	WIND TUNNELS
1213	WEST CAFETERIA
1215	WEST HEATING PLANT
1217	ELECTRICAL STORAGE BUILDING
1218	FORMERLY 22FT TUNNEL
1219	LANGLEY RESEARCH CENTER HEADQUARTERS
1220	FORMERLY AIRCRAFT LOADS CALIBRATION LAB.
1221	INTERNAL AERODYNAMICS LABORATORY
1222	MORALE ACTIVITIES BUILDING
1223	SEWAGE DISPOSAL PLANT
[illegible]	ROCKET CHEMICAL SHED
1225	WEST MACHINE SHOP
1227	TEMPORARY BUILDING 1
1228	WEST AREA PASS OFFICE
1229	PHYSICAL RESEARCH LABORATORY
1229-A	FLUTTER TUNNEL
1230	INSTRUMENT RESEARCH LABORATORY
1231	HELICOPTER APPARATUS
1232	FORMERLY PILOTLESS AIRCRAFT RESEARCH LAB. AND FABRICATION SHOP
1233	MUNICIPAL ROAD SUBSTATION
1234	JET EXIT TEST FACILITY
1235	FREQUENCY CONVERTER BUILDING
1236	4- BY 4-FOOT SUPERSONIC PRESSURE TUNNEL
1239	WARNER ROAD SUBSTATION
1240	TEMPORARY WAREHOUSE 3
1241	DRIVE CONTROL BUILDING
1242	PROPELLER STATIC TEST STAND
1243	YORKTOWN ROAD SUBSTATION
1244	FORMERLY FLIGHT RESEARCH LABORATORY
1244-A	WATER TANK NO. 2
1244-B	CONTROL LINE FACILITY
1245	TEMPORARY WAREHOUSE 1
1246	TEMPORARY WAREHOUSE 2
1247-A	FORMERLY GAS DYNAMICS LABORATORY CENTER
1247-B	WEST WING
1247-C	COOLING TOWER
1247-D	EAST WING
1247-E	COMPRESSOR BUILDING
1247-F	AMES ROAD SUBSTATION
1247-G	HIGH-PRESSURE SHOCK TUBE
1249	TEMPORARY WAREHOUSE 4
1251	UNITARY PLAN WIND TUNNEL
1252	WATER TANK NO. 1
1253	TEMPORARY WAREHOUSE 5
1254	AMMUNITION STORAGE 1
1255	TEMPORARY WAREHOUSE 6
1256	9- BY 6-FOOT THERMAL STRUCTURES TUNNEL
1257	LANDING LOADS TRACK

FACILITY NO.	DESCRIPTION
1258	LANDING LOADS TRACK COMPRESSOR BUILDING
1259	NORTH ARRESTING GEAR HOUSING
1260	SOUTH ARRESTING GEAR HOUSING
1261	LANDING LOADS TRACK SHOP
1262	HIGH-SPEED HYDRODYNAMICS OFFICE AND SHOP
1263	CERAMIC-HEATED JET (PILOT MODEL)
1264	HIGH-TEMPERATURE MACH 7 JET (PILOT MODEL)
1265	8-FOOT HIGH-TEMPERATURE STRUCTURES TUNNEL
1266	MOFFETT ROAD SUBSTATION
1267	HIGH-TEMPERATURE MATERIALS LABORATORY
1268	DATA REDUCTION BUILDING
1269	GATE HOUSE (HYPERSONIC PHYSICS TEST AREA)
1270	ROCKET PROPELLANT TEST UNIT, HPTA
1271	OPEN SHED, HPTA
1272	HEATING PLANT, HPTA
1273	OPERATIONS CENTER, HPTA
1274	CERAMIC-HEATED MACH 15 JET, HPTA
1275	IMPACT AND PROJECTILE TEST UNIT, HPTA
1276	IGNITER ASSEMBLY BUILDING, HPTA
1277	STORAGE A
1278	STORAGE B
1279	STORAGE C
1280	STORAGE D
1281	STORAGE E
1282	STORAGE F
1283	STORAGE G
1284	ROCKET PROPELLANT PROCESSING BUILDING, HPTA
1285	STORAGE H
1286	ROCKET ASSEMBLY AND PROPELLANT ALTERATION BUILDING
1287	TEMPORARY SHED
1288	SOLAR ENERGY COLLECTOR
1289	TEMPORARY STORAGE
1290	SUBSTATION
1291	FUMC STATION
1292	FACILITIES MAINTENANCE BUILDING
1293	DYNAMICS RESEARCH LABORATORY
1294	ROCKET MOTOR TEST APPARATUS
1295	SHOP AND INSTRUMENTATION FOR 60-FOOT SPHERE
1296	SHOP BUILDING
1297	LUNAR LANDING RESEARCH FACILITY

FACILITIES AUTHORIZED AND UNDER CONSTRUCTION

A	EQUIPMENT FOR MAGNETOPLASMADYNAMICS RESEARCH
B	ADDITION TO HEATING PLANT
C	ADD. POWER SUPPLY AND IMPROVED ARC CHAMBER FOR 10-MEGAWATT ARC TUNNEL
D	ENVIRONMENTAL RESEARCH FACILITIES FOR SPACECRAFT COMPONENTS AND MATERIALS
E	PARTICLE ACCELERATOR FOR SIMULATION OF MICRO-METEOROID IMPACT
F	STABILIZATION AND CONTROL EQUIPMENT LABORATORY
G&H	VEHICLE ANTENNA TEST FACILITY AND ADDITION TO VEHICLE ANTENNA TEST FACILITY
I	ELECTRONIC INSTRUMENTATION LABORATORY
J	UTILITY INSTALLATIONS
K	HOT GAS RADIATION RESEARCH FACILITY
L	THERMAL CONTROL HOUSING AND BUILDING ADDITION FOR DYNAMICS RESEARCH LABORATORY
M	FATIGUE RESEARCH LABORATORY
N	CENTRAL HIGH-PRESSURE AIR SUPPLY
O	UTILITY IMPROVEMENTS

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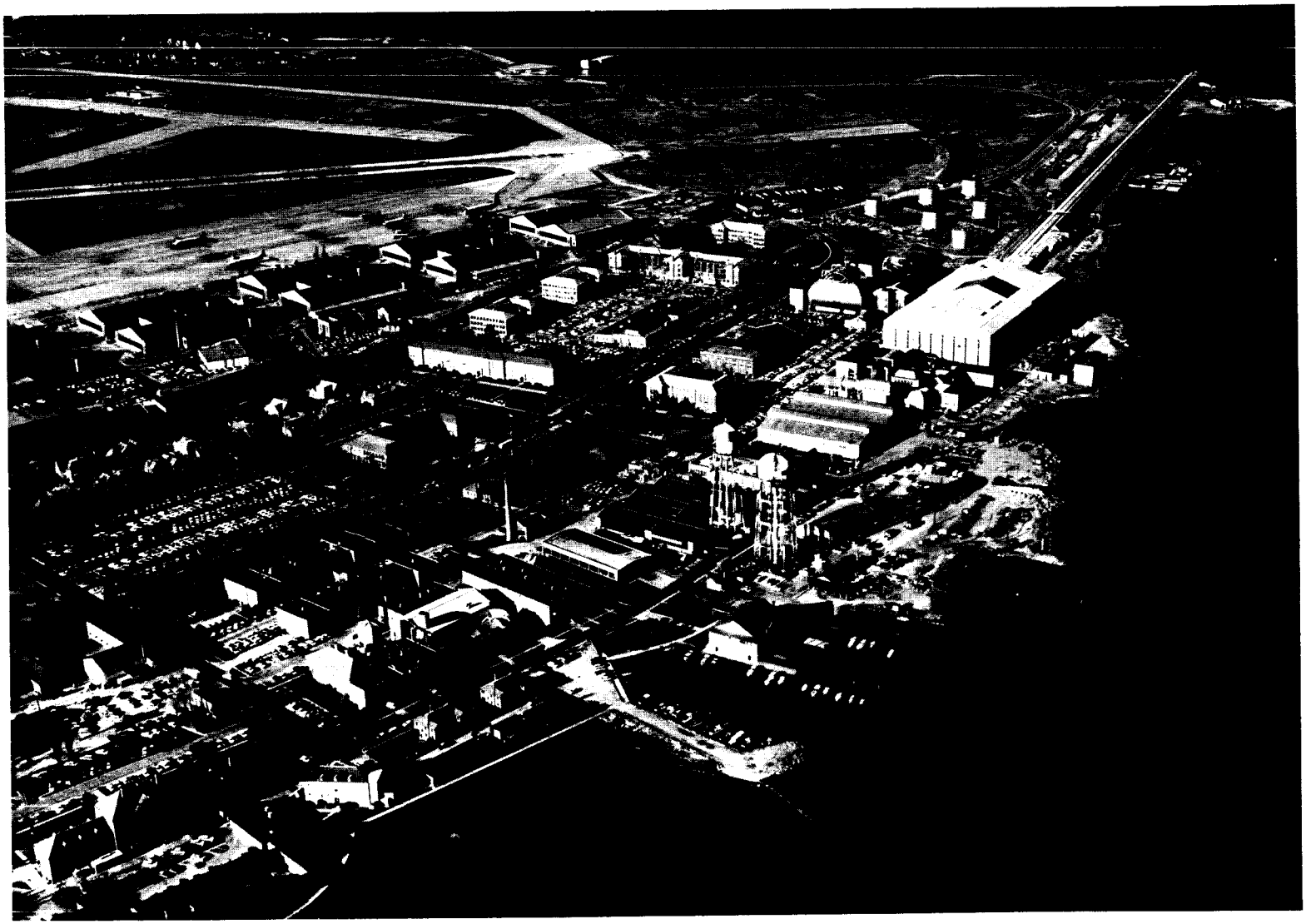
WEST AREA

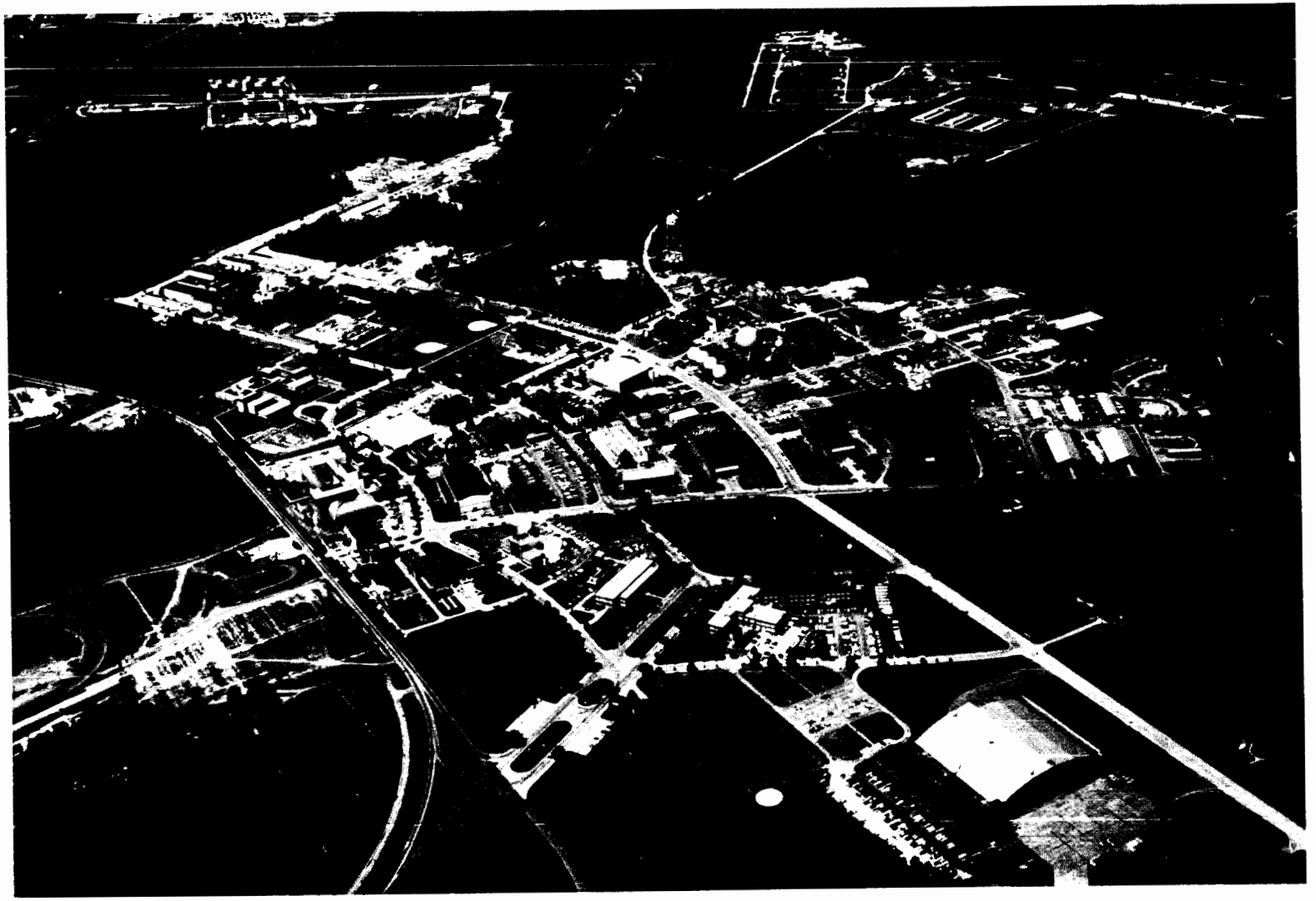
NASA
L-62-422

LANGLEY RESEARCH CENTER
Hampton, Virginia



AERIAL VIEW - East Area

LANGLEY RESEARCH CENTER
Hampton, Virginia



AERIAL VIEW - West Area

RESEARCH STAFF OFFICE

	65	66
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	1	1
All other GS	-	-
Wage Board	-	-
Total	8	8

PROGRAM CONTROL ANALYSIS AND BUDGET OFFICE

	65	66
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	1	1
All other GS	6	6
Wage Board	-	-
Total	8	8

TECHNOLOGY UTILIZATION OFFICE

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	1	1
All other GS	2	2
Wage Board	-	-
Total	3	3

RESEARCH CONTRACTS AND INFORMATION OFFICE

	65	66
Excepted	-	-
GS-16	-	-
GS-15	2	2
GS-14	-	-
All other GS	-	-
Wage Board	-	-
Total	2	2

RESEARCH REPORTS DIVISION

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	1	1
All other GS	52	52
Wage Board	-	-
Total	53	53

OFFICE OF ASSISTANT DIRECTOR (GROUP 1)

	65	66
Excepted	1	1
GS-16	-	-
GS-15	1	1
GS-14	-	-
All other GS	-	-
Wage Board	-	-
Total	2	2

OFFICE OF ASSISTANT DIRECTOR (GROUP 2)

	65	66
Excepted	1	1
GS-16	-	-
GS-15	-	1
GS-14	-	-
All other GS	-	-
Wage Board	-	-
Total	1	2

OFFICE OF ASSISTANT DIRECTOR (GROUP 3)

	65	66
Excepted	1	1
GS-16	-	-
GS-15	1	1
GS-14	-	-
All other GS	-	-
Wage Board	-	-
Total	2	2

OFFICE OF ASSISTANT DIRECTOR FOR FLIGHT PROJECTS

	65	66
Excepted	1	1
GS-16	-	-
GS-15	1	1
GS-14	1	1
All other GS	1	1
Wage Board	-	-
Total	4	4

OFFICE OF ASSISTANT DIRECTOR FOR ADMINISTRATION

	65	66
Excepted	1	1
GS-16	-	-
GS-15	-	-
GS-14	-	-
All other GS	1	1
Wage Board	-	-
Total	2	2

ANALYSIS AND COMPUTATION DIVISION

	65	66
Excepted	1	1
GS-16	1	1
GS-15	3	3
GS-14	4	4
All other GS	148	148
Wage Board	12	12
Total	169	169

DYNAMIC LOADS DIVISION

	65	66
Excepted	2	2
GS-16	4	4
GS-15	6	6
GS-14	20	20
All other GS	106	106
Wage Board	2	2
Total	140	140

AERO-PHYSICS DIVISION

	65	66
Excepted	3	3
GS-16	7	7
GS-15	12	12
GS-14	15	15
All other GS	146	146
Wage Board	1	1
Total	179	179

FLIGHT REENTRY PROGRAMS OFFICE

	65	66
Excepted	2	2
GS-16	-	-
GS-15	2	2
GS-14	2	2
All other GS	14	14
Wage Board	-	-
Total	20	20

INSTRUMENT RESEARCH DIVISION

	65	66
Excepted	2	2
GS-16	1	1
GS-15	9	9
GS-14	26	26
All other GS	300	300
Wage Board	97	97
Total	435	435

STRUCTURES RESEARCH DIVISION

	65	66
Excepted	3	3
GS-16	2	2
GS-15	13	13
GS-14	12	12
All other GS	117	117
Wage Board	-	-
Total	147	147

FLIGHT MECHANICS AND TECHNOLOGY DIVISION

	65	66
Excepted	3	3
GS-16	1	1
GS-15	9	9
GS-14	12	12
All other GS	70	70
Wage Board	34	34
Total	129	129

LUNAR ORBITER OFFICE

	65	66
Excepted	2	2
GS-16	-	-
GS-15	5	5
GS-14	8	8
All other GS	25	25
Wage Board	-	-
Total	40	40

LUNAR FIELD PROJECTS OFFICE

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	1	1
All other GS	8	8
Wage Board	-	-
Total	9	9

MORL STUDIES OFFICE

	65	66
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	2	2
All other GS	6	6
Wage Board	-	-
Total	9	9

SPACE MECHANICS DIVISION

	65	66
Excepted	1	1
GS-16	3	3
GS-15	9	8
GS-14	8	8
All other GS	70	70
Wage Board	-	-
Total	91	90

FULL-SCALE RESEARCH DIVISION

	65	66
Excepted	3	3
GS-16	-	-
GS-15	20	20
GS-14	14	14
All other GS	146	146
Wage Board	-	-
Total	183	183

SCOUT PROJECT OFFICE

	65	66
Excepted	-	-
GS-16	-	-
GS-15	3	3
GS-14	7	7
All other GS	40	40
Wage Board	-	-
Total	50	50

APPLIED MATERIALS AND PHYSICS DIVISION

	65	66
Excepted	4	4
GS-16	1	1
GS-15	8	8
GS-14	24	24
All other GS	174	174
Wage Board	13	13
Total	224	224

OFFICE OF CHIEF COUNSEL

	65	66
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	2	2
All other GS	2	2
Wage board	-	-
Total	5	5

OFFICE OF PATENT COUNSEL

	65	66
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	2	2
All other GS	4	4
Wage Board	-	-
Total	7	7

PUBLIC AFFAIRS OFFICE

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	2	2
All other GS	3	3
Wage Board	-	-
Total	5	5

SECURITY OFFICE

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	1	1
All other GS	11	11
Wage Board	-	-
Total	12	12

ADMINISTRATIVE SERVICES DIVISION

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	1	1
All other GS	89	89
Wage Board	12	12
Total	102	102

SAFETY OFFICE

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	-	-
All other GS	3	3
Wage Board	-	-
Total	3	3

FISCAL DIVISION

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	1	1
All other GS	105	105
Wage Board	-	-
Total	106	106

COST ENGINEERING STAFF

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	1	1
All other GS	7	7
Wage Board	-	-
Total	8	8

PERSONNEL DIVISION

	65	66
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	3	3
All other GS	51	51
Wage Board	-	-
Total	55	55

PROGRAM SCHEDULES AND ANALYSIS UNIT

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	-	-
All other GS	13	13
Wage Board	-	-
Total	13	13

PHOTOGRAPHIC DIVISION

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	-	-
All other GS	38	38
Wage Board	46	46
Total	84	84

PLANNING CONTROL OFFICE

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	-	-
All other GS	10	10
Wage Board	-	-
Total	10	10

PROCUREMENT DIVISION

	65	66
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	4	4
All other GS	128	128
Wage Board	30	30
Total	163	163

TECHNICAL SERVICE CONTRACT SUPPORT UNIT

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	-	-
All other GS	12	12
Wage Board	-	-
Total	12	12

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
ORGANIZATION AND STAFFING CHART
LANGLEY RESEARCH CENTER

STAFFING SUMMARY

	65	66
Excepted	38	38
GS-16	16	16
GS-15	129	129
GS-14	222	222
All other GS	2,286	2,286
Wage Board	1,547	1,547
Total Permanent	4,238	4,238
Temporary	70	70
Total Positions	4,308	4,308

DIRECTOR
ASSOCIATE DIRECTOR

	65	66
Excepted	2	2
GS-16	-	-
GS-15	3	3
GS-14	1	1
All other GS	5	5
Wage Board	-	-
Total	11	11

SENIOR STAFF

Excepted	
GS-16	
GS-15	
GS-14	
All other GS	
Wage Board	
Total	

RESEARCH STAFF OFFICE

	65	66
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	1	1
All other GS	6	6
Wage Board	-	-
Total	8	8

PROGRAM CONTROL ANALYSIS AND BUDGET OFFICE

	65	66
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	1	1
All other GS	6	6
Wage Board	-	-
Total	8	8

TECHNOLOGY UTILIZATION OFFICE

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	1	1
All other GS	2	2
Wage Board	-	-
Total	3	3

RESE IN

Excepted	
GS-16	
GS-15	
GS-14	
All other	
Wage Boar	
Total	

OFFICE OF ASSISTANT DIRECTOR (GROUP 1)

	65	66
Excepted	1	
GS-16	-	-
GS-15	1	1
GS-14	-	-
All other GS	-	-
Wage Board	-	-
Total	2	2

ANALYSIS AND COMPUTATION DIVISION

	65	66
Excepted	1	1
GS-16	1	1
GS-15	3	3
GS-14	4	4
All other GS	145	145
Wage Board	12	12
Total	166	166

INSTRUMENT RESEARCH DIVISION

	65	66
Excepted	2	2
GS-16	1	1
GS-15	9	9
GS-14	26	26
All other GS	300	300
Wage Board	97	97
Total	435	435

SPACE MECHANICS DIVISION

	65	66
Excepted	1	1
GS-16	3	3
GS-15	9	9
GS-14	8	8
All other GS	70	70
Wage Board	-	-
Total	91	91

OFFICE OF ASSISTANT DIRECTOR (GROUP 2)

	65	66
Excepted	1	1
GS-16	-	-
GS-15	-	1
GS-14	-	-
All other GS	-	-
Wage Board	-	-
Total	1	2

DYNAMIC LOADS DIVISION

	65	66
Excepted	2	2
GS-16	4	4
GS-15	5	6
GS-14	20	20
All other GS	105	106
Wage Board	2	2
Total	140	140

STRUCTURES RESEARCH DIVISION

	65	66
Excepted	3	3
GS-16	2	2
GS-15	13	13
GS-14	12	12
All other GS	117	117
Wage Board	-	-
Total	147	147

OFFICE OF ASSISTANT DIRECTOR (GROUP 3)

	65	66
Excepted	1	1
GS-16	-	-
GS-15	1	1
GS-14	-	-
All other GS	-	-
Wage Board	-	-
Total	2	2

AERO-PHYSICS DIVISION

	65	66
Excepted	3	3
GS-16	2	2
GS-15	12	12
GS-14	15	15
All other GS	146	146
Wage Board	1	1
Total	179	179

FLIGHT MECHANICS AND TECHNOLOGY DIVISION

	65	66
Excepted	3	3
GS-16	1	1
GS-15	9	9
GS-14	12	12
All other GS	70	70
Wage Board	34	34
Total	129	129

FULL-SCALE RESEARCH DIVISION

	65	66
Excepted	3	3
GS-16	-	-
GS-15	20	20
GS-14	14	14
All other GS	146	146
Wage Board	-	-
Total	183	183

OFFICE OF ASSISTANT DIRECTOR FOR FLIGHT PROJECTS

	65	66
Excepted	1	1
GS-16	-	-
GS-15	1	1
GS-14	1	1
All other GS	1	1
Wage Board	-	-
Total	4	4

FLIGHT REENTRY PROGRAMS OFFICE

	65	66
Excepted	2	2
GS-16	-	-
GS-15	2	2
GS-14	2	2
All other GS	14	14
Wage Board	-	-
Total	20	20

LUNAR ORBITER OFFICE

	65	66
Excepted	2	2
GS-16	-	-
GS-15	5	5
GS-14	8	8
All other GS	25	25
Wage Board	-	-
Total	40	40

SCOUT PROJECT OFFICE

	65	66
Excepted	-	-
GS-16	-	-
GS-15	3	3
GS-14	7	7
All other GS	40	40
Wage Board	-	-
Total	50	50

APPLIED MATERIALS AND PHYSICS DIVISION

	65	66
Excepted	4	4
GS-16	1	1
GS-15	8	8
GS-14	24	24
All other GS	174	174
Wage Board	15	15
Total	226	226

AEROSPACE FIELD PROJECTS OFFICE

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	1	1
All other GS	8	8
Wage Board	-	-
Total	9	9

MORL STUDIES OFFICE

	65	66
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	2	2
All other GS	6	6
Wage Board	-	-
Total	9	9

OFFICE

Excepted	
GS-16	
GS-15	
GS-14	
All otle	
Wage Boa	
Total	

OFFICE

Excepted	
GS-16	
GS-15	
GS-14	
All other	
Wage Boar	
Total	

PUB

Excepted	
GS-16	
GS-15	
GS-14	
All othe	
Wage Boa	
Total	

SE

Excepted	
GS-16	
GS-15	
GS-14	
All other	
Wage Boar	
Total	

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ORGANIZATION AND STAFFING CHART

LANGLEY RESEARCH CENTER

DIRECTOR
ASSOCIATE DIRECTOR

	65	66
Excepted	2	2
GS-16	-	-
GS-15	3	3
GS-14	1	1
All other GS	5	5
Wage Board	-	-
Total	11	11

SENIOR STAFF SCIENTIST

	65	66
Excepted	1	1
GS-16	-	-
GS-15	-	-
GS-14	-	-
All other GS	-	-
Wage Board	-	-
Total	1	1

COOPERATIVE PROJECTS OFFICE

	65	66
Excepted	1	1
GS-16	-	-
GS-15	-	-
GS-14	-	-
All other GS	-	-
Wage Board	-	-
Total	1	1

MANNED SPACECRAFT PROJECTS OFFICE

	65	66
Excepted	1	1
GS-16	-	-
GS-15	-	-
GS-14	-	-
All other GS	-	-
Wage Board	-	-
Total	1	-

RESEARCH CONTRACTS AND INFORMATION OFFICE

	65	66
Excepted	-	-
GS-16	-	-
GS-15	2	2
GS-14	-	-
All other GS	-	-
Wage Board	-	-
Total	2	2

RESEARCH REPORTS DIVISION

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	1	1
All other GS	52	52
Wage Board	-	-
Total	53	53

OFFICE OF ASSISTANT DIRECTOR FOR FLIGHT PROJECTS

	65	66
Excepted	1	1
GS-16	-	-
GS-15	1	1
GS-14	1	1
All other GS	1	1
Wage Board	-	-
Total	4	4

OFFICE OF ASSISTANT DIRECTOR FOR ADMINISTRATION

	65	66
Excepted	1	1
GS-16	-	-
GS-15	-	-
GS-14	-	-
All other GS	1	1
Wage Board	-	-
Total	2	2

OFFICE OF CHIEF, ENGINEERING AND TECHNICAL SERVICES

	65	66
Excepted	2	2
GS-16	-	-
GS-15	1	1
GS-14	1	1
All other GS	4	4
Wage Board	-	-
Total	8	8

[illegible]

	65	66
Excepted	2	2
GS-16	-	-
GS-15	2	2
GS-14	2	2
All other GS	14	14
Wage Board	-	-
Total	20	20

[illegible]FICE

	65	66
Excepted	2	2
GS-16	-	-
GS-15	5	5
GS-14	8	8
All other GS	25	25
Wage Board	-	-
Total	40	40

[illegible]FICE

	65	66
Excepted	-	-
GS-16	-	-
GS-15	3	3
GS-14	7	7
All other GS	40	40
Wage Board	-	-
Total	50	50

LRC [illegible] FIELD PROJECTS OFFICE

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	1	1
All other GS	8	8
Wage Board	-	-
Total	9	9

MORL STUDIES OFFICE

	65	66
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	2	2
All other GS	6	6
Wage Board	-	-
Total	9	9

APPLIED MATERIALS AND PHYSICS DIVISION

	65	66
Excepted	4	4
GS-16	1	1
GS-15	8	8
GS-14	24	24
All other GS	174	174
Wage Board	15	15
Total	226	226

OFFICE OF CHIEF COUNSEL

	65	66
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	2	2
All other GS	2	2
Wage Board	-	-
Total	5	5

OFFICE OF PATENT COUNSEL

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	1
GS-14	2	2
All other GS	4	4
Wage Board	-	-
Total	6	7

PUBLIC AFFAIRS OFFICE

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	2	2
All other GS	3	3
Wage Board	-	-
Total	5	5

SECURITY OFFICE

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	1	1
All other GS	11	11
Wage Board	-	-
Total	12	12

ADMINISTRATIVE SERVICES DIVISION

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	1	1
All other GS	89	89
Wage Board	12	12
Total	102	102

FISCAL DIVISION

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	1	1
All other GS	105	105
Wage Board	-	-
Total	106	106

PERSONNEL DIVISION

	65	66
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	3	3
All other GS	51	51
Wage Board	-	-
Total	55	55

PHOTOGRAPHIC DIVISION

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	-	-
All other GS	38	38
Wage Board	46	46
Total	84	84

PROCUREMENT DIVISION

	65	66
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	4	4
All other GS	128	128
Wage Board	30	30
Total	163	163

SAFETY OFFICE

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	-	-
All other GS	3	3
Wage Board	-	-
Total	3	3

COST ENGINEERING STAFF

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	1	1
All other GS	7	7
Wage Board	-	-
Total	8	8

PROGRAM SCHEDULES AND ANALYSIS UNIT

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	-	-
All other GS	13	13
Wage Board	-	-
Total	13	13

PLANNING CONTROL OFFICE

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	-	-
All other GS	10	10
Wage Board	-	-
Total	10	10

TECHNICAL SERVICE CONTRACT SUPPORT UNIT

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	-	-
All other GS	12	12
Wage Board	-	-
Total	12	12

ELECTRICAL SYSTEMS DIVISION

	65	66
Excepted	-	-
GS-16	-	-
GS-15	3	3
GS-14	6	6
All other GS	67	67
Wage Board	209	209
Total	285	285

FLIGHT VEHICLES AND SYSTEMS DIVISION

	65	66
Excepted	-	-
GS-16	1	1
GS-15	6	6
GS-14	16	16
All other GS	114	114
Wage Board	-	-
Total	137	137

MECHANICAL SERVICE DIVISION

	65	66
Excepted	-	-
GS-16	-	-
GS-15	2	2
GS-14	5	5
All other GS	25	25
Wage Board	905	905
Total	937	937

PLANT MAINTENANCE DIVISION

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	1	1
All other GS	5	5
Wage Board	179	179
Total	185	185

RESEARCH MODELS AND FACILITIES DIVISION

	65	66
Excepted	-	-
GS-16	-	-
GS-15	3	3
GS-14	15	15
All other GS	152	152
Wage Board	5	5
Total	175	175

ADMINISTRATIVE OPERATIONS

FISCAL YEAR 1966 ESTIMATES

LANGLEY RESEARCH CENTER

MISSION AND CAPABILITIES:

The Langley Research Center directs its research effort toward: new problems that confront future progress in flight; the establishment of the characteristics of the aerospace environment and their interactions with flight systems and personnel; the formulation and refinement of engineering-design concepts and methods, construction technologies, operational techniques for advanced aircraft and space vehicle configurations; systems components and ground support equipment; safe and efficient flight in extended regimes of performance; and the support of the Aerospace Industry and Government services in the development of their advanced flight systems.

The Installation has developed a highly talented and dedicated research team specializing preeminently in aerodynamics, thermodynamics, flight environments, high temperature structures and materials, vehicle structural loads and dynamics, guidance and control systems, flight crew integration and life support, flight mechanics and operations, solid-propellant rocketry and aerospace electronics.

Research on flight problems has pioneered the development and application of a wide range of advanced research techniques, equipment, flight vehicles, and laboratory facilities for investigations in these disciplines. These capabilities are being directed to the evaluation and refinement of aircraft and space vehicle configurations under current development, and to the establishment of rational concepts and design criteria for more advanced flight systems.

A number of flight projects are conducted, many in support of the Apollo program, for advanced flight conditions which cannot be simulated in laboratory facilities. The Installation also is pursuing the development of the Lunar Orbiter Space System and is responsible for the management and operational support of the Scout Launch vehicle.

Broad investigations are underway to identify and resolve critical technological problems confronting the development and operation of manned orbital research laboratories.

A number of unique aerospace simulators are available at the Installation. Complex space flight simulators devised and used by scientists in basic research problems have been effectively utilized in the training of astronauts in preparation of manned flights in the Gemini and Apollo projects.

SUMMARY OF RESOURCES REQUIREMENTS:

	1964	1965	1966
Number of Positions, end of year.	4,330	4,308	4,308
Average Number of All Employees..	4,260	4,292	4,281
Administrative Operations.....	$52,642,000	$57,258,000	$61,783,000

INSTALLATION DESCRIPTION:

Langley Research Center is located at Hampton, Virginia. The Center is divided into two separate areas adjacent to the runway facilities of Langley Air Force Base and occupies 772 acres of government owned land. Four hundred and thirty acres are owned by NASA and 342 acres are occupied under permit from the United States Air Force. Runways, some utilities, and certain other facilities are used jointly by NASA and the United States Air Force. In addition, there are 110 acres of NASA-owned land located in the city of Newport News, Virginia. The total capital investment as of June 30, 1964 including the acreage located at Newport News, Virginia was $249,776,000.

ANALYSIS OF RESOURCES REQUIREMENTS BY OBJECT CLASSIFICATION:

		1964	1965	1966
11.	Personnel Compensation.....	$ 35,926,000	$38,826,000	$38,896,000
12.	Personnel Benefits.....	2,654,000	2,861,000	2,889,000
	Total, personnel costs...	$ 38,580,000	$41,687,000	$41,785,000
21.	Travel and Transportation of Persons.....	1,288,000	1,380,000	1,370,000
22.	Transportation of Things...	450,000	440,000	440,000
23.	Rents, Communications, and Utilities.....	4,718,000	5,424,000	4,110,000
24.	Printing and Reproduction..	191,000	200,000	200,000
25.	Other Services.....	2,540,000	2,517,000	2,866,000
	Services of other agencies	533,000	90,000	90,000
26.	Supplies and Materials.....	2,718,000	2,600,000	2,600,000
31.	Equipment.....	998,000	2,419,000	7,821,000
32.	Lands and Structures.....	626,000	500,000	500,000
42.	Insurance Claims and Indemnities.....	---	1,000	1,000
	Total.....	$ 52,642,000	$57,258,000	$61,783,000

JUSTIFICATION BY OBJECT CLASSIFICATION:

Personnel Distribution

	1964	1965	1966
Direct personnel by program			
Manned Space Flight			
Gemini	3	2	2
Apollo	26	8	-
Advanced missions	18	18	18
Space Science and Applications			
Physics and Astronomy	44	40	34
Lunar and Planetary Exploration	89	147	148
Launch vehicle development	36	24	27
Meteorological Satellites	9	13	13
Communication Satellites	16	11	11
Launch vehicle procurement	65	65	65
Advanced Research and Technology			
Nuclear electric systems	-	1	-
Solar and chemical power	27	39	39
Space vehicle systems	702	665	660
Electronics systems	465	473	482
Aeronautics	650	674	671
Human factor systems	38	45	45
Chemical propulsion	66	49	49
Basic research	362	364	374
Tracking and Data Acquisition	32	20	20
Technology Utilization	3	3	3
Sub-total, direct positions	2,651	2,661	2,661
Support personnel			
Director and staff	33	33	33
Administration	577	577	577
Research and development support	1,018	967	967
Sub-total, support positions	1,628	1,577	1,577
Total, permanent positions	4,279	4,238	4,238

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	1964	1965	1966
Other positions:			
Positions under cooperative training agreements.....	51	51	51
Other temporary positions.....	0	19	19
Total, all positions.....	4,330	4,308	4,308

Personnel Requirements:

The personnel program proposed for the Langley Research Center will continue to reflect major emphasis on problems relating to vehicle configurations, materials and structures, flight mechanics, and specific investigations associated with reentry, supersonic, and hypersonic flight. Minor reassignments of personnel between programs will be affected in conformity with changing program priorities.

The nominal increase in personnel costs is essentially required to meet the full-year cost of personnel added in FY 1965. It is expected that the FY 1966 man-years of effort will approximate the FY 1965 level.

Personnel Costs

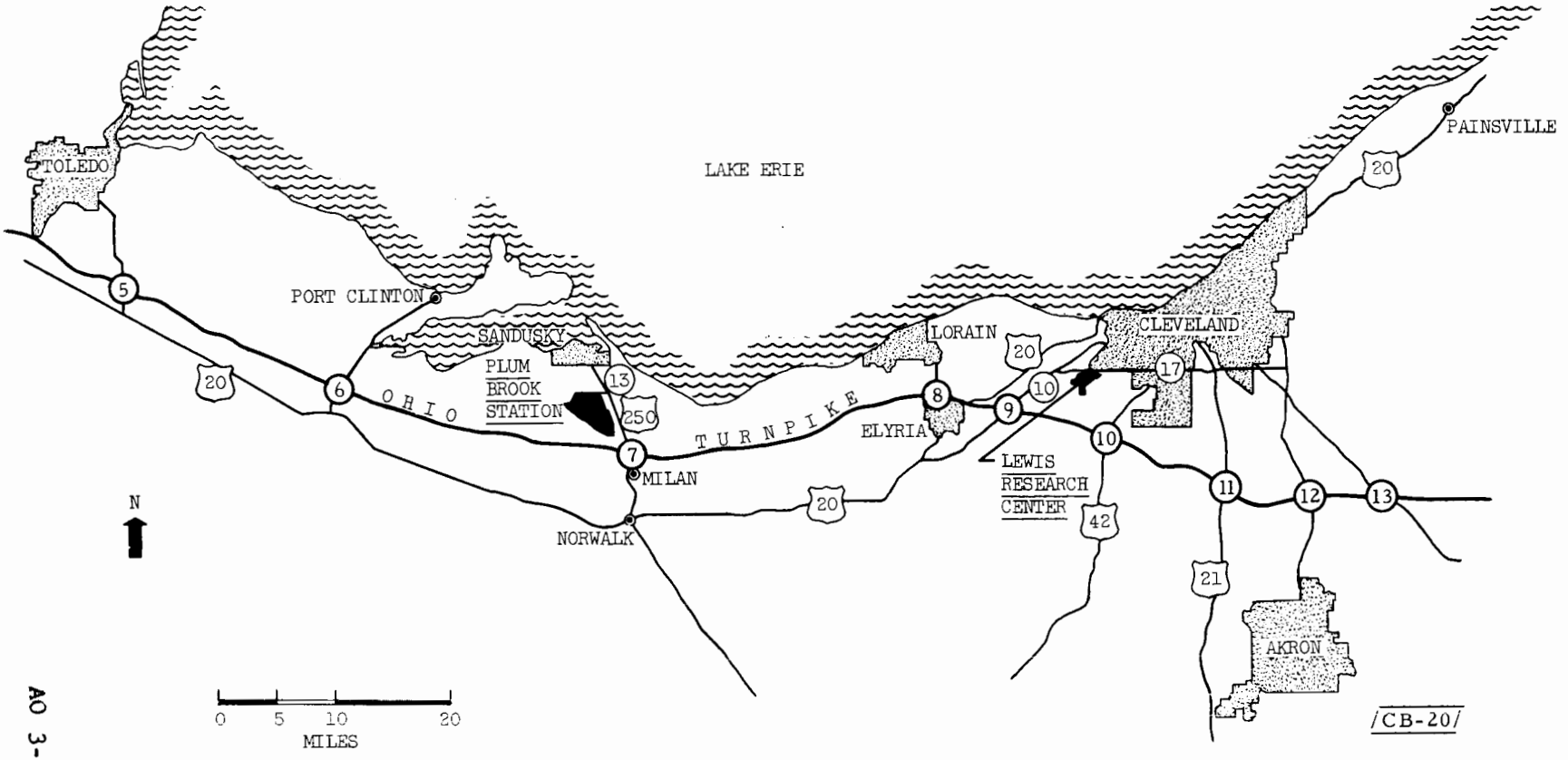
	1964	1965	1966
Total Positions.....	4,330	4,308	4,308
Permanent.....	4,279	4,238	4,238
Other.....	51	70	70
Personnel Compensation:			
Annual cost of permanent positions.....	$35,966,000	$37,424,000	$37,424,000
Pay above the stated annual rate	305,000	175,000	175,000
Lapses (deduct).....	-1,606,000	-216,000	-80,000
Net cost of permanent positions.	34,665,000	37,383,000	37,519,000
Other personnel compensation....	1,261,000	1,443,000	1,377,000
Total compensation.....	35,926,000	38,826,000	38,896,000
NASA funded.....	35,926,000	38,826,000	38,896,000
Reimbursable.....	---	---	---
Personnel benefits.....	2,654,000	2,861,000	2,889,000
NASA funded.....	2,654,000	2,861,000	2,889,000
Reimbursable.....	---	---	---

	1964	1965	1966
Total personnel costs.....	38,580,000	41,687,000	41,785,000
NASA funded.....	38,580,000	41,687,000	41,785,000
Reimbursable.....	---	---	---
Average Number of All Employees (Man-Years).....	4,260	4,292	4,281

Requirements for all other objects, excluding the proposed computer purchase program, reflects an increase of $60,000 over the amount estimated to be required for FY 1965. An increase of $4,367,000 in the overall computer operations at the Langley Research Center will be required for the purpose of procuring selected electronic computing equipment to meet long-range research computing requirements.

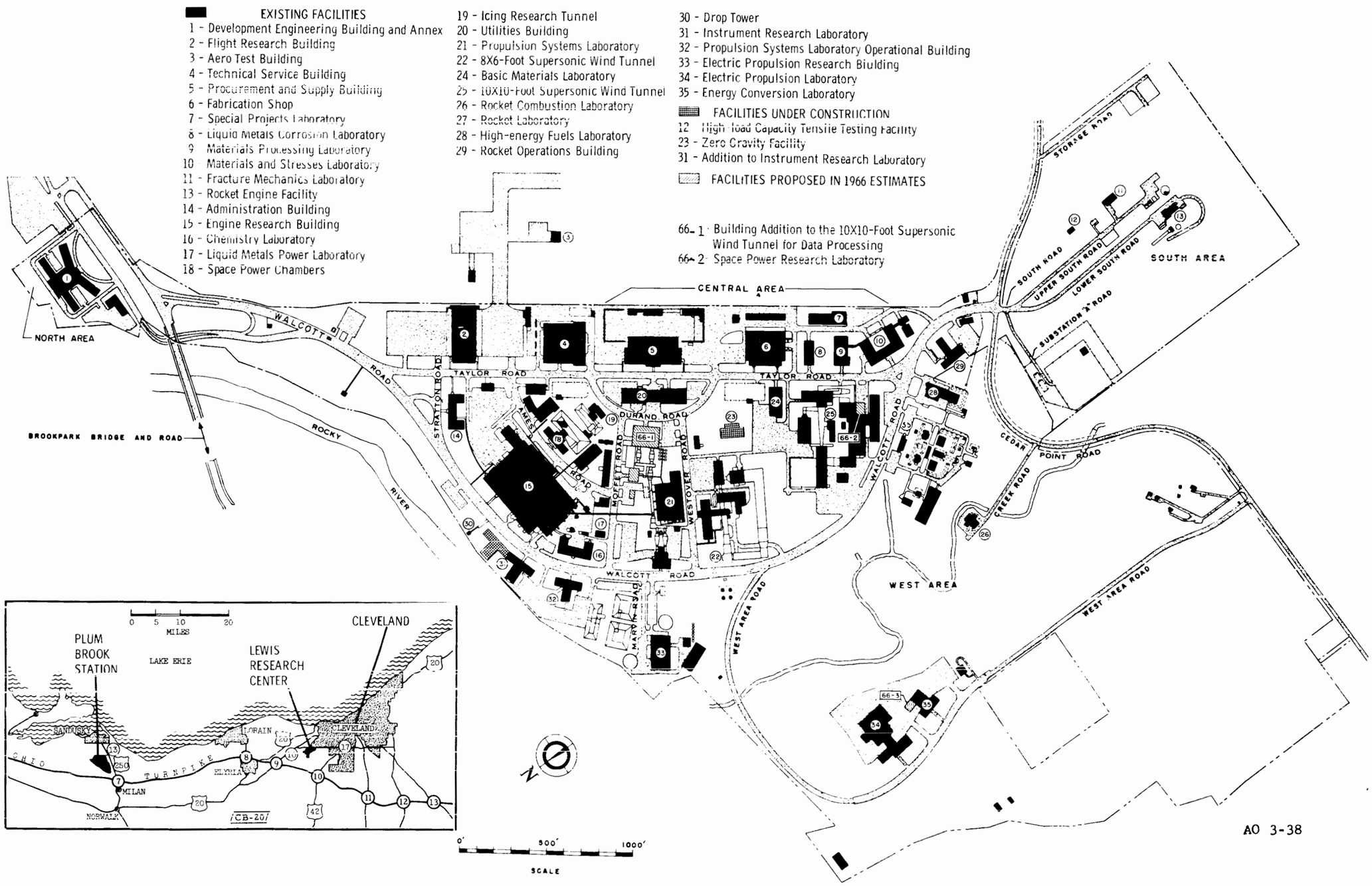
Lower requirements in certain object classes are offset by an increase in other contractual services required for increased maintenance and operation costs of new facilities coming into initial operation in FY 1966, as well as the full-year cost for those facilities placed in initial operation in FY 1965.

LOCATION OF LEWIS RESEARCH CENTER INCLUDING PLUM BROOK STATION



LEWIS RESEARCH CENTER
FISCAL YEAR 1966 ESTIMATES

LOCATION PLAN



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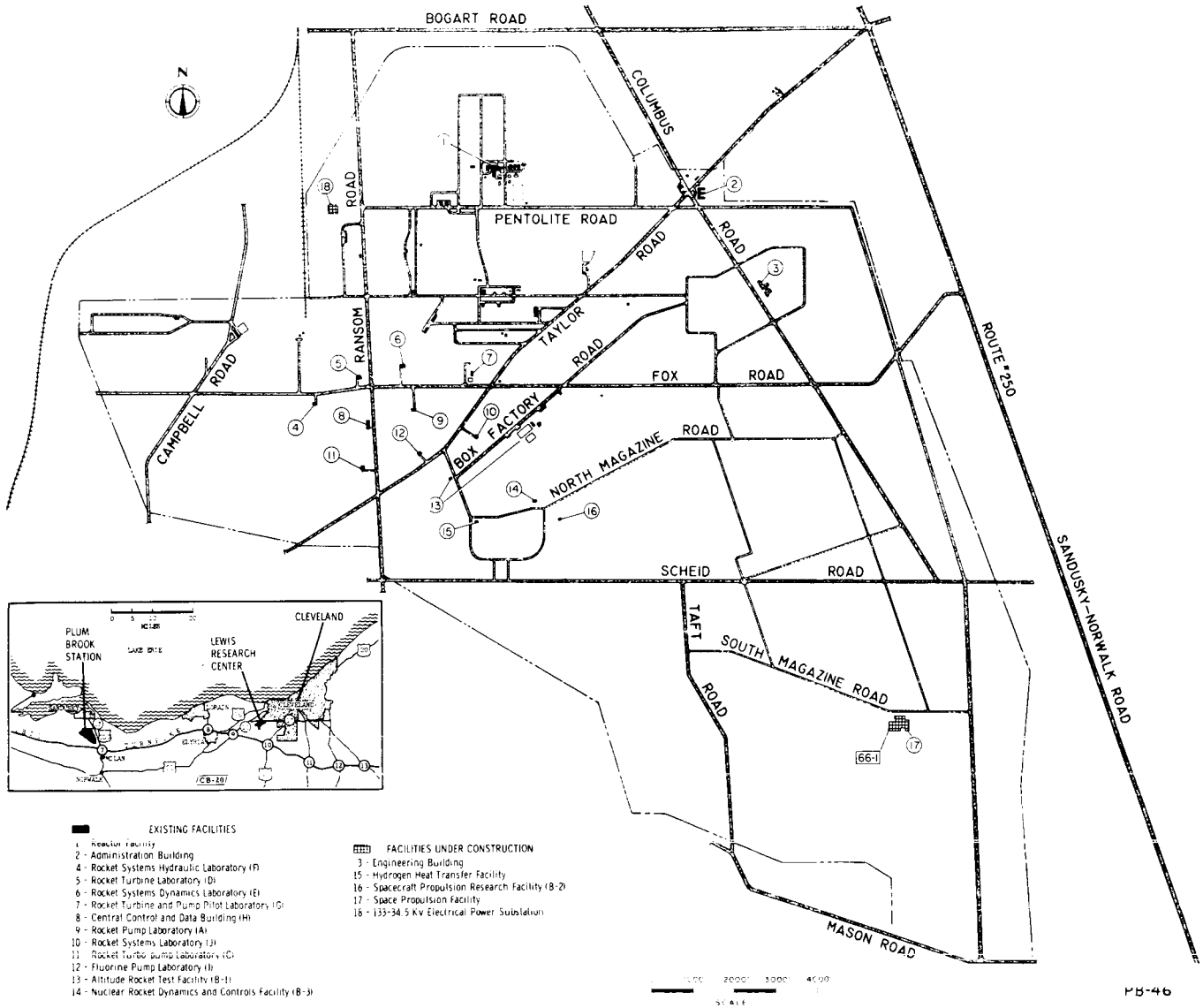
LEWIS RESEARCH CENTER
PLUM BROOK STATION
FISCAL YEAR 1966 ESTIMATES

LOCATION PLAN



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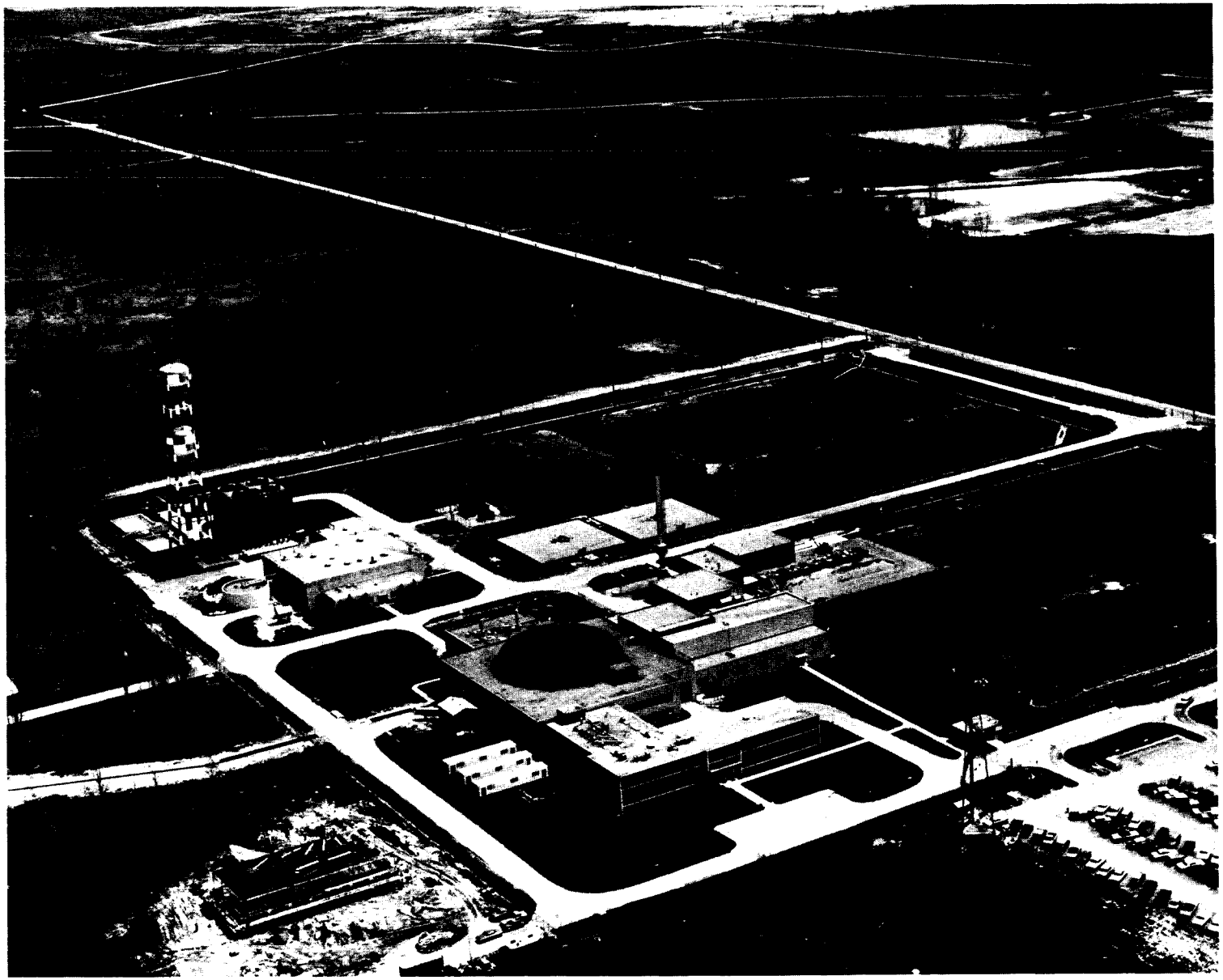
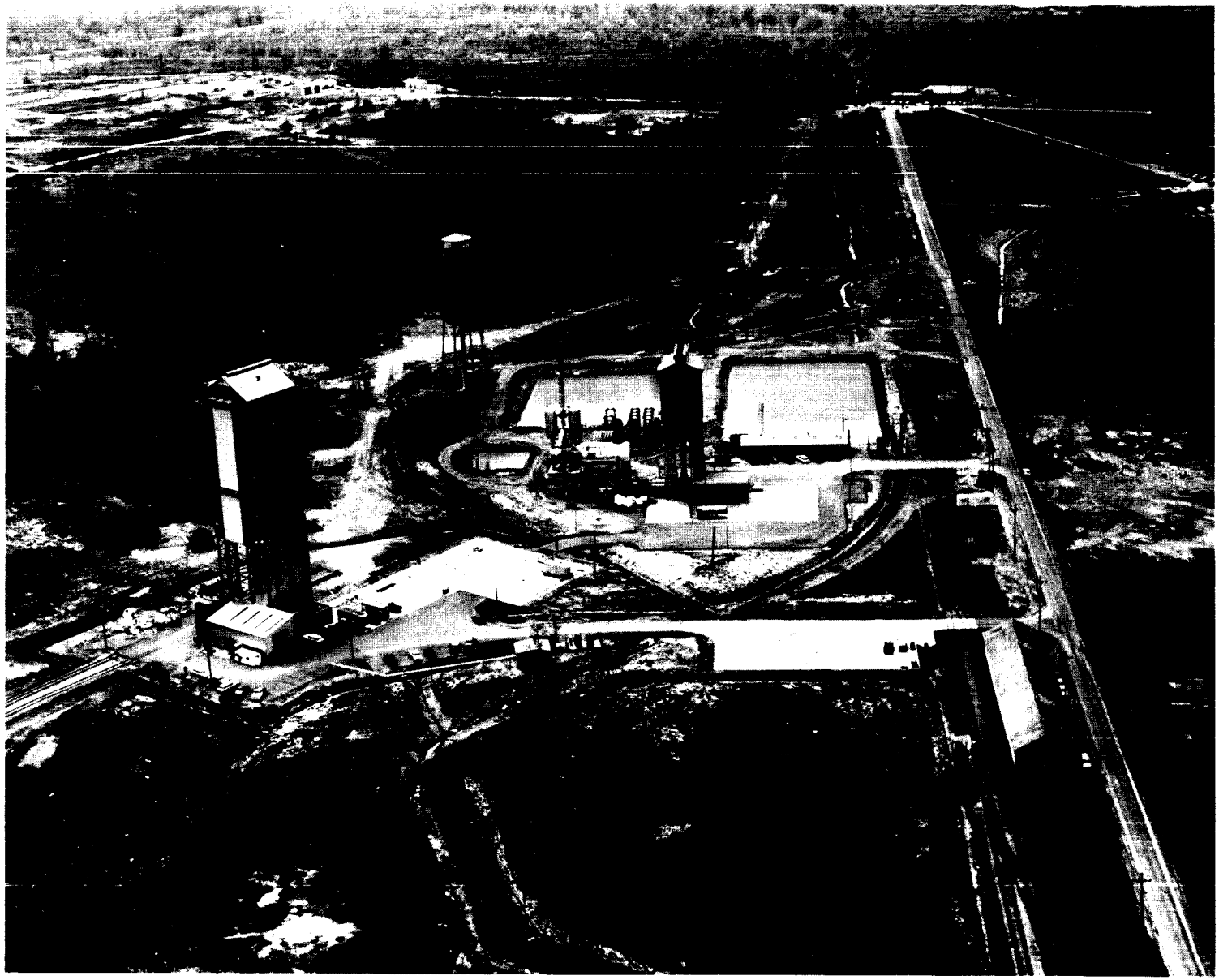
LEWIS RESEARCH CENTER

PLUM BROOK STATION - SOUTH AREA



PLUM BROOK STATION - WEST AREA



	65	66
Excepted	1	1
GS-16	-	-
GS-15	1	1
GS-14	-	-
All other GS	1	1
Wage Board	-	-
Total	3	3

OFFICE OF RESEARCH PLANS AND PROGRAMS	65	66
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	1	1
All other GS	2	2
Wage Board	-	-
Total	4	4

DIRECTOR FOR DEVELOPMENT	65	66
Excepted	1	1
GS-16	-	-
GS-15	1	1
GS-14	-	-
All other GS	2	2
Wage Board	-	-
Total	4	4

OFFICE OF DEVELOPMENT PLANS AND PROGRAMS	65	66
Excepted	1	1
GS-16	-	-
GS-15	1	1
GS-14	4	4
All other GS	8	8
Wage Board	-	-
Total	14	14

OFFICE OF DIRECTOR	65	66
Excepted	1	1
GS-16	-	-
GS-15	1	1
GS-14	-	-
All other GS	5	5
Wage Board	-	-
Total	7	7

STAFF ASSISTANTS	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	3	3
All other GS	44	44
Wage Board	-	-
Total	47	47

DIRECTOR FOR ADMINISTRATION	65	66
Excepted	1	1
GS-16	-	-
GS-15	-	-
GS-14	-	-
All other GS	6	6
Wage Board	-	-
Total	7	7

STAFF ASSISTANTS	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	1	1
All other GS	32	32
Wage Board	-	-
Total	33	33

OFFICE OF TECHNICAL	
Excepted	
GS-16	
GS-15	
GS-14	
All other GS	
Wage Board	
Total	

CHEMISTRY AND ENERGY CONVERSION DIVISION	65	66
Excepted	1	1
GS-16	2	2
GS-15	16	16
GS-14	26	26
All other GS	84	84
Wage Board	1	1
Total	131	131

MISSION ANALYSES BRANCH	65	66
Excepted	-	-
GS-16	-	-
GS-15	3	3
GS-14	2	2
All other GS	17	17
Wage Board	-	-
Total	22	22

OFFICE OF RELIABILITY AND QUALITY ASSURANCE	65	66
Excepted	1	1
GS-16	-	-
GS-15	-	-
GS-14	17	17
All other GS	24	24
Wage Board	-	-
Total	42	42

ROCKET SYSTEMS DIVISION	65	66
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	7	7
All other GS	55	55
Wage Board	-	-
Total	63	63

PERSONNEL DIVISION	65	66
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	2	2
All other GS	71	71
Wage Board	-	-
Total	74	74

PLANT SERVICE	
Excepted	
GS-16	
GS-15	
GS-14	
All other GS	
Wage Board	
Total	

ELECTROMAGNETIC PROPULSION DIVISION	65	66
Excepted	2	2
GS-16	1	1
GS-15	9	9
GS-14	14	14
All other GS	101	101
Wage Board	-	-
Total	127	127

SPACE POWER SYSTEM DIVISION	65	66
Excepted	2	2
GS-16	-	-
GS-15	6	6
GS-14	28	28
All other GS	123	123
Wage Board	-	-
Total	159	159

REACTOR DIVISION	65	66
Excepted	-	-
GS-16	1	1
GS-15	2	2
GS-14	8	8
All other GS	89	89
Wage Board	-	-
Total	100	100

FINANCE DIVISION	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	1	1
All other GS	67	67
Wage Board	-	-
Total	68	68

TEST INSTR DIVI	
Excepted	
GS-16	
GS-15	
GS-14	
All other GS	
Wage Board	
Total	

MATERIAL AND STRUCTURES DIVISION	65	66
Excepted	1	1
GS-16	1	1
GS-15	14	14
GS-14	20	20
All other GS	109	109
Wage Board	-	-
Total	147	147

CENTAUR PROJECT	65	66
Excepted	2	2
GS-16	1	1
GS-15	14	14
GS-14	28	28
All other GS	140	140
Wage Board	1	1
Total	186	186

ENGINEERING DIVISION	65	66
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	6	6
All other GS	41	41
Wage Board	1	1
Total	49	49

ADMINISTRATIVE SERVICES DIVISION	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	1	1
All other GS	37	37
Wage Board	8	8
Total	46	46

FACILITIES O DIVIS	
Excepted	
GS-16	
GS-15	
GS-14	
All other GS	
Wage Board	
Total	

INSTRUMENT AND COMPUTING DIVISION	65	66
Excepted	2	2
GS-16	1	1
GS-15	9	9
GS-14	12	12
All other GS	171	171
Wage Board	87	87
Total	282	282

AGENA PROJECT	65	66
Excepted	1	1
GS-16	2	2
GS-15	8	8
GS-14	20	20
All other GS	85	85
Wage Board	-	-
Total	116	116

ADMINISTRATION DIVISION	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	-	-
All other GS	22	22
Wage Board	4	4
Total	26	26

PROCUREMENT AND SUPPLY DIVISION	65	66
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	7	7
All other GS	186	186
Wage Board	27	27
Total	221	221

FABRICATION	
Excepted	
GS-16	
GS-15	
GS-14	
All other GS	
Wage Board	

FLUID SYSTEMS COMPONENTS DIVISION	65	66
Excepted	3	3
GS-16	3	3
GS-15	14	14
GS-14	24	24
All other GS	97	97
Wage Board	-	-
Total	141	141

CHEMICAL ROCKET SYSTEMS DIVISION	65	66
Excepted	2	2
GS-16	1	1
GS-15	6	6
GS-14	18	18
All other GS	103	103
Wage Board	-	-
Total	130	130

TECHNICAL INFORMATION DIVISION	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	1	1
All other GS	92	92
Wage Board	22	22
Total	115	115

ENGINEERING DES	
Excepted	
GS-16	
GS-15	
GS-14	
All other GS	
Wage Board	

NUCLEAR REACTOR DIVISION	65	66
Excepted	1	1
GS-16	4	4
GS-15	13	13
GS-14	19	19
All other GS	100	100
Wage Board	-	-
Total	137	137

ADVANCED DEVELOPMENT AND EVALUATION DIVISION	65	66
Excepted	-	-
GS-16	-	-
GS-15	8	8
GS-14	21	21
All other GS	127	127
Wage Board	-	-
Total	156	156

FACILITIES ENG DIVISIO	
Excepted	
GS-16	
GS-15	
GS-14	
All other GS	
Wage Board	
Total	

SPACECRAFT TECHNOLOGY DIVISION	65	66
Excepted	-	-
GS-16	-	-
GS-15	7	7
GS-14	8	8
All other GS	87	87
Wage Board	-	-
Total	103	103

CONSTRUCTION	
Excepted	
GS-16	
GS-15	
GS-14	
All other GS	
Wage Board	
Total	

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
ORGANIZATION AND STAFFING CHART
LEWIS RESEARCH CENTER

STAFFING SUMMARY

	65	66
Excepted	35	35
GS-16	17	17
GS-15	155	155
GS-14	319	319
All other GS	2,541	2,541
Wage Board	1,648	1,648
Total Permanent	4,715	4,715
Temporary	32	32
Total Positions	4,747	4,747

RESOURCES PLANNING OFFICE

	65	66
Excepted	1	1
GS-16	-	-
GS-15	-	-
GS-14	2	2
All other GS	9	9
Wage Board	-	-
Total	12	12

OFFICE OF THE DIRECTOR

	65	66
Excepted	2	2
GS-16	-	-
GS-15	-	-
GS-14	-	-
All other GS	3	3
Wage Board	-	-
Total	5	5

OFFICE OF ASSOCIATE DIRECTOR FOR RESEARCH

	65	66
Excepted	1	1
GS-16	-	-
GS-15	1	1
GS-14	-	-
All other GS	1	1
Wage Board	-	-
Total	3	3

OFFICE OF RESEARCH PLANS AND PROGRAMS

	65	66
Excepted	-	-
GS-16	-	
GS-15	1	
GS-14	1	
All other GS	2	
Wage Board	-	-
Total	4	4

OFFICE OF ASSOCIATE DIRECTOR FOR DEVELOPMENT

	65	66
Excepted	1	1
GS-16	-	-
GS-15	1	1
GS-14	-	-
All other GS	2	2
Wage Board	-	-
Total	4	4

OFFICE OF DEVELOPMENT PLANS AND PROGRAMS

	65	66
Excepted	1	1
GS-16	-	-
GS-15	1	1
GS-14	4	4
All other GS	8	8
Wage Board	-	-
Total	14	14

PLUM BROOK STATION OFFICE OF DIRECTOR

	65	66
Excepted	1	-
GS-16	-	-
GS-15	1	1
GS-14	-	-
All other GS	5	5
Wage Board	-	-
Total	7	7

STAFF ASSISTANTS

	65	66
Excepted	-	
GS-16	-	
GS-15	3	
GS-14		
All other GS	44	
Wage Board	-	
Total	47	

CHEMISTRY AND ENERGY CONVERSION DIVISION

	65	66
Excepted	1	1
GS-16	2	2
GS-15	15	18
GS-14	20	20
All other GS	89	89
Wage Board	1	1
Total	131	131

MISSION ANALYSES BRANCH

	65	66
Excepted	-	-
GS-16	-	-
GS-15	3	3
GS-14	2	2
All other GS	17	17
Wage Board	-	-
Total	22	22

OFFICE OF RELIABILITY AND QUALITY ASSURANCE

	65	66
Excepted	1	1
GS-16	-	-
GS-15	-	-
GS-14	17	17
All other GS	24	24
Wage Board	-	-
Total	42	42

ROCKET SYSTEMS DIVISION

	65	66
Excepted	-	-
GS-16	1	1
GS-15	7	7
GS-14	55	55
All other GS	-	-
Wage Board	-	-
Total	63	63

ELECTROMAGNETIC PROPULSION DIVISION

	65	66
Excepted	2	2
GS-16	1	1
GS-15	9	9
GS-14	14	14
All other GS	101	101
Wage Board	-	-
Total	127	127

SPACE POWER SYSTEM DIVISION

	65	66
Excepted	2	2
GS-16	-	-
GS-15	6	6
GS-14	28	28
All other GS	123	123
Wage Board	-	-
Total	159	159

REACTOR DIVISION

	65	66
Excepted	-	-
GS-16	1	1
GS-15	2	2
GS-14	8	8
All other GS	89	89
Wage Board	-	-
Total	100	100

MATERIAL AND STRUCTURES DIVISION

	65	66
Excepted	3	3
GS-16	1	1
GS-15	14	14
GS-14	20	20
All other GS	109	109
Wage Board	-	-
Total	147	147

CENTAUR PROJECT

	65	66
Excepted	2	2
GS-16	1	1
GS-15	14	14
GS-14	28	28
All other GS	140	140
Wage Board	1	1
Total	186	186

ENGINEERING DIVISION

	65	66
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	6	6
All other GS	41	41
Wage Board	1	1
Total	49	49

INSTRUMENT AND COMPUTING DIVISION

	65	66
Excepted	2	-
GS-16	-	1
GS-15	9	9
GS-14	12	12
All other GS	171	171
Wage Board	87	87
Total	282	282

AGENA PROJECT

	65	66
Excepted	1	1
GS-16	2	2
GS-15	8	8
GS-14	20	20
All other GS	85	85
Wage Board	-	-
Total	116	116

ADMINISTRATION DIVISION

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	-	-
All other GS	22	22
Wage Board	4	4
Total	26	26

FLUID SYSTEMS COMPONENTS DIVISION

	65	66
Excepted	3	3
GS-16	3	3
GS-15	14	16
GS-14	24	24
All other GS	97	97
Wage Board	-	-
Total	141	141

CHEMICAL ROCKET SYSTEMS DIVISION

	65	66
Excepted	2	2
GS-16	1	1
GS-15	6	6
GS-14	18	18
All other GS	103	103
Wage Board	-	-
Total	130	130

FACILITIES SERVICE DIVISION

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	1	1
All other GS	20	20
Wage Board	296	296
Total	317	317

NUCLEAR REACTOR DIVISION

	65	66
Excepted	1	1
GS-16	-	-
GS-15	13	13
GS-14	19	19
All other GS	100	100
Wage Board	-	-
Total	133	133

ADVANCED DEVELOPMENT AND EVALUATION DIVISION

	65	66
Excepted	3	3
GS-16	-	-
GS-15	8	8
GS-14	21	21
All other GS	127	127
Wage Board	-	-
Total	159	159

SPACECRAFT TECHNOLOGY DIVISION

	65	66
Excepted	1	1
GS-16	-	-
GS-15	7	7
GS-14	8	8
All other GS	87	87
Wage Board	-	-
Total	103	103

SPACE ADMINISTRATION
STAFFING CHART
CH CENTER

DIRECTOR

	65	66
	5/2	6/2
	-	-
	-	-
	-	-
	3	3
	-	-
	5	5

K STATION
DIRECTOR

	65	66
	1	1
	-	-
	3	3
	-	-
	3	3
	-	-
	7	7

STAFF ASSISTANTS

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	3	3
All other GS	44	44
Wage Board	-	-
Total	47	47

OFFICE OF ASSISTANT DIRECTOR FOR ADMINISTRATION

	65	66
Excepted	1	1
GS-16	-	-
GS-15	-	-
GS-14	-	-
All other GS	6	6
Wage Board	-	-
Total	7	7

STAFF ASSISTANTS

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	1	1
All other GS	32	32
Wage Board	-	-
Total	33	33

OFFICE OF CHIEF OF TECHNICAL SERVICES

	65	66
Excepted	1	1
GS-16	-	-
GS-15	1	1
GS-14	1	1
All other GS	3	3
Wage Board	-	-
Total	6	6

OFFICE OF ASSISTANT DIRECTOR FOR PUBLIC AFFAIRS

	65	66
Excepted	1	1
GS-16	-	-
GS-15	1	1
GS-14	1	1
All other GS	17	17
Wage Board	-	-
Total	20	20

EMS DIVISION

	65	66
	-	-
	-	-
	1	1
	7	7
	55	55
	-	-
	63	63

PERSONNEL DIVISION

	65	66
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	2	2
All other GS	71	71
Wage Board	-	-
Total	74	74

PLANT SERVICES DIVISION

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	1	1
All other GS	35	35
Wage Board	136	132
Total	172	172

DE DIVISION

	65	66
	-	-
	1	1
	2	2
	8	8
	89	89
	-	-
	100	100

FINANCE DIVISION

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	1	1
All other GS	67	67
Wage Board	-	-
Total	68	68

TEST INSTALLATIONS DIVISION

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	1	1
All other GS	5	5
Wage Board	410	410
Total	416	416

RING DIVISION

	65	66
	-	-
	-	-
	1	1
	6	6
	41	41
	1	1
	49	49

ADMINISTRATIVE SERVICES DIVISION

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	1	1
All other GS	37	37
Wage Board	8	8
Total	46	46

FACILITIES OPERATIONS DIVISION

	65	66
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	1	1
All other GS	31	31
Wage Board	530	530
Total	563	563

TRATION DIVISION

	65	66
	-	-
	-	-
	-	-
	-	-
S	22	22
	4	4
	26	26

PROCUREMENT AND SUPPLY DIVISION

	65	66
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	7	7
All other GS	186	186
Wage Board	27	27
Total	221	221

FABRICATION DIVISION

	65	66
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	1	1
All other GS	28	28
Wage Board	220	220
Total	250	250

LITIES SERVICE DIVISION

	65	66
	-	-
	-	-
	-	-
	1	1
GS	20	20
a	296	296
	317	317

TECHNICAL INFORMATION DIVISION

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	1	1
All other GS	92	92
Wage Board	22	22
Total	115	115

ENGINEERING DESIGN DIVISION

	65	66
Excepted	-	-
GS-16	-	-
GS-15	5	5
GS-14	8	8
All other GS	159	159
Wage Board	5	5
Total	177	177

FACILITIES ENGINEERING DIVISION

	65	66
Excepted	1	1
GS-16	-	-
GS-15	5	5
GS-14	9	9
All other GS	76	76
Wage Board	-	-
Total	91	91

CONSTRUCTION OFFICE

	65	66
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	-	-
All other GS	22	22
Wage Board	-	-
Total	23	23

ADMINISTRATIVE OPERATIONS

FISCAL YEAR 1966 ESTIMATES

LEWIS RESEARCH CENTER

MISSION AND CAPABILITIES:

The Lewis Research Center is primarily engaged in research and development in the areas of advanced propulsion and space power generation. Included in this mission is work on high energy chemical, nuclear, and electric rocket engines along with research on space power systems for converting chemical, nuclear, and solar energy into electricity. Basic and applied research is conducted on materials and metallurgy; cryogenic and liquid-metal heat-transfer fluids; pumps and turbines; combustion processes, propellants, tankage, injectors, chambers, and nozzles; system control dynamics; plasmas and magnetohydrodynamics; space meteoroid damage and zero-gravity effects. In the space power area, a major effort is concentrated on turboelectric, thermo-electrical, and thermionic energy-conversion systems.

Lewis Research Center's in-house research provides technical input and direction to the related development, or contractual, efforts for which the Installation has managerial responsibility. For example, this Installation maintains technical management of NASA contracts on electric propulsion, nuclear and solar turboelectric space power systems, and liquid-hydrogen rocket technology. In addition, Lewis has the development responsibility for the Atlas-Centaur and Atlas-Agena launch vehicles and the 1.5 million-pound-thrust hydrogen-oxygen engine. Plans are now being made to adapt the Atlas to the use of FLOX.

Major research tools and facilities, at the Lewis Research Center and the Plum Brook Station are designed to simulate various flight conditions and range from atmospheric wind tunnels to large space environment facilities. A large 60-megawatt thermal reactor is now available for studying nuclear radiation effects on materials and components, simulating various flux levels associated with spacecraft applications of nuclear energy. Other specialized experimental facilities include vacuum electron-beam furnaces for refinement of tungsten, liquid-metal power loops for component evaluations, zero-gravity drop tower, chemical-rocket static thrust stands, full-scale non-nuclear NERVA stand for the study of engine control dynamics, and various cryogenic component rigs.

SUMMARY OF RESOURCES REQUIREMENTS:

	1964	1965	1966
Number of Positions, end of year..	4,859	4,847	4,847
Average Number of All Employees...	4,799	4,866	4,827
Administrative Operations.....	$61,694,000	$70,971,000	$63,880,000

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INSTALLATION DESCRIPTION:

The Lewis Research Center occupies two sites. The older one is on the southwest edge of Cleveland, Ohio, and consists of over 100 laboratory buildings, shops, wind tunnels, space environment tanks and other special facilities, all built for conducting research on advanced propulsion systems or spacecraft power generating systems. The Cleveland facilities occupy 364 acres. The newer site is located just south of Sandusky, Ohio, on land formerly occupied by the Plum Brook Ordnance Works. Its 6,031 acres were transferred to NASA. The research programs at Plum Brook Station are under the technical direction of personnel located at Cleveland. They are conducted at the larger site because of the need for large separation distances to minimize hazards. A nuclear reactor is used to test components of nuclear powered propulsion systems; large rockets are operated with fluorine, hydrogen and other high-energy fuels; and turbo-pumps are developed for cryogenic propellants. The total capital investment as of June 30, 1964 was $239,998,000.

ANALYSIS OF RESOURCES REQUIREMENTS BY OBJECT CLASSIFICATION:

		1964	1965	1966
11.	Personnel Compensation.....	$42,969,000	$45,610,000	$45,635,000
12.	Personnel Benefits.....	3,112,000	3,314,000	3,338,000
	Total, personnel costs.....	$46,081,000	$48,924,000	$48,973,000
21.	Travel and Transportation of persons.....	1,461,000	1,660,000	1,650,000
22.	Transportation of Things.....	627,000	650,000	650,000
23.	Rents, Communications, and Utilities.....	4,378,000	3,987,000	2,825,000
24.	Printing and Reproduction....	58,000	65,000	65,000
25.	Other Services.....	2,300,000	2,563,000	2,849,000
	Services of other agencies.	7,000	45,000	50,000
26.	Supplies and Materials.....	2,865,000	3,150,000	3,050,000
31.	Equipment.....	2,542,000	9,325,000	3,315,000
32.	Lands and Structures.....	1,373,000	600,000	450,000
42.	Insurance Claims and Indemnities.....	2,000	2,000	3,000
	Total.....	$61,694,000	$70,971,000	$63,880,000

JUSTIFICATION BY OBJECT CLASSIFICATION:

Personnel Distribution

	1964	1965	1966
Direct Personnel by Program			
Manned Space Flight			
Advanced missions	45	45	45
Space Science and Applications			
Physics and astronomy	1	1	-
Launch vehicle development	261	254	249
Launch vehicle procurement	160	177	165
Advanced Research and Technology			
Nuclear electric systems	519	474	474
Nuclear rockets	373	373	373
Solar and chemical power	165	170	170
Space vehicle systems	189	173	153
Electronics systems	56	52	52
Aeronautics	69	114	252
Human factor systems	-	1	1
Chemical propulsion	307	308	208
Basic research	416	408	408
Technology Utilization	5	5	5
Sub-total, direct positions	2,566	2,555	2,555
Support personnel			
Director and staff	16	17	17
Administration	579	573	573
Research and development support	1,690	1,670	1,670
Sub-total, support personnel	2,285	2,260	2,260
Total, permanent positions	4,851	4,815	4,815
Other positions:			
Positions under cooperative training agreements	4	11	11
Other temporary positions	4	21	21
Total, all positions	4,859	4,847	4,847

Personnel Requirements

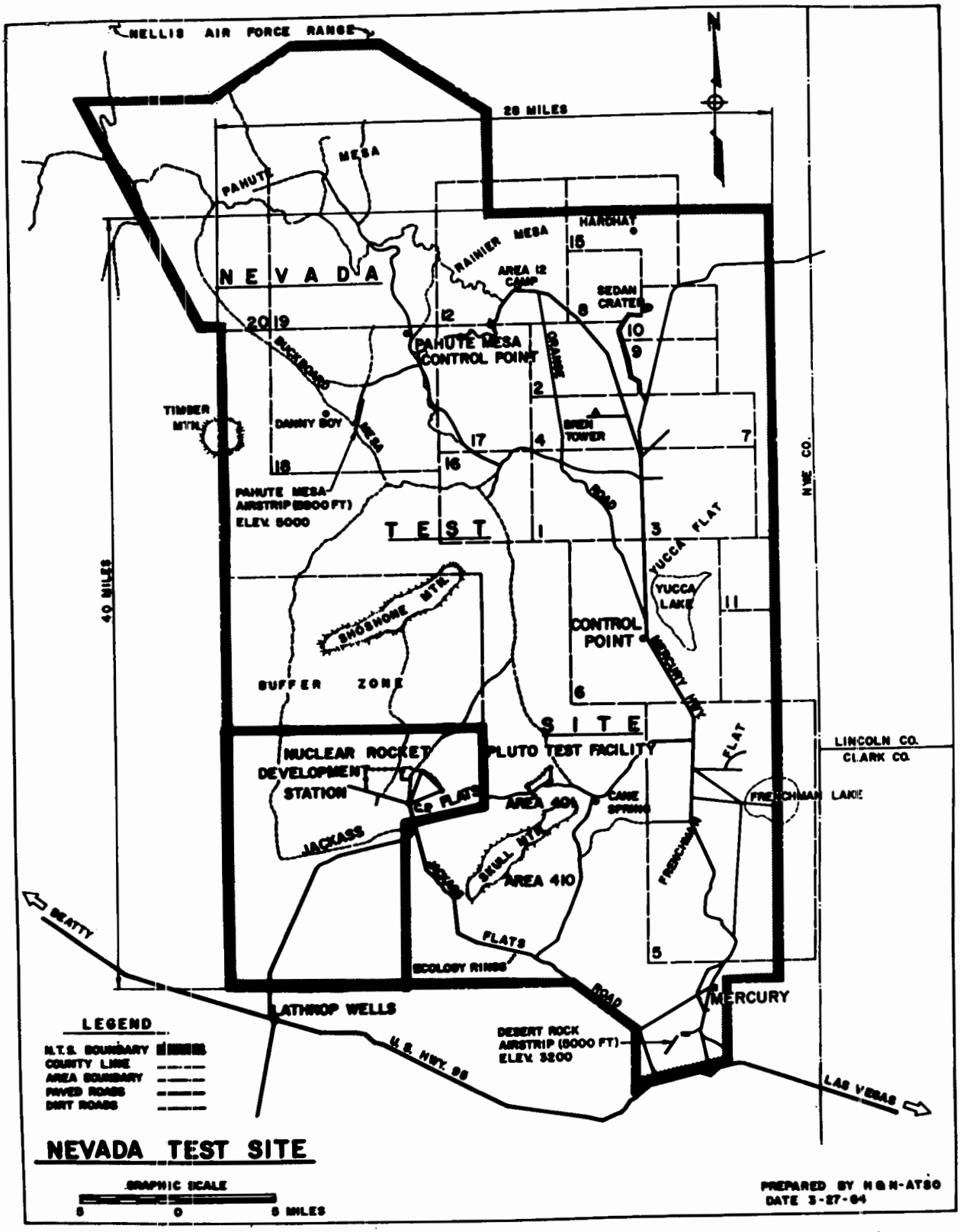
Although major effort will continue to be expended in FY 1966 relating to the technical management, contract monitoring, and evaluation of the launch vehicle development programs, a significant change in program emphasis will entail the reassignment of personnel to provide added support in another area. The suspension of effort under the M-1 engine program and the large solid motor demonstration project will result in the reassignment of 100 employees to support increased activity associated with the aeronautics program. Other minor personnel reassignments will be effected to meet changing program needs.

The personnel cost requested for FY 1966 is reflected below:

Personnel Costs

	1964	1965	1966
Total Positions	4,859	4,847	4,847
Permanent	4,851	4,815	4,815
Other	8	32	32
Personnel Compensation:			
Annual cost of permanent positions	$42,557,000	$43,611,000	$43,610,000
Pay above the stated annual rate	361,000	173,000	173,000
Lapses (deduct)	-1,950,000	-219,000	-90,000
Net cost of permanent positions	40,968,000	43,565,000	43,693,000
Other personnel compensation	2,001,000	2,045,000	1,942,000
Total compensation	42,969,000	45,610,000	45,635,000
NASA funded	42,969,000	45,610,000	45,635,000
Reimbursable	---	---	---
Personnel benefits	3,112,000	3,314,000	3,338,000
NASA funded	3,112,000	3,314,000	3,338,000
Reimbursable	---	---	---
Total personnel costs	46,081,000	48,924,000	48,973,000
NASA funded	46,081,000	48,924,000	48,973,000
Reimbursable	---	---	---
Average Number of All Employees (Man Years)	4,799	4,866	4,827

Excluding the FY 1965 computer purchase program, the FY 1966 estimates reflect an increase of $270,000 over the amount estimated to be required during the current fiscal year. Essentially, the entire increase is required for contractual services relating to the maintenance and repair of scientific and research equipment and for additional maintenance costs connected with the new facilities coming into initial operation in FY 1966, as well as the full-year costs of facilities placed in initial operation in FY 1965.


NELLIS AIR FORCE RANGE
28 MILES
40 MILES
N
PAHUTE MESA
RAINIER MESA
HARDHAT
AREA 12 CAMP
SEDAN CRATER
NEVADA
PAHUTE MESA CONTROL POINT
BUCKBOARD
GRANITE
TIMBER MTN.
DANNY BOY
MESA
BREN TOWER
PAHUTE MESA AIRSTRIP (5500 FT) ELEV. 5000
TEST
ROAD
YUCCA FLAT
YUCCA LAKE
NYE CO.
SHOSHONE MTN.
CONTROL POINT
MERCURY HWY.
BUFFER ZONE
SITE
NUCLEAR ROCKET DEVELOPMENT STATION
PLUTO TEST FACILITY
LINCOLN CO.
CLARK CO.
FRENCHMAN LAKE
C.P. FLATS
AREA 401
CANE SPRING
JACKASS
SKULL MTN.
AREA 410
FRENCHMAN
FLAT
BEATTY
FLATS
ECOLOGY RINGS
ROAD
MERCURY
LATHROP WELLS
DESERT ROCK AIRSTRIP (5000 FT) ELEV. 3200
U.S. HWY. 95
LAS VEGAS
LEGEND
N.T.S. BOUNDARY
COUNTY LINE
AREA BOUNDARY
PAVED ROADS
DIRT ROADS
NEVADA TEST SITE
GRAPHIC SCALE
5 0 5 MILES
PREPARED BY H&N-ATSO
DATE 3-27-64

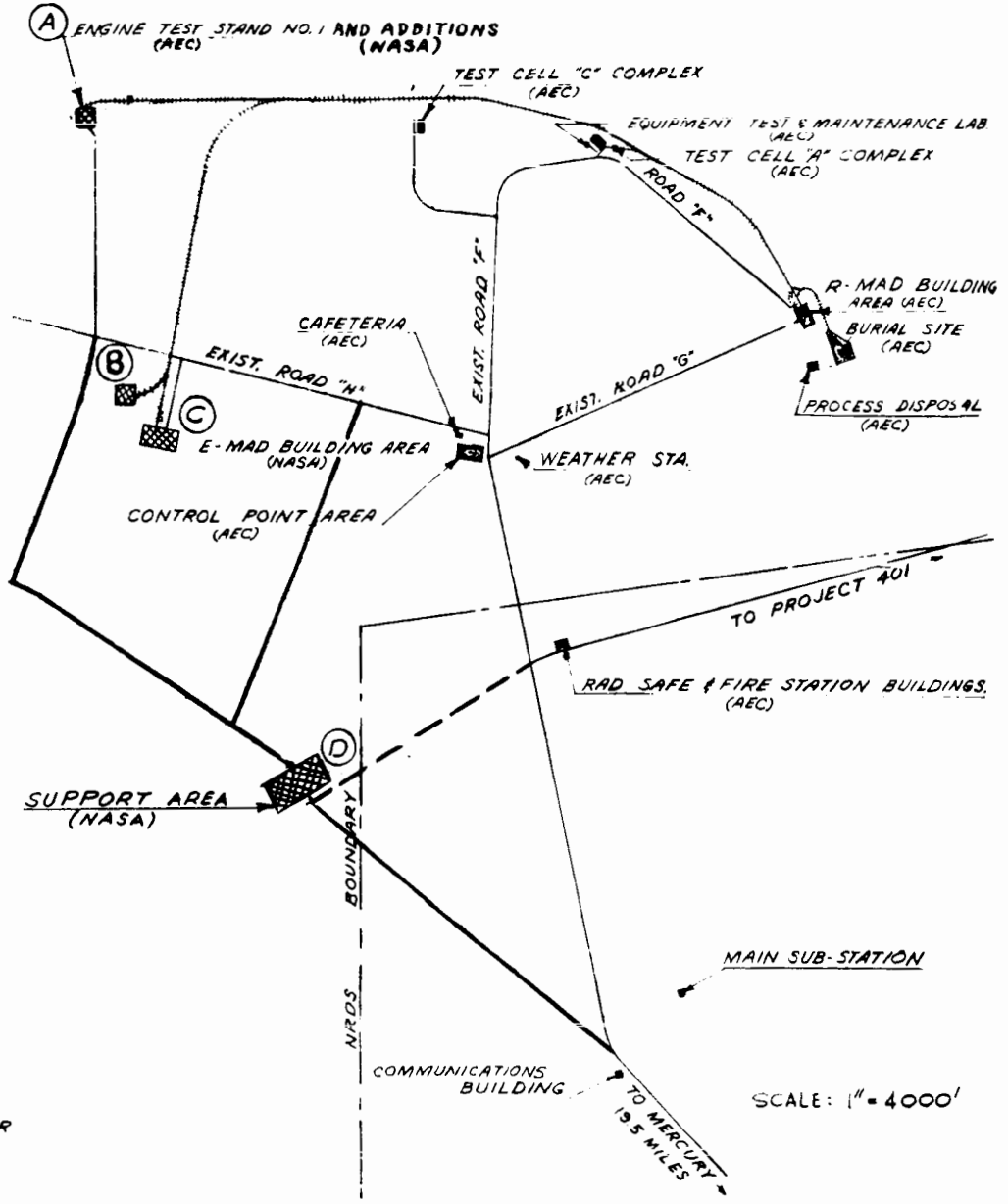
AO 3-49

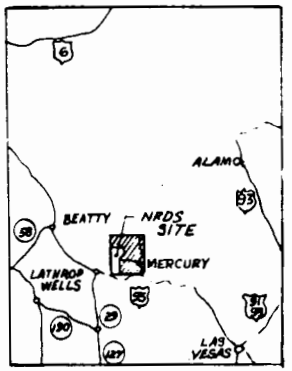
NUCLEAR ROCKET DEVELOPMENT STATION

LOCATION PLAN

FACILITIES AUTHORIZED AND UNDER CONSTRUCTION

A. ENGINE TEST STAND NO. 1
B. RADIOACTIVE MATERIAL HANDLING COMPLEX
C. E-MAD BUILDING
D. SUPPORT FACILITIES





KEY MAP
NO SCALE

LEGEND
- EXIST. FACILITY
- FAC. AUTHORIZED & UNDER CONSTRUCTION

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ORGANIZATION AND STAFFING CHART

SPACE NUCLEAR PROPULSION OFFICE

STAFFING SUMMARY

	65	66
Excepted	3	3
GS-16	3	3
GS-15	16	16
GS-14	20	20
All other GS	74	74
Wage Board	-	-
Total Permanent	116	116
Temporary	-	-
Total Positions	116	116

OFFICE OF THE MANAGER

	65	66
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	-	-
All other GS	2	2
Wage Board	-	-
Total	3	3

ALBUQUERQUE EXTENSION

	65	66
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	1	1
All other GS	-	-
Wage Board	-	-
Total	1	1

NERVA BRANCH

	65	66
Excepted	1	1
GS-16	-	-
GS-15	3	3
GS-14	-	-
All other GS	1	1
Wage Board	-	-
Total	5	5

CLEVELAND EXTENSION

	65	66
Excepted	2	2
GS-16	1	1
GS-15	9	9
GS-14	14	14
All other GS	45	45
Wage Board	-	-
Total	71	71

ADVANCED ENGINE BRANCH

	65	66
Excepted	-	-
GS-16	1	1
GS-15	1	1
GS-14	-	-
All other GS	-	-
Wage Board	-	-
Total	2	2

NEVADA EXTENSION

	65	66
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	5	5
All other GS	25	25
Wage Board	-	-
Total	31	31

FACILITIES BRANCH

	65	66
Excepted	-	-
GS-16	1	1
GS-15	1	1
GS-14	-	-
All other GS	1	1
Wage Board	-	-
Total	3	3

ADMINISTRATIVE OPERATIONS

FISCAL YEAR 1966 ESTIMATES

SPACE NUCLEAR PROPULSION OFFICE

MISSION AND CAPABILITIES:

The Space Nuclear Propulsion Office (SNPO) is a joint office of the National Aeronautics and Space Administration and the Atomic Energy Commission. The primary mission of SNPO is to provide the necessary research, design and engineering data, test hardware, and general technology required to assure that nuclear rocket systems can be developed at the power levels, operating times, restart conditions, and specific impulse values needed in advanced space exploration missions.

SNPO was established to assure the formulation and execution of a well integrated program for nuclear rockets which fulfills the responsibilities of both the Atomic Energy Commission and the National Aeronautics and Space Administration. Implementation of the assigned program entails: basic research on reactors, engine systems, and nuclear vehicle technology; development of practical heat-exchanger-type rocket reactors and engine systems; and ground testing of reactors and engines, and the development of reliability.

SUMMARY OF RESOURCES REQUIREMENTS:

	1964	1965	1966
Number of Positions, end of year..	112	116	116
Average Number of All Employees...	103	114	116
Administrative Operations.....	$1,472,000	$1,725,000	$1,838,000

INSTALLATION DESCRIPTION:

The Space Nuclear Propulsion Office was established by agreement of August 1960 between the AEC and the NASA. The Installation consists of a headquarters office located at Germantown, Maryland, and three field extensions located in Ohio, New Mexico, and Nevada. By agreement between AEC and NASA of February 1962, the Nuclear Rocket Development Station (NRDS) was established to provide a site for ground static testing of the reactors, engines, and eventually, vehicles associated with nuclear rocket development. The NRDS, a 90,000 acre site carved out of the AEC's Nevada Test Site, is located in Nye County, Nevada, approximately 90 miles northwest of Las Vegas. The total capital investment of NASA funded facilities as of June 30, 1964 was $8,069,000.

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ANALYSIS OF RESOURCES REQUIREMENTS BY OBJECT CLASSIFICATION:

	1964	1965	1966
11. Personnel Compensation.....	$1,125,000	$1,391,000	$1,424,000
12. Personnel Benefits.....	82,000	109,000	111,000
Total, personnel costs.....	$1,207,000	$1,500,000	$1,535,000
21. Travel and Transportation of Persons.....	171,000	200,000	200,000
22. Transportation of Things.....	11,000	10,000	3,000
23. Rents, Communications, and Utilities.....	---	---	---
24. Printing and Reproduction.....	---	---	---
25. Other Services.....	---	15,000	100,000
Services of other agencies..	83,000	---	---
26. Supplies and Materials.....	---	---	---
31. Equipment.....	---	---	---
32. Lands and Structures.....	---	---	---
42. Insurance Claims and Indemnities.....	---	---	---
Total.....	$1,472,000	$1,725,000	$1,838,000

JUSTIFICATION BY OBJECT CLASSIFICATION:

Personnel Distribution

	1964	1965	1966
Direct Personnel by Program			
Advanced Research and Technology			
Nuclear rockets.....	106	110	110
Technology Utilization.....	1	1	1
Support personnel			
Director and Staff.....	1	1	1
Administration.....	1	1	1
Research and development support...	3	3	3
Sub-total, support positions.....	5	5	5
Total, permanent positions.....	112	116	116
Other positions:	---	---	---
Total, all positions.....	112	116	116

Personnel Requirements

The manpower required for the effective monitoring and management of the nuclear rocket program will remain constant in FY 1966. The small increase in personnel costs is required to fund expected salary adjustments to become effective in FY 1966. The limited staff and funding flexibility necessitates support for these items in order to maintain a constant man-year effort.

Personnel Costs

	1964	1965	1966
Total Positions	112	116	116
Permanent	112	116	116
Other	---	---	---
Personnel Compensation:			
Annual cost of permanent positions	$1,249,000	$1,389,000	$1,415,000
Pay above the stated annual rate	9,000	6,000	6,000
Lapses (deduct)	-136,000	-10,000	-3,000
Net cost of permanent positions	1,122,000	1,385,000	1,418,000
Other personnel compensation	3,000	6,000	6,000
Total compensation	1,125,000	1,391,000	1,424,000
NASA funded	1,125,000	1,391,000	1,424,000
Reimbursable	---	---	---
Personnel benefits	82,000	109,000	111,000
NASA funded	82,000	109,000	111,000
Reimbursable	---	---	---
Total personnel costs	1,207,000	1,500,000	1,535,000
NASA funded	1,207,000	1,500,000	1,535,000
Reimbursable	---	---	---
Average Number of All Employees (Man Years)	103	114	116

Other requirements reflect an increase of $78,000 over the amount estimated to be required for FY 1965. All of the increase is required for the periodical updating of the master planning for the Nuclear Rocket Development Station at Nevada. This includes special studies and engineering services designed to minimize future operational costs of the station.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ORGANIZATION AND STAFFING CHART

NASA HEADQUARTERS

STAFFING SUMMARY

NASA-Wide	65	66
Excepted	170	169
GS-16	39	39
GS-15	384	384
GS-14	302	302
All other GS	1,242	1,243
Wage Board	19	19
Total	2,156	2,156
Temporary	65	65
Total Positions	2,221	2,221

ADMINISTRATOR

	65	66
Excepted	5	5
GS-16	-	-
GS-15	-	-
GS-14		
All other GS	7	7
Wage Board	1	1
Total	13	13

LEGISLATIVE AFFAIRS

	65	66
Excepted	3	3
GS-16	-	-
GS-15	4	4
GS-14	2	2
All other GS	20	20
Wage Board	1	1
Total	30	30

INTERNATIONAL AFFAIRS

	65	66
Excepted	2	2
GS-16	1	1
GS-15	3	3
GS-14	-	-
All other GS	21	21
Wage Board	-	-
Total	27	27

EXECUTIVE SECRETARIAT

	65	66
Excepted	1	1
GS-16	-	-
GS-15	2	2
GS-14	3	3
All other GS	29	29
Wage Board	-	-
Total	35	35

POLICY PLANNING

	65	66
Excepted	4	4
GS-16	-	-
GS-15	4	4
GS-14	3	3
All other GS	13	13
Wage Board	-	-
Total	24	24

TECHNOLOGY UTILIZATION

	65	66
Excepted	3	3
GS-16	-	-
GS-15	10	10
GS-14	11	11
All other GS	53	53
Wage Board	-	-
Total	77	77

GENERAL COUNSEL

	65	66
Excepted	5	5
GS-16	-	-
GS-15	11	11
GS-14	8	8
All other GS	27	27
Wage Board	-	-
Total	51	51

PUBLIC AFFAIRS

	65	66
Excepted	3	3
GS-16	-	-
GS-15	16	16
GS-14	23	23
All other GS	73	73
Wage Board	-	-
Total	115	115

ASSOCIATE ADMINISTRATOR

	65	66
Excepted	3	3
GS-16	-	-
GS-15	2	2
GS-14	2	2
All other GS	8	8
Wage Board	-	-
Total	15	15

INDUSTRY AFFAIRS

	65	66
Excepted	5	5
GS-16	1	1
GS-15	15	15
GS-14	25	25
All other GS	79	79
Wage Board	-	-
Total	125	125

PROGRAMMING

	65	66
Excepted	7	7
GS-16	-	-
GS-15	15	15
GS-14	15	15
All other GS	50	50
Wage Board	-	-
Total	87	87

DEFENSE AFFAIRS

	65	66
Excepted	3	3
GS-16	-	-
GS-15	1	1
GS-14	1	1
All other GS	5	5
Wage Board	-	-
Total	10	10

ADMINISTRATION

NASA-Wide	65	66
Excepted	10	10
GS-16	1	1
GS-15	43	43
GS-14	50	50
All other GS	181	185
Wage Board	-	-
Total	285	289

Headquarters Operations		
Excepted	1	1
GS-16	-	-
GS-15	6	6
GS-14	6	6
All other GS	201	197
Wage Board	17	17
Total	229	225

DSACASR*

	65	66
Excepted	-	-
GS-16		
GS-15	1	1
GS-14	11	11
All other GS	8	8
Wage Board	-	-
Total	20	20

TRACKING AND DATA ACQUISITION

	65	66
Excepted	5	5
GS-16	2	2
GS-15	20	20
GS-14	7	7
All other GS	26	26
Wage Board	-	-
Total	60	60

MANNED SPACE FLIGHT

	65	66
Excepted	44	43
GS-16	7	7
GS-15	120	120
GS-14	84	84
All other GS	206	207
Wage Board	-	-
Total	461	461

SPACE SCIENCE AND APPLICATIONS

	65	66
Excepted	33	33
GS-16	14	14
GS-15	53	53
GS-14	26	26
All other GS	144	144
Wage Board	-	-
Total	270	270

ADVANCED RESEARCH AND TECHNOLOGY

	65	66
Excepted	33	33
GS-16	13	13
GS-15	60	60
GS-14	25	25
All other GS	91	91
Wage Board	-	-
Total	222	222

* NASA Staffing for:

Defense Supply Agency Contract Administration Services Regions

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ADMINISTRATIVE OPERATIONS

FISCAL YEAR 1966 ESTIMATES

NASA HEADQUARTERS

MISSION AND CAPABILITIES:

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

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

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

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

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

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

The Office of Manned Space Flight - Responsible for all NASA activities directly involving manned space flight missions. Programs include Gemini - to develop an operational capability to fly a two-man spacecraft in near-earth orbit for periods up to fourteen days and to learn new techniques, including rendezvous, docking and extra-vehicular activity; Apollo - to develop a three-man operational capability in near-earth orbit, in lunar environment, including manned landing on the lunar surface, and return to earth; and Advanced Missions - to plan a broad program of exploration which will achieve and maintain a position of space leadership for the United States.

This office also has overall institutional responsibility for the three installations primarily concerned with the manned Space flight programs. These installations are: George C. Marshall Space Flight Center, including Mississippi Test Facility, Michoud Plant, and at Slidell where a computer facility is located; the Manned Spacecraft Center, including NASA activities at the White Sands Missile Range; and the John F. Kennedy Space Center.

The Office of Space Science and Applications - Responsible for all NASA programs for the unmanned scientific investigation of space with sounding rockets, earth satellites, and deep space probes to the moon, planets and interplanetary space and for the scientific experiments to be conducted by man in space; for research and development of useful applications of space flight in the areas of meteorology, communications, navigation, geodesy, and for the support of operational systems using these developments; for the development and procurement of the light and medium class of launch vehicles up to and including the Atlas/Centaur; and for the sustaining university program.

In addition to the foregoing, this Office has overall institutional responsibility for the installations primarily involved in carrying out NASA's space science and applications programs. These installations are: Goddard Space Flight Center, Wallops Station, Pacific Launch Operations Office; and the NASA Resident Office at JPL, which administers the NASA contract with the California Institute of Technology for the operation of the Jet Propulsion Laboratory.

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

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

The Office of Tracking and Data Acquisition - Responsible for the development, implementation, and operation of tracking, data acquisition, communications, and data processing facilities, systems,

and services required for NASA flight programs. In addition, the Office is responsible for the agency-wide coordination of the management of automatic data processing.

SUMMARY OF RESOURCES REQUIREMENTS:

	1964	1965	1966
Number of Positions, end of year.	2,133	2,221	2,221
Average Number of All Employees..	1,944	2,070	2,150
Administrative Operations:			
NASA Headquarters.....	$49,115,000	$52,668,000	$56,103,000
Jet Propulsion Laboratory (purchase of computers).....	---	20,587,000	---
Total, Administrative Operations.....	$49,115,000	$73,255,000	$56,103,000

INSTALLATION DESCRIPTION:

The NASA Headquarters is located at 400 Maryland Avenue, S.W., Washington, D.C., and also occupies other buildings in the District of Columbia and nearby Virginia. Except for space leased in the Universal North Building and a storage area in Virginia, personnel occupy Government-owned buildings.

ANALYSIS OF RESOURCES REQUIREMENTS BY OBJECT CLASSIFICATION:

		1964	1965	1966
11.	Personnel Compensation.....	$22,302,000	$25,897,000	$26,822,000
12.	Personnel Benefits.....	1,678,000	1,834,000	1,912,000
	Total, personnel costs....	$23,980,000	$27,731,000	$28,734,000
21.	Travel and Transportation of Persons.....	2,607,000	2,634,000	2,627,000
22.	Transportation of Things....	456,000	460,000	281,000
23.	Rents, Communications, and Utilities.....	1,969,000	2,058,000	2,218,000
24.	Printing and Reproduction...	1,233,000	1,640,000	1,701,000
25.	Other Services.....	17,747,000	16,767,000	19,875,000
26.	Supplies and Materials.....	566,000	421,000	414,000
31.	Equipment.....	555,000	21,534,000 a/	243,000

a/ Includes $20,587,000 for purchase of ADP equipment for the Jet Propulsion Laboratory, Pasadana, California.

	1964	1965	1966
32. Land and Structures	1,000	---	---
42. Insurance Claims and Indemnities.....	1,000	10,000	10,000
Total.....	$49,115,000	$73,255,000	$56,103,000

The above estimates, other than for personnel compensation and benefits and travel, have been distributed between NASA-wide support functions with all centers benefiting and for operation of Headquarters. The following table shows this comparison by object classification.

Analysis of Funding for NASA-wide Support and Headquarters Operations

Object Class	FY 1965 Total	FY 1965 NASA-wide Support	FY 1965 Hdqrts. Operat.	FY 1966 Total	FY 1966 NASA-wide Support	FY 1966 Hdqrts. Operat.
	(In thousands of dollars)					
22. Transportation of Things.....	$460	$400	$60	$281	$221	$60
23. Rents, Communications and Utilities.....	2,058	882	1,176	2,218	1,116	1,102
24. Printing and Reproduction..	1,640	1,454	186	1,701	1,511	190
25. Other Services..	16,767	15,592	1,175	19,875	18,646	1,229
26. Supplies and Materials.....	421	30	391	414	23	391
31. Equipment.....	21,534	20,699[a]	835	243	74	169
32. Lands and Structures.....	---	---	---	---	---	---
42. Insurance Claims and Indemnities.....	10	---	10	10	---	10
Total.....	$42,890	$39,057	$3,833	$24,742	$21,591	$3,151

a/ Includes $20,587,000 for purchase of ADP equipment for the Jet Propulsion Laboratory, Pasadena, California.

JUSTIFICATION BY OBJECT CLASSIFICATION:

Personnel Distribution

	1964	1965	1966
Direct Personnel by Program			
Manned Space Flight			
Gemini	73	104	104
Apollo	286	297	297
Advanced missions	60	60	60
Space Science and Applications			
Bioscience	23	23	23
Sustaining university program	68	73	73
Physics and astronomy	56	52	52
Lunar and planetary exploration	54	57	57
Communication satellites	14	10	9
Launch vehicle development	12	13	13
Meteorological satellites	20	20	20
Launch vehicle procurement	14	14	14
Applications technology satellites	3	8	9
Advanced Research and Technology			
Nuclear rockets	27	28	28
Nuclear-electric systems	4	4	4
Chemical propulsion	21	21	21
Space vehicle systems	44	46	46
Electronics systems	35	35	35
Aeronautics	22	26	26
Human factor systems	22	23	23
Basic research	26	27	27
Solar and chemical power	10	12	12
Tracking and Data Acquisition	51	60	60
Technology Utilization	14	13	13
Sub-total, direct positions	959	1,026	1,026

	1964	1965	1966
Support personnel:			
NASA-wide support	865	901	905
Administration	267	229	225
Sub-total, support positions	1,132	1,130	1,130
Total, permanent positions	2,091	2,156	2,156
Other positions:			
Positions under cooperative training agreements	---	---	---
Other temporary positions	42	65	65
Total, all positions	2,133	2,221	2,221

Personnel Costs

	1964	1965	1966
Total Positions	2,133	2,221	2,221
Permanent	2,091	2,156	2,156
Other	42	65	65
Personnel Compensation:			
Annual cost of permanent positions	$22,249,000	$25,652,000	$25,645,000
Pay above the stated annual rate	160,000	99,000	99,000
Lapses (deduct)	-1,448,000	-1,272,000	-355,000
Net cost of permanent positions	20,961,000	24,479,000	25,389,000
Other personnel compensation	1,341,000	1,418,000	1,433,000
Total compensation	22,302,000	25,897,000	26,822,000
NASA funded	22,302,000	25,897,000	26,822,000
Reimbursable	---	---	---
Personnel benefits	1,678,000	1,834,000	1,912,000
NASA funded	1,678,000	1,834,000	1,912,000
Reimbursable	---	---	---
Total personnel costs	23,980,000	27,731,000	28,734,000
NASA funded	23,980,000	27,731,000	28,734,000
Reimbursable	---	---	---
Average Number of All Employees (Man Years)	1,944	2,070	2,150

Personnel Costs - $28,734,000

The personnel costs for FY 1966 are estimated to be $1,003,000 above the requirement for FY 1965, of which $925,000 is for personnel compensation and $78,000 for personnel benefits, to cover the cost of 80 man years resulting from full year employment in FY 1966 of personnel hired in FY 1965.

Travel and Transportation of Persons - $2,627,000

There is a slight decrease below the FY 1965 level for travel and transportation of persons during FY 1966. The estimate includes $2,322,000 for NASA employee travel, of which, $2,150,000 will be used for direction and coordination of program and administrative activities; $107,000 for the contract charter airlift service; $30,000 for costs relating to initial duty stations, temporary assignments and transfers; and $35,000 for meetings of NASA technical committees and working panels. The balance of $305,000 is for non-NASA employee travel of technical and research advisory committees; and for costs of local transportation and rental of passenger motor vehicles.

Transportation of Things - $281,000

The FY 1966 estimate for transportation of things is projected at $179,000 below the FY 1965 level primarily as a result of a reduction in the transportation of exhibits and for cargo airlift costs.

The requirement of $281,000 in FY 1966 under this object class includes $140,000 for the domestic and overseas shipment of exhibits and spacemobiles; $42,000 for the "cargo" portion of the charter airlift service; $56,000 for costs of transportation of household goods and personal effects; and $43,000 for freight, express, drayage and parcel post costs of shipments to NASA installations, and rental of trucks from GSA.

The distribution of $281,000 in FY 1966 includes $221,000 for NASA-wide support and $60,000 for Headquarters operations.

Rents, Communications, and Utilities - $2,218,000

The FY 1966 estimate for rents and communications reflects a net increase of $160,000 over FY 1965 -- $107,000 for rents and $53,000 for communications.

The net increase of $107,000 for rents includes: 1) an increase of $278,000 for rental of space to house the NASA Scientific and Technical Information Facility on a full year basis in FY 1966. This space will be acquired through the General Services Administration during the latter part of FY 1965. In previous years, the rental of space was included as a part of the contract with Documentation, Inc.; and 2) a decrease of $171,000 for rental of ADP equipment.

The increase of $53,000 for communications costs reflects minor increases for local telephone and exchange services, Federal Telecommunications systems lines, telegraph and TWX service and for postage costs.

The request of $2,218,000 in FY 1966 includes $1,116,000 for NASA-wide support and $1,102,000 for Headquarters operations.

The following table reflects changes for this object classification:

	Increase or Decrease
Rents	$+107,000
Space	+278,000
ADP equipment	-171,000
Other equipment	---
Office equipment	---
Communications	+53,000
Leased lines	-16,000
Local telephone and exchange service	+39,000
Long distance tolls	-10,000
FTS charges	+10,000
Telegraph	+10,000
TWX	+10,000
Postage	+10,000
Total	$+160,000

Printing and Reproduction - $1,701,000

The FY 1966 estimates reflect an increase of $61,000 over FY 1965 for these services. About 89 per cent, or $1,511,000 of the $1,701,000 requested covers printing costs for NASA-wide support activities associated with the scientific and technical documentation programs; such as printing of scientific and technical aerospace reports covering world-wide interdisciplinary report literature in the aerospace field, special publications on research program developments and integrated reports of orbital, lunar, and planetary flights; and proceedings of symposia and conferences on selected scientific topics; and for printing of educational media concerning the Agency's program results in formats suitable for dissemination to the educational community and to the general public. The remaining 11 per cent, or $190,000, is required for Headquarters operations for printing and reproduction of forms, regulations and general printing and reproduction services.

About 93 per cent, or $1,577,000 of the FY 1966 estimate is for printing and allied services which will be performed through Government sources. The remaining 7 per cent, or $124,000, is for printing and photostating to be done by commercial sources.

Other Services - $19,875,000

The FY 1966 estimate for other services is $3,108,000 higher than for FY 1965. The following table shows an analysis of the major increases in this area:

	Increases
NASA scientific and technical information facility	$800,000
Technical documentation program	1,000,000
Scientific information systems development	200,000
Preparation of manuscript material for specialized scientific and technical publications and monographs	490,000
Audio visual processing/depository service	180,000
International graduate fellowship program	170,000
Various minor adjustments in other Headquarters programs and projects	268,000
Total	$3,108,000

Of the net increase of $3,108,000, about 80 per cent, or $2,490,000, is requested for the scientific and technical information program. This includes:

1. $800,000 to provide for the documentation in NASA's contractor-operated Scientific and Technical Information Facility of the greatly increasing volume of scientific and technical data required for direct use in NASA's research and development programs. The FY 1966 workload is expected to be at least 25% greater than the FY 1965 level.

2. $1,000,000 for documentation of world-wide aerospace journal literature, primarily to align the funding of a contract to a full fiscal year basis in FY 1966. In addition, it would provide a small expansion in the program to process this literature for immediate use in the NASA technical programs. The global output of aerospace literature is increasing at an accelerated rate.

3. $200,000 for information systems development to increase the effectiveness of the NASA technical information program and to permit the most economical interchange of NASA computerized documentation output with those of Department of Defense, Atomic Energy Commission, and other government agencies.

4. $490,000 for preparation of manuscript material for specialized scientific and technical publications, handbooks, data compilations, and monographs on aerospace subjects such as radio propagation through re-entry systems, design of meteorological sounding rockets, stabilization standards for interplanetary probes, space probe instrumentation, satellite scientific instrumentation, and launch facilities.

The remaining 20 per cent, or $618,000, includes an increase of $170,000 for the International Graduate Fellowship program sponsored by foreign countries and administered by the National Academy of Sciences; $180,000 for services in connection with the processing, indexing, storage, and distribution of audio visual material including maintenance of control over receipt cataloging and storage of film; and $268,000 for various items such as, reliability and quality assurance studies of selected assessments of hardware design, security reinvestigation program, toxicity studies relating to the NASA-wide occupational medical program, and procurement programs, policies and procedures studies.

Of the total $19,875,000 requested for this object classification in FY 1966, about 94 per cent will be used for NASA-wide activities and 6 per cent for Headquarters Operations.

Supplies and Materials - $414,000

The estimate for FY 1966 for this category is $7,000 less than in FY 1965. Funds requested are for the purchase of expendable and non-expendable items such as: office supplies and materials, pamphlets and documents for the technical documentation and educational services programs, periodical subscriptions for the law and technical libraries, and photographic and drafting supplies.

Of the $414,000 about 6 per cent, or $23,000, is used for NASA-wide activities and 94 per cent, or $391,000 for Headquarters Operations.

Equipment - $243,000

The FY 1966 estimate reflects a reduction from FY 1965 requirements. The principal reason is the non-recurring item of $21,200,000 in FY 1965 for the purchase of ADP equipment ($20,587,000 for the Jet Propulsion Laboratory and $613,000 for NASA Headquarters). In addition, a reduction of $91,000 is estimated for the requirement for the purchase of miscellaneous office and other equipment.

The estimate of $243,000 for office and other equipment in FY 1966 includes $74,000 for the procurement of 10 replacements for existing spacemobiles and for the purchase of models and equipment needed in support of spacemobile lecturers. The balance of $169,000 is required for purchase of office furniture and equipment for Headquarters Operations.

Insurance Claims and Indemnities - $10,000

The FY 1966 requirement is estimated at the same level as for FY 1965. These funds are to cover payment of claims of $2,500 or less under the provisions of 28 U.S.C. 2672 for injury or loss of property, personal injury, or death caused by the negligent or wrongful act or omission of any employee of NASA while acting within the scope of the responsibility of his office or employment.

ADMINISTRATIVE OPERATIONS

FISCAL YEAR 1966 ESTIMATES

NORTH EASTERN OFFICE

MISSION AND CAPABILITIES:

The North Eastern Office was merged with the Electronics Research Center effective September 1, 1964. The fiscal year 1965 and 1966 requirements of this office are included with the estimates for the Electronics Research Center.

SUMMARY OF RESOURCES REQUIREMENTS:

	1964	1965	1966
Number of Positions, end of year.	33	---	---
Average Number of All Employees..	30	---	---
Administrative Operations.....	$379,000	---	---

INSTALLATION DESCRIPTION:

The North Eastern Office was located in Cambridge, Massachusetts.

ANALYSIS OF RESOURCES REQUIREMENTS BY OBJECT CLASSIFICATION:

		1964	1965	1966
11.	Personnel Compensation.....	$280,000	---	---
12.	Personnel Benefits.....	20,000	---	---
	Total, personnel costs....	$300,000	---	---
21.	Travel and Transportation of Persons.....	27,000	---	---
22.	Transportation of Things....	1,000	---	---
23.	Rents, Communications, and Utilities.....	28,000	---	---
24.	Printing and Reproduction...	4,000	---	---
25.	Other Services.....	3,000	---	---
	Services of other agencies	3,000	---	---
26.	Supplies and Materials.....	10,000	---	---
31.	Equipment.....	3,000	---	---
	Total.....	$379,000	---	---

JUSTIFICATION BY OBJECT CLASSIFICATION:

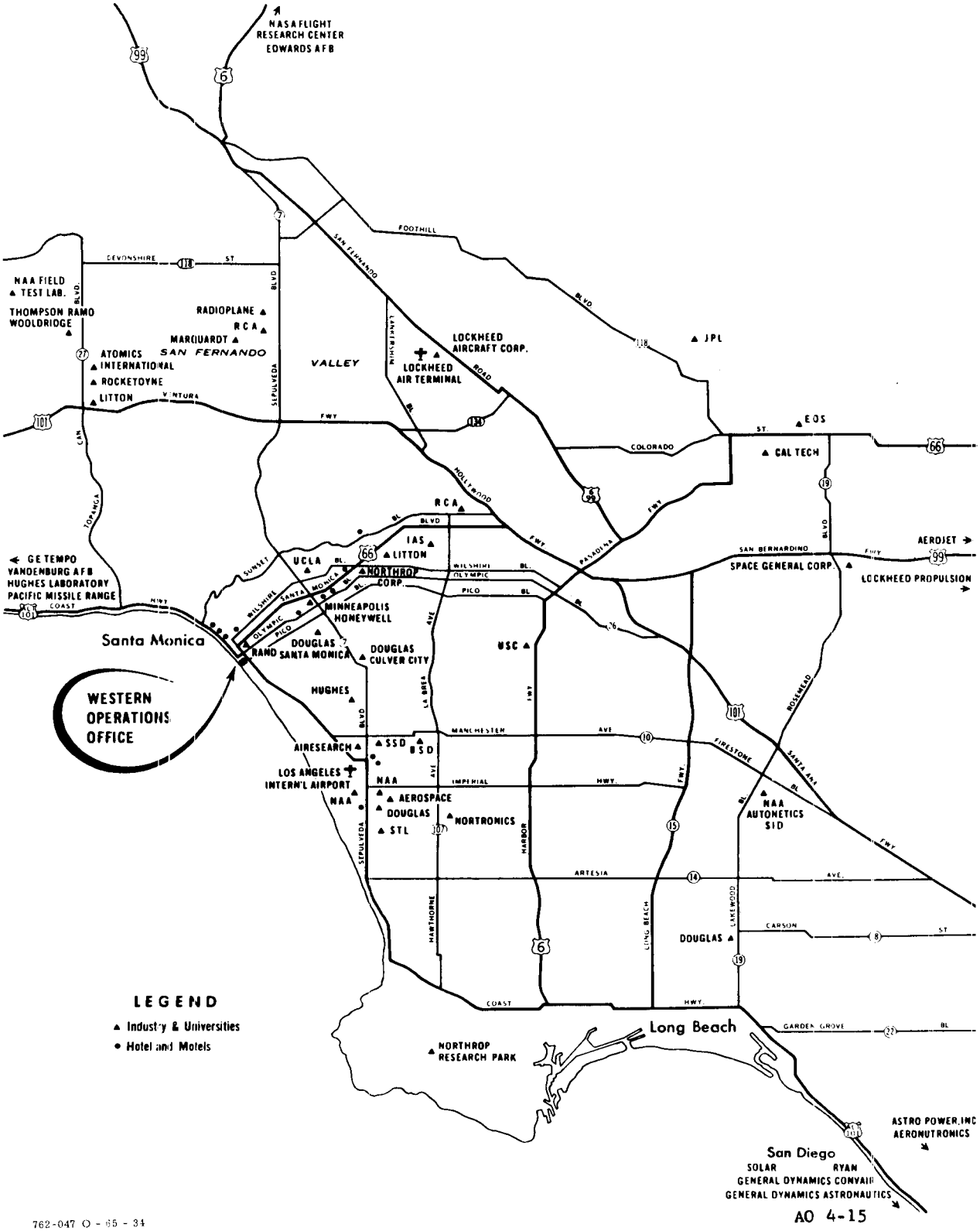
Personnel Distribution

Support personnel

	1964	1965	1966
Director and staff.....	2	---	---
NASA-wide support.....	30	---	---
Sub-total, support positions....	32	---	---
Total, permanent positions.....	32	---	---
Other positions:			
Positions under cooperative training agreements.....	--	---	---
Other temporary positions.....	1	---	---
Total, all positions.....	33	---	---

Personnel Costs

	1964	1965	1966
Total Positions.....	33	---	---
Permanent.....	32	---	---
Other.....	1		
Personnel Compensation:			
Annual cost of permanent positions	$305,000	---	---
Pay above the stated annual rate..	2,000	---	---
Lapses (deduct).....	-39,000	---	---
Net cost of permanent positions...	268,000	---	---
Other personnel compensation.....	12,000	---	---
Total compensation.....	280,000	---	---
NASA funded.....	280,000	---	---
Reimbursable.....	---	---	---
Personnel benefits.....	20,000	---	---
NASA funded.....	20,000	---	---
Reimbursable.....	---	---	---
Total personnel costs.....	300,000	---	---
NASA funded.....	300,000	---	---
Reimbursable.....	---	---	---
Average Number of All Employees (Man Years).....	30	---	---



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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ORGANIZATION AND STAFFING CHART

WESTERN OPERATIONS OFFICE

STAFFING SUMMARY

	65	66
Excepted	3	3
GS-16	1	1
GS-15	15	15
GS-14	49	49
All other GS	333	333
Wage Board	-	-
Total Permanent	401	401
Temporary	5	5
Total	406	406

NASA RESIDENCY OFFICE - JPL

	65	66
GS-15	7	7
GS-14	6	6
All other GS	14	14
Total	27	27

DIRECTOR

	65	66
Excepted	2	2
Other GS	5	5
Total	7	7

PROFESSIONAL STAFFING

	65	66
Other GS	2	2
Total	2	2

NASA-O

	65	66
GS-15	2	2
GS-14	6	6
Other GS	129	129
Total	137	137

CONTRACT MANAGEMENT

	65	66
Excepted	1	1
GS-15	-	-
GS-14	6	6
Other GS	48	48
Total	55	55

TECHNICAL DIVISION

	65	66
GS-16	1	1
GS-15	4	4
GS-14	25	25
Other GS	52	52
Total	82	82

LEGAL DIVISION

	65	66
GS-15	2	2
GS-14	4	4
Other GS	4	4
Total	10	10

FINANCIAL MANAGEMENT DIVISION

	65	66
GS-14	1	1
Other GS	23	23
Total	24	24

EDUCATIONAL PROGRAMS

	65	66
GS-14	1	1
Other GS	3	3
Total	4	4

ADMINISTRATIVE SERVICES

	65	66
Other GS	38	38
Total	38	38

PUBLIC INFORMATION

	65	66
Other GS	6	6
Total	6	6

PERSONNEL DIVISION

	65	66
Other GS	9	9
Total	9	9

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ORGANIZATION AND STAFFING CHART

WESTERN OPERATIONS OFFICE

STAFFING SUMMARY

	65	66
Excepted	3	3
GS-16	1	1
GS-15	15	15
GS-14	49	49
All other GS	333	333
Wage Board	-	-
Total Permanent	401	401
Temporary	5	5
Total	406	406

NASA RESIDENCY OFFICE - JPL

	65	66
GS-15	7	7
GS-14	6	6
All other GS	14	14
Total	27	27

DIRECTOR

	65	66
Excepted	2	2
Other GS	5	5
Total	7	7

PROFESSIONAL STAFFING

	65	66
Other GS	2	2
Total	2	2

NASA-O

	65	66
GS-15	2	2
GS-14	6	6
Other GS	129	129
Total	137	137

CONTRACT MANAGEMENT

	65	66
Excepted	1	1
GS-15	-	-
GS-14	6	6
Other GS	48	48
Total	55	55

TECHNICAL DIVISION

	65	66
GS-16	1	1
GS-15	4	4
GS-14	25	25
Other GS	52	52
Total	82	82

LEGAL DIVISION

	65	66
GS-15	2	2
GS-14	4	4
Other GS	4	4
Total	10	10

FINANCIAL MANAGEMENT DIVISION

	65	66
GS-14	1	1
Other GS	23	23
Total	24	24

EDUCATIONAL PROGRAMS

	65	66
GS-14	1	1
Other GS	3	3
Total	4	4

ADMINISTRATIVE SERVICES

	65	66
Other GS	38	38
Total	38	38

PUBLIC INFORMATION

	65	66
Other GS	6	6
Total	6	6

PERSONNEL DIVISION

	65	66
Other GS	9	9
Total	9	9

ADMINISTRATIVE OPERATIONS

FISCAL YEAR 1966 ESTIMATES

WESTERN OPERATIONS OFFICE

MISSION AND CAPABILITIES:

The primary mission of the Western Operations Office is to provide technical, contractual, and administrative support to NASA field centers and NASA Headquarters for programs and projects located in Southern California and other areas west of Denver. The Western Operations Office functions as a field service in such areas as procurement, technical and contract administration, legal and patent reviews, and personnel, administrative support, and financial management activities in the area west of Denver.

Technical management support as assigned by field centers and NASA project managers includes the technical management and administration of research and development and facilities contracts; monitoring of related quality assurance requirements; quality assurance surveys of industrial plants and organizations; monitoring of advanced technology contracts; negotiation of contracts; procurement of pressurants and propellants for NASA and contractor requirements; and the operation of a contract administration and quality assurance organization for the Apollo and Saturn projects at the North American Aviation, Inc., plant at Downey, California.

The mission of the Western Operations Office also includes administrative support and services for the NASA Resident Office at the Jet Propulsion Laboratory. The Resident Office, physically located at the Jet Propulsion Laboratory in Pasadena, California, has principal contract administration responsibilities for the NASA contract with the California Institute of Technology which operates the Jet Propulsion Laboratory.

SUMMARY OF RESOURCES REQUIREMENTS:

	1964	1965	1966
Number of Positions, end of year...	376	406	406
Average Number of All Employees....	336	390	405
Administrative Operations.....	$4,924,000	$5,989,000	$6,337,000

INSTALLATION DESCRIPTION:

The main Western Operations Office is located at 150 Pico Boulevard, Santa Monica, California. The Office occupies a group of leased buildings and no Government investment in buildings or acreage is involved at this location. In about two years, the main office will move to a new GSA Federal Office Building to be constructed in nearby West Los Angeles.

Over one-third of the Western Operations Office staff is located in Government-owned facilities at Downey, California, which are currently being utilized by the Space Information Systems Division of North American Aviation, Inc. The Government-owned portion of the North American Aviation Downey complex is located on 166 acres and the land and plant acquisition value is approximately $44 million as of June 30, 1964. The responsibility for management of property and facilities was transferred from the Air Force to NASA on July 1, 1964. A few additional Western Operations personnel are assigned to other contractor locations within the Los Angeles area where full time project support is required. The map on page AO 4-15 shows the location of the Western Operations Office in the Los Angeles area and the Downey Operations Office is identified therein as NAA Autonetics - SID.

ANALYSIS OF RESOURCES REQUIREMENTS BY OBJECT CLASSIFICATION:

		1964	1965	1966
11.	Personnel Compensation.....	$3,378,000	$4,155,000	$4,378,000
12.	Personnel Benefits.....	231,000	291,000	304,000
	Total, personnel costs....	$3,609,000	$4,446,000	$4,682,000
21.	Travel and Transportation of Persons.....	243,000	296,000	303,000
22.	Transportation of Things....	13,000	24,000	20,000
23.	Rents, Communications and Utilities.....	315,000	448,000	469,000
24.	Printing and Reproduction...	13,000	17,000	17,000
25.	Other Services.....	456,000	567,000	672,000
	Services of other agencies	173,000	50,000	38,000
26.	Supplies and Materials.....	51,000	65,000	65,000
31.	Equipment.....	51,000	76,000	71,000
32.	Lands and Structures.....	-	-	-
42.	Insurance Claims and Indemnities.....	-	-	-
	Total.....	$4,924,000	$5,989,000	$6,337,000

JUSTIFICATION BY OBJECT CLASSIFICATION:

Personnel Distribution

	1964	1965	1966
Direct Personnel by Program			
Manned Space Flight			
Gemini.....	1	1	1
Apollo.....	146	149	149
Advanced Manned Missions.....	4	4	4

	1964	1965	1966
Space Science and Applications			
Lunar and planetary exploration.....	8	19	19
Communication satellites.....	6	5	5
Launch vehicle development.....	3	4	4
Launch vehicle procurement.....	4	4	4
Meteorological satellites.....	13	15	15
Advanced Research and Technology			
Solar and chemical power.....	27	30	30
Chemical propulsion.....	5	5	5
Space vehicle systems.....	3	3	3
Technology Utilization.....	2	2	2
Sub-total, direct positions.....	222	241	241
Support Personnel			
Director and Staff.....	9	10	10
NASA-wide support.....	144	150	150
Sub-total, support positions.....	153	160	160
Total, permanent positions.....	375	401	401
Other positions:			
Positions under cooperative training agreements.....	-	-	-
Other temporary positions.....	1	5	5
Total, all positions.....	376	406	406

Personnel Costs

	1964	1965	1966
Total Positions.....	376	406	406
Permanent.....	375	401	401
Other.....	1	5	5

	1964	1965	1966
Personnel Compensation:			
Annual cost of permanent positions..	$3,551,000	$4,077,000	$4,078,000
Pay above the stated annual rate....	31,000	16,000	15,000
Lapses (deduct).....	-498,000	-231,000	-1,000
Net cost of permanent positions.....	3,084,000	3,862,000	4,092,000
Other personnel compensation.....	294,000	293,000	286,000
Total compensation.....	3,378,000	4,155,000	4,378,000
NASA funded.....	3,378,000	4,155,000	4,378,000
Reimbursable.....	---	---	---
Personnel benefits.....	231,000	291,000	304,000
NASA funded.....	231,000	291,000	304,000
Reimbursable.....	---	---	---
Total personnel costs.....	3,609,000	4,446,000	4,682,000
NASA funded.....	3,609,000	4,446,000	4,682,000
Reimbursable.....	---	---	---
Average Number of All Employees (Man Years).....	336	390	405

Personnel Compensation and Benefits - $4,682,000

Personnel costs in FY 1966 are estimated to be $236,000 higher than in FY 1965, of which $223,000 is for personnel compensation and $13,000 is for personnel benefits. The higher estimate primarily reflects full year employment in FY 1966 for personnel hired during the last half of FY 1965.

Travel and Transportation of Persons - $303,000

Employee travel requirements are estimated to increase $7,000 in FY 1966 due to a larger professional staff on-board at the end of FY 1965. The total estimate includes $256,000 for the travel of staff personnel. This amount is needed for program and administrative direction and coordination, for attendance at NASA technical meetings and working panels; and for costs of temporary assignments and transfers and travel to initial duty stations. The balance of $47,000 covers expenses of local transportation and toll charges and the rental of passenger motor vehicles from the General Services Administration.

Transportation of Things - $20,000

The FY 1966 estimate is projected $4,000 below the FY 1965 requirements primarily for movement of household goods for new employees and for local drayage costs.

The estimate of $20,000 consists of $14,000 for movement of household and personal effects; $4,000 for commercial shipments by land, water, and air; and $2,000 for local drayage and parcel post.

Rents, Communications and Utilities - $469,000

The estimate of $469,000 for this category is $21,000 higher than for FY 1965. The FY 1966 request includes $190,000 for the commercial lease of real estate and the term rental of equipment. This is the same funding level as the projected FY 1965 requirement. These rental costs cover the lease of 45,120 square feet of building space for $170,000 or an average annual cost of $3.75 a square foot. The balance of the estimate, amounting to $20,000, is needed for the rental of office and other types of equipment.

The cost of communications services is expected to increase $21,000 in FY 1966. The increase includes additional funding of $16,000 for the installation of more leased teletype circuits at the West Coast Communications Center required for effective communication with major project offices located in contractor plants. The remaining $5,000 of the increase is required for local telephone and exchange services. The major categories of communications services requirements are the following:

	FY 1966
Leased lines	$103,000
Long distance tolls	45,000
Local telephone and exchange	90,000
All other communications	30,000
Total	$268,000

The balance of the estimate for FY 1966 is related to the $11,000 required for utilities.

Printing and Reproduction - $17,000

Funding of FY 1966 requirements for the printing and reproduction of technical and administrative reports, publications and forms is expected to remain at the FY 1965 level. Approximately 90 per cent of the estimate, or $15,000, is for commercial printing of technical documents and related materials. The remaining $2,000 will cover printing of administrative and educational materials by other Government agencies.

Other Services - $672,000

The estimate for other services in FY 1966 reflects an increase of $105,000 over FY 1965 requirements, of which $50,000 is for supplementary technical support in evaluating advanced technological data required for accomplishment of mission operations, $42,000 is for enlarging the capacity of the reliable electrical connections school to meet the increasing demand

of aerospace contractors for certified instructors to train their production employees for compliance with more stringent quality assurance requirements. The balance of the increase, amounting to $13,000, will be used to finance the operation of the technical reference library on a full year basis and for various minor contractual services of a non-recurring nature.

The following table shows FY 1966 funding requirements by category of service:

ADP equipment operation	$50,000
Custodial services	19,000
Advanced technology support	50,000
JPL administrative aircraft lease and operation	247,000
Technical reference library	65,000
Reliable electrical connections school	210,000
Miscellaneous minor services	31,000
Total	$672,000

Services of Other Agencies - $38,000

Reimbursable services provided by other Government agencies are estimated to decrease $12,000 in FY 1966 to $33,000 as a result of a projected reduction in the requirement for contract administration services by the NASA resident office at the Jet Propulsion Laboratory. An additional $5,000 is required to support continuation of consulting engineering services to the resident office by the Army Corps of Engineers.

Supplies and Materials - $65,000

The FY 1966 requirement for supplies and materials is expected to remain at the FY 1965 level. $53,000 of the amount requested is for office use; the remaining $12,000 will be used for procurement of expendable electrical, photographic, maintenance and operating supplies. Purchase of non-expendable items will be necessary only for inventory replacement.

Equipment - $71,000

The amount of $71,000 requested is to provide for the purchase of passenger-carrying vehicles, photographic and non-capitalized equipment, and replacement of unserviceable office equipment and furniture. The FY 1966 requirements for these items is $5,000 less than in FY 1965.

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