National Aeronautics and Space Administration

BUDGET ESTIMATES

FISCAL YEAR 1967

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

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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: The attainment of a capability for manned space operations and exploration through extended earth orbital flights, development of rendezvous and docking techniques, and manned lunar landing and return.

SPACE SCIENCE AND APPLICATIONS: An unmanned space flight program directed toward scientific investigations of the Earth, Moon, Sun, planets, stars and interplanetary space; and the development of technology and spacecraft systems that can be used in operational systems, such as meteorology and communications.

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

TRACKING AND DATA ACQUISITION: The effort required for the operational support of the NASA manned and unmanned flight programs.

MANNED SPACE FLIGHT

The greatest portion of the FY 1967 request is for the support of the manned space flight program. The development of a capability for manned space operations with a supporting base of engineering, scientific and production capacity remains unchanged as the basic objective of this program. Within this basic objective there is a specific goal of landing men on the lunar surface for limited lunar exploration and returning them safely to earth in this decade. Projects Gemini and Apollo continue to be the hard core of the present flight and ground test and development effort. Supplementing these projects are studies and supporting development activity which are directed toward the exploitation of the hardware and techniques developed by Gemini and Apollo.

Gemini has already established man's capability for useful activities in space for periods of up to two weeks. In FY 1967 its flight operations will be completed. These flights will provide Apollo with important development information on space navigation, guidance, rendezvous and docking techniques.

In addition to continuation of the ground test activities, FY 1967 Apollo efforts will expand into manned spacecraft flight tests using the Saturn IB launch vehicle, and the initial development flights of the Saturn V launch vehicle.

In the area of advanced flight missions, studies and advanced component development will be continued. The aim of this effort will be to exploit and extend the capability of the Apollo spacecraft.

SPACE SCIENCE AND APPLICATIONS

In the FY 1967 budget request the next major program is that of space science and applications. Part of the scientific program is concerned with unmanned space flights, which are used to study the environment and surface of the Earth, Moon, and planets, as well as the intervening space environment. The flight projects concerned with the above objectives include sounding rockets, Geophysical satellites, Explorers, Pioneer probes, Mariners and Surveyor. The project involved with the study of the Sun is the Orbiting Solar Observatory; while the purpose of the Orbiting Astronomical Observatory is to study the stars. The biosatellite program will continue development so as to launch its first flight in 1966. In the area of applications, project Nimbus will continue to support the present and future requirements of the operational weather satellite systems for the Weather Bureau. Effort will also continue in the development of the Applications Technology Satellite which will give useful information for application to meteorology and communications as well as scientific spacecraft systems.

ADVANCED RESEARCH AND TECHNOLOGY

The advanced research and technology effort constitutes a continuing overall program aimed at meeting the technology goals of the nation with particular attention to providing the technical base for carrying out attractive future aero-space missions. This effort covers the spectrum of activity from basic research to improve our fundamental knowledge of physical and life science phenomena, through applied technology to improve our practical capability for developing advanced systems. The specific areas of effort in the advanced research and technology program are basic research, biotechnology and human research, electronics and control, nuclear systems and space power, chemical propulsion, space vehicle research and technology, and aeronautics.

TRACKING AND DATA ACQUISITION

The tracking and data acquisition effort is directed toward providing the necessary support required by the increasing activity of the NASA space flight programs. During FY 1967 increased numbers of launches are scheduled for both the manned and unmanned space flight programs, thereby requiring additional effort by the world-wide network of tracking stations. Additionally, the program provides for supplementing and maintaining the tracking and data acquisition capability of the network as required.

TECHNOLOGY UTILIZATION

The technology utilization program provides for the distribution and dissemination of the scientific, technological and engineering information and concepts resulting from NASA programs so as to permit their fullest use in accomplishing national objectives. In order to assure fulfillment of this basic objective, several subsidiary objectives must be realized. They are: 1. Establishing effective mechanisms and systems for assuring that all new knowledge is identified, collected, evaluated and made available in the most useful manner; and 2. Establishing effective mechanisms for announcing and disseminating this new knowledge in order to assure the widest possible application and utilization thereof.

FINANCING

The FY 1967 budget to support the research and development program, which is discussed in detail in this volume, is $4,246,600,000. This compares with a program totaling $4,511,644,000 for FY 1966.

Expenditures for the current fiscal year are estimated at $4,520,000,000 and $4,340,000,000 for FY 1967

NATIONAL AERONATUICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

GENERAL STATEMENT

This appropriation provides for contractual services for the design, construction and modification of facilities; the purchase of equipment related to construction and modification; and advance design of facilities planned for future authorization. The principal projects in the 1967 program are described below:

MANNED SPACE FLIGHT: The estimates include funding requirements for operational and testing facilities, utility installation, and additions and modifications to existing facilities, to support the Apollo spacecraft and Saturn launch vehicle programs and other research and support activities.

SCIENTIFIC INVESTIGATIONS IN SPACE: Projects in this category will support activities in space science. The estimates provide for modifications to launch facilities; new launch and servicing facilities for Delta vehicles, an Aerobee launch facility, and additional utility installations.

SPACE TECHNOLOGY: These projects comprise research laboratories, a support facility, and a chemical distribution facility.

AIRCRAFT TECHNOLOGY: Funds will provide for a V/STOL wind tunnel, expansion of the propulsion systems laboratory, and modifications for a hypersonic propulsion facility.

SUPPORTING ACTIVITIES: Funds are included for facility planning and design; a 40-foot antenna test bed, and a utility installation to support tracking and data acquisition requirements.

The appropriation for FY 1966 was $60,000,000 and the authorization was $62,376,350. The request for 1967 is $101,500,000; an increase of $41,500,000 from the 1966 appropriation. Total expenditures are estimated to be $300,000,000 in FY 1967, a decrease of $195,000,000 from the $495,000,000 estimated for FY 1966.

The budget request contains $20,000 to provide a fall-out shelter protection for a new facility at Kennedy Space Center. The amount has been determined in consultation with the Department of Defense based on DOD policy and criteria.

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. These installations are institutionally administered by the Associate Administrator who has prime responsibility for the Research and Development 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 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, and the Electronics Research Center, the Flight Research Center, the Langley Research Center, the Lewis Research Center, and the Space Nuclear Propulsion Office. Headquarters reports directly to the Deputy Associate Administrator, and the Western Operations Office reports to the Assistant Administrator for Industry Affairs. Installation descriptions and funding requirements are grouped in this volume in accordance with the prime missions of the installations.

Manpower

NASA originally planned for a total of 34,100 civilian personnel positions in FY 1966. However, due to the successful acceleration in the manned space flight program, additional manpower was required to support this program. As a result, an additional 424 positions were assigned to the Manned Spacecraft Center and the Kennedy Space Center bringing the total end of year positions to 34,524. In FY 1967 an additional 450 positions are planned for the Electronics Research Center in accordance with the phased build up for that installation. Post-flight studies of the early Gemini flights showed a strong relationship between spacecraft hours in flight and manhours in flight, and requirements for supporting personnel for launch, mission operations, and tracking. As a result of these workload indicators, in addition to the 424 positions assigned in FY 1966, a further allocation of 365 positions for the Kennedy Space Center and the Goddard Space Flight Center to support the heavy emphasis on launching and tracking of manned space flight missions is planned. These increases are partially offset by a target reduction of 400 positions throughout the agency which will not be filled upon becoming vacant. A total of 34,939 positions is requested for FY 1967.

The number of positions requested and the grade level of the employees is a product of the Human Resources Study conducted by NASA over a six month period. This study included a detailed position-by-position study at all NASA installations with the intent of eliminating organizational entities or positions not considered necessary for the assigned missions. The study verified that manpower was and is being used effectively and that every effort is being made to provide for new requirements by adjustments within the authorized manpower level. An important part of the study was the development of a computer-assisted technique for assignment of grade and salary levels throughout the agency. The historical study had indicated that the factors which had the greatest impact on grade and salary levels were: (1) promotion practices, (2) rate of separation, (3) level of accessions, and (4) statutory within grade pay increases. The computer program utilized these four forcing factors to evaluate sensitivity of policies relating to promotions, separations, and accessions and provided a method to make long range forecasts of the effect on average grade and salary of differing concepts of personnel management. The estimates for personnel compensation contained in the budget have been established through this technique. In addition to developing a technique for estimating grade and salary requirements, the Human Resources Study includes a follow-up procedure which continuously evaluates the progress of the manpower activity against the projection.

The following tabulations indicate the distribution of NASA personnel by program and the numbers of personnel by center:

Personnel Distribution

	1965	1966	1967
Direct Personnel by Program			
Manned Space Flight			
Gemini	1,050	1,168	197
Apollo	9,369	9,528	10,356
Advanced missions	250	273	302
Sub-total, MSF	10,669	10,969	10,855
Space Science and Applications			
Physics and astronomy	1,357	1,330	1,295
Lunar and planetary exploration	342	376	387
Sustaining university program	72	71	71
Launch vehicle development	265	241	176
Launch vehicle procurement	317	351	352
Bioscience	260	267	269
Meteorological satellites	275	244	237
Communication and applications technology satellites	154	158	161
Sub-total, SSA	3,042	3,038	2,948

	1965	1966	1967
Advanced Research and Technology			
Basic research.................	1,258	1,284	1,286
Space vehicle systems..........	1,483	1,488	1,485
Electronics systems............	1,068	1,264	1,629
Human factor systems...........	230	235	245
Space power and electric propulsion systems..............	931	807	800
Nuclear rockets................	774	607	593
Chemical propulsion............	505	660	680
Aeronautics....................	1,513	1,679	1,743
Sub-total, ART................	7,762	8,024	8,461
Tracking and Data Acquisition....	780	831	953
Technology Utilization...........	47	45	45
Sub-total, direct positions..	22,300	22,907	23,262
Support Personnel			
Director and staff...............	1,092	1,096	1,092
Administration...................	4,872	4,940	4,941
Research and development support.	4,936	4,981	5,044
Sub-total, support positions...	10,900	11,017	11,077
Total, permanent positions.....	33,200	33,924	34,339
Total, other positions.........	1,100	600	600
Grand Total, all positions.........	34,300	34,524	34,939

Personnel Requirements

	1965	1966	1967
Manned Space Flight			
Kennedy Space Center...........	2,428	2,620	2,750
Manned Spacecraft Center.......	4,237	4,809	4,747
Marshall Space Flight Center...	7,510	7,317	7,221
Sub-total, MSF..............	14,175	14,746	14,718

	1965	1966	1967
Space Science and Applications			
Goddard Space Flight Center.....	3,704	3,577	3,759
Pacific Launch Operations Office	19	---	---
Wallops Station.................	518	518	518
Sub-total, SSA................	4,241	4,095	4,277
Advanced Research and Technology			
Ames Research Center............	2,210	2,220	2,191
Electronics Research Center.....	244	550	1,000
Flight Research Center..........	605	604	596
Langley Research Center.........	4,244	4,234	4,179
Lewis Research Center...........	4,815	4,810	4,747
Space Nuclear Propulsion Office.	117	117	115
Sub-total, ART................	12,235	12,535	12,828
Supporting Activities			
Headquarters, NASA..............	2,163	2,162	2,135
Western Operations Office.......	386	386	381
Sub-total	2,549	2,548	2,516
Permanent positions.............	33,200	33,924	34,339
Other positions.................	1,100	600	600
Grand total, all positions........	34,300	34,524	34,939

Funding

The FY 1966 NASA budget included a request for $609,400,000 for Administrative Operations. This was reduced by the Authorization Act to $591,048,850 and further reduced by the Appropriation Act to $584,000,000. A detailed analysis of requirements to be funded under Administrative Operations resulted in the conclusion that the estimate could be reduced by $5,892,000 to a total of $603,508,000. With the peak workload approaching, however, any amount below this level would make it impossible to conduct successfully the planned flight missions. In addition to this requirement, the recent Federal Employees Salary Act of 1965 created a new funding requirement of $8,312,000 for a total of $611,820,000 for the Administrative Operations appropriation. As a result, a total of $27,820,000 has been reprogrammed and transferred from the Research and Development appropriation to increase funding to $611,820,000.

The FY 1967 funding request for Administrative Operations is $663,900,000 an increase of $52,080,000. The major reason for the increase requested is related to the manned lunar landing program with the Cape Kennedy Merritt Island Launch Area approaching its full development and the Manned Spacecraft Center approaching its full operational capability, as well as the support of this program in other centers, particularly the Goddard Space Flight Center. The other major area of increase is related to the build up of the Electronics Research Center. The object classification description of resources requested is tabulated below:

ANALYSIS OF RESOURCES REQUIREMENTS BY OBJECT CLASSIFICATION

(Thousands of Dollars)

	1965	1966	1967
11. Personnel compensation.............	332,722	355,511	375,354
12. Personnel benefits.................	23,713	25,299	27,090
21. Travel and transportation of persons..........................	20,427	20,841	21,279
22. Transportation of things...........	4,543	4,689	5,048
23. Rent, communications and utilities	46,424	49,795	56,417
24. Printing and reproduction..........	4,174	4,615	4,916
25. Other services.....................	85,045	107,584	127,538
26. Supplies and materials.............	24,553	21,156	26,122
31. Equipment..........................	86,370	16,998	14,696
32. Lands and structures...............	6,539	5,300	5,408
42. Insurance claims and indemnities...	27	32	32
Total..................................	634,537 a/	611,820 b/	663,900

The analysis of changes by Object Classification FY 1966 to FY 1967 follows:

	1965	1966	1967	Change in FY 1967
Personnel Compensation and Benefits	$356,435	$380,810	$402,444	+$21,634

In FY 1967 the cost of personnel compensation and benefits will be $21.6 million greater than FY 1966. Of this amount $3.8 million is caused by the full year effect of the Federal Employees Salary Act of 1965, effective in October 1965. The most significant increase reflects the cost of providing for a net increase of 846 manyears for permanent personnel. Actual increases include 621 manyears for new FY 1967 positions at the Kennedy Space Center, the Electronics Research Center, and the Goddard Space Flight Center, and an increase of 425 manyears related to the new positions filled during FY 1966.

a/Includes $14,573,000 comparative transfer from Research and Development.
b/Includes $27,820,000 appropriation transter from Research and Development.

These increases of 1,046 manyears are partially offset by the saving of 200 manyears resulting from not filling 400 vacancies due to the 1965 retirement legislation. The cost of the net additional manyears is estimated at $9.8 million.

Reimbursement to the Department of Defense for military personnel detailed to NASA will increase by $1.1 million in FY 1967 over FY 1966. In FY 1966, 128 trained military personnel, who became available because of the phase-out of the Atlas and Titan I missile systems, were detailed to NASA for the support of Gemini and Apollo flight operations. In FY 1966 the Department of Defense paid the entire cost of these personnel. NASA will assume the funding responsibility for these personnel in FY 1967.

In addition to the increased costs resulting from the salary increase, additional manyears, and reimbursement for military personnel, there is an increase of $9.9 million resulting from the structural changes in the personnel complement. The total increase of $24.6 million is offset by a decrease of $.4 million in temporary employment and $2.6 million in overtime and holiday pay, for a net increase of $21.6 million. The net increase for personnel compensation and benefits consists of $19.8 million for compensation and $1.8 million for benefits.

	1965	1966	1967	Change in FY 1967
Travel and Transportation of Persons	$20,427	$20,841	$21,279	+$438

The estimate for travel and transportation of persons in FY 1967 represents an increase of $525 thousand for Electronics Research Center, Kennedy Space Center, and Manned Spacecraft Center offset by a reduction of $87 thousand in other centers. The increase of $45 thousand for the Electronics Research Center is related to the growth of the Center. The increases of $93 thousand at the Kennedy Space Center and $387 thousand at the Manned Spacecraft Center are directly related to the increased flight activity which includes the last third of the Gemini flights, the first manned Apollo spacecraft launching on the Saturn IB and the first Saturn V launch during this time period.

	1965	1966	1967	Change in FY 1967
Transportation of Things	$4,543	$4,689	$5,048	+$359

The majority of the FY 1967 increase of $359 thousand in this object class results from the expansion of personnel and facilities at the Merritt Island Launch Area and Launch Complex 39 at Cape Kennedy as the Apollo program moves into the flight stage. Other increases are related to additional facilities coming into use at the Goddard Space Flight Center and the phased build up at the Electronics Research Center.

	1965	1966	1967	Change in FY 1967
Rent, Communications and Utilities	$46,424	$49,795	$56,417	+$6,622

The major increases in FY 1967 requirements over FY 1966 include: increased space rental at the Electronics Research Center, increased rental of ADP equipment, increased communications, and increased utilities. In FY 1967 the Electronics Research Center will add 450 positions as part of the approved center build up plan. It is estimated that an additional 100,000 square feet of space will be rented at a cost of $544 thousand to accommodate these personnel.

The estimate for ADP rental cost in FY 1967 is $2.7 million greater than in FY 1966. The majority of the increase will be at the Goddard Space Flight Center where an overlapping of equipment will be required during the phase-out of second generation equipment and the installation of the super-speed complex. The Electronics Research Center will begin installation of ADP equipment. In FY 1967 the initial ADP system will be installed, and the cost will increase from $27 thousand in FY 1966 for EAM equipment to $543 thousand for ADP and EAM equipment in FY 1967. The Langley and Ames Research Centers require an increase in equipment rentals to supplement NASA owned systems as a prerequisite to solving the more complex problems presented by planned research programs. Other Centers' requirements reflect minor reductions as the full effects of FY 1965 and FY 1966 equipment purchases are realized.

There is a net increase in the manned space flight centers in FY 1967 of $.3 million. At the Marshall Space Flight Center third generation equipment will be installed to replace the present second generation equipment. In addition, the new equipment will change the method of operation at this Center by replacing several small systems separately located in each of the laboratories with a large central processor with remote inquiry stations. Because of this change in method of operation, NASA will initially lease this equipment. This will cause overlapping of lease costs in FY 1967 in the amount of $.7 million. Offsetting the increase at the Marshall Space Flight Center, the lease cost at the Manned Spacecraft Center will be $.4 million lower in FY 1967 which represents the first full year effect of the lease savings resulting from the FY 1965 equipment purchase program.

The increase in manned flight activity, and the effect of increased Federal Telecommunications Systems rates and lines for the full year, will result in about about $.6 million more communication costs.

In FY 1967 the number of facilities becoming operational will result in an increase of $2.7 million in utility costs. About one-half of this will be for the activation of the Merritt Island Launch Area and Launch Complex 39 at the Kennedy Space Center, NASA. The increase in costs at other centers is a result of the completion of facilities authorized in prior years.

In summary, the increase of $6.6 million consists of $.5 million for rental of space, $2.7 million for ADP leases, $.6 million for communications, $2.7 million for utilities, and $.1 million for all other items in this category.

	1965	1966	1967	Change in FY 1967
Printing and Reproduction	$4,174	$4,615	$4,916	+$301

The majority of the increase in this object class is for Headquarters and for the Kennedy Space Center, NASA. The Headquarters increase of $150 thousand results from the growing volume of scientific and technical information being generated by the NASA research and development programs and the statutory requirement to make this information available to the scientific community. Another increase of $122 thousand is at the Kennedy Space Center, NASA, to provide the necessary support for the greater number of personnel manning the completed Merritt Island Launch Area and Launch Complex 39 facilities. There are minor increases also at the Electronics Research Center and the Goddard Space Flight Center related to increased activity at these centers.

	1965	1966	1967	Change in FY 1967
Other Services	$85,045	$107,584	$127,538	+$19,954

The increase in other services represents requirements resulting from program development and the completion of new construction begun in prior years. The largest increases are strictly related to the support of the planned flight schedules. Flight schedules are being met and the indications are that this will continue. As a result of the greater complexity of the missions, considerably more support is required. This is particularly true at the Kennedy Space Center, where the logistic support for all launch vehicle stage contractors will be provided through this account, and where the huge Merritt Island Launch Area and Launch Complex 39 will become fully operational. The completion of additional facilities at nearly all locations will require additional custodial and maintenance services, and the large scale procurement of ADP equipment in prior years will require increases in maintenance costs and programming effort.

The largest increase for other services is to support the expanded activity at the Kennedy Space Center. FY 1967 requirements reflect the full year effect of the FY 1966 base support services build up. During 1966 the majority of the Merritt Island Launch Area and Launch Complex 39 facilities will be completed and will become operational. Accordingly, as each facility is completed, it will be manned by NASA and contractor personnel. To provide base operational support, $5.7 million more will be required in FY 1967 than in FY 1966. In addition, administrative support for the expanded effort will require an increase of $2.8 million, for a total increase of

$8.5 million for contractual services outside the government.

As the NASA manned and unmanned flight activity increases at Cape Kennedy, NASA is assuming the funding responsibility for more facilities from the Air Force. Also, as the overall NASA activity increases, the amount of services provided by the Air Force on a reimbursable basis increases accordingly. This will result in an increase of $1.3 million in FY 1967.

The combination of the rise in Air Force reimbursements coupled with the increase in contractual services outside the government results in a total increase for other services at Kennedy Space Center, NASA of $9.8 million.

Another significant increase in FY 1967 over FY 1966 will be for the technical documentation and scientific and technical information programs. This expanded activity is occasioned by the advancement in the Apollo program from design and development effort to testing, qualification and flight. In addition, as other NASA flight and research programs achieve additional milestones, the necessity for documentation, classification and dissemination of the results obtained increases. It is estimated that the cost of this effort will require an additional $2.4 million in FY 1967.

The requirements for ADP programming, operations support, and maintenance are estimated to increase in FY 1967 by $2.7 million. The cost of maintaining NASA owned ADP equipment will be $.5 million greater than in FY 1966. This increase reflects the effects of the FY 1965 and FY 1966 purchase programs. The estimates for ADP programming and operations support are $2.2 million higher in FY 1967. The largest increases are in support of the Electronics Research Center and the increased complexity of the work conducted by the Goddard Space Flight Center Institute of Space Studies.

In FY 1967 the estimated cost of maintenance and custodial services will be $3.7 million higher than in FY 1966. The increased physical plant for which custodial services are required, coupled with the full year effect of the Service Contract Act of 1965 on NASA service contracts, will raise the cost in this area by $1.5 million. As the NASA capital investment grows larger and facilities become older, the cost of maintenance and repair increases accordingly. In FY 1967 it is estimated that the cost of maintaining the NASA plant, including equipment, will be $2.2 million greater than in FY 1966.

The balance of the increase over FY 1966 is reflected in minor changes in many categories of service. The largest items in this category are the increase in medical services at the Manned Spacecraft Center caused by greater astronaut activity, and an intensive study by Headquarters of the incentive contracting policy and procedure.

	1965	1966	1967	Change in FY 1967
Supplies and Materials	$24,553	$21,156	$26,122	+$4,966

In FY 1967 the requirement for supplies and materials to support the larger number of facilities which will become operational in FY 1966 and FY 1967, and the greater number of personnel, both civil service and contractor, will increase by $4.6 million as the Apollo program moves into the flight mission stage. The balance of the increase, $.4 million, is required to support the build up at the Electronics Research Center and for adjustments at other centers.

	1965	1966	1967	Change in FY 1967
Equipment	$86,370	$16,998	$14,696	-$2,302

The total cost of equipment required in FY 1967 is $2.3 million less than that needed in FY 1966. The reduction is directly attributable to the ADP equipment purchase program which has been reduced from $7.9 million in FY 1966 to $2.8 million in FY 1967. This reduction is partially offset by an increase of $2.1 million to provide equipment to support the build up required for manned flight support operations at the Kennedy Space Center, the Manned Spacecraft Center, and the Goddard Space Flight Center. The other $.7 million increase is required to offset the deferment of equipment purchases in recent years and to allow for modernization of laboratory equipment.

	1965	1966	1967	Change in FY 1967
Lands and Structures	$6,539	$5,300	$5,408	+$108

In FY 1967 the amount requested for lands and structures reflects a net increase in requirements of $108 thousand. The additional resources required to support the expansion of Apollo flight activity are estimated to be slightly in excess of $313 thousand, offset by a reduction at Ames Research Center of $205 thousand.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1967 ESTIMATES

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

	Fiscal Year 1965	Fiscal Year 1966	Fiscal Year 1967
Budget Activity:			
1. Manned Space Flight:			
(a) Gemini............	$308,400,000	$226,611,000	$40,600,000
(b) Apollo............	2,614,619,000	2,967,385,000	2,974,200,000
(c) Advanced mission studies.........	26,000,000	10,000,000	8,000,000
2. Scientific Investigations in Space:			
(a) Physics and astronomy......	176,029,000	189,132,000	167,300,000
(b) Lunar and planetary exploration....	267,442,000	326,523,000	260,800,000
(c) Bioscience.......	31,001,000	46,200,000	39,900,000
(d) Launch vehicle development....	138,191,000	90,300,000	61,700,000
3. Space Applications.....	70,467,000	83,682,000	88,100,000
4. Space Technology.......	299,320,000	248,500,000	247,900,000
5. Aircraft Technology....	35,240,000	41,496,000	33,000,000
6. Supporting Activities:			
(a) Tracking and data acquisition....	253,236,000	231,065,000	279,300,000
(b) Sustaining university program........	46,000,000	46,000,000	41,000,000
(c) Technology utilization....	4,750,000	4,750,000	4,800,000
Total Budget Plan....	$4,270,695,000	$4,511,644,000	$4,246,600,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1967 ESTIMATES

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

	Fiscal Year 1965	Fiscal Year 1966	Fiscal Year 1967
Financing:			
Appropriation..............	$4,363,594,000	$4,531,000,000	$4,246,600,000
Transferred to-			
"Construction of facilities" (78 Stat. 658)....................	-3,545,000	---	---
"Administrative operations" (79 Stat. 534)....................	---	-27,896,000	---
Appropriation (adjusted)..........	4,360,049,000	4,503,104,000	4,246,600,000
Transferred to "Construction of facilities" in FY 1966	-354,000	---	---
Prior year funding applied - available from adjustments to FY 1962 and prior budget plans.............	2,263,000	---	---
Reprogramming to (-) or from prior year budget plans.....................	-76,690,000	8,540,000	---
Comparative transfer to "Administrative Operations"	-14,573,000	---	---
Total financing of the budget plan..........	$4,270,695,000	$4,511,644,000	$4,246,600,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1967 ESTIMATES

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

BUDGET ACTIVITY	OFFICE/PROGRAM	Fiscal Year 1965	Fiscal Year 1966	Fiscal Year 1967
	MANNED SPACE FLIGHT.......	$2,949,019,000	$3,203,996,000	$3,022,800,000
1a	Gemini..................	308,400,000	226,611,000	40,600,000
1b	Apollo..................	2,614,619,000	2,967,385,000	2,974,200,000
1c	Advanced missions.......	26,000,000	10,000,000	8,000,000
	SPACE SCIENCE AND APPLICATIONS............	$732,362,000	$783,237,000	$661,400,000
2a	Physics and astronomy...	139,082,000	143,500,000	131,400,000
2b	Lunar and planetary exploration...........	206,027,000	251,337,000	197,900,000
6b	Sustaining university program...............	46,000,000	46,000,000	41,000,000
2d	Launch vehicle development...........	96,500,000	55,300,000	33,700,000
*	Launch vehicle procurement...........	154,487,000	178,700,000	152,000,000
2c	Bioscience..............	28,501,000	36,700,000	35,400,000
3	Meteorological satellites............	30,991,000	38,900,000	43,600,000
3	Communication and applications technology satellites.	30,774,000	32,800,000	26,400,000
	ADVANCED RESEARCH AND TECHNOLOGY.............	$331,328,000	$288,596,000	$278,300,000
4	Basic research..........	21,231,000	22,000,000	23,000,000
4	Space vehicle systems...	44,193,000	35,000,000	36,000,000
4	Electronics systems.....	25,622,000	32,300,000	36,800,000
4	Human factor systems....	13,320,000	14,900,000	17,000,000
4	Space power and electric propulsion systems....	58,220,000	45,200,000	42,500,000
4	Nuclear rockets.........	57,000,000	58,000,000	53,000,000
4	Chemical propulsion.....	76,502,000	39,700,000	37,000,000
5	Aeronautics.............	35,240,000	41,496,000	33,000,000
6a	TRACKING AND DATA ACQUISITION.............	$253,236,000	$231,065,000	$279,300,000

BUDGET ACTIVITY	OFFICE/PROGRAM	Fiscal Year 1965	Fiscal Year 1966	Fiscal Year 1967
6c	TECHNOLOGY UTILIZATION...	$4,750,000	$4,750,000	$4,800,000
	TOTAL BUDGET PLAN......	$4,270,695,000	$4,511,644,000	$4,246,600,000

*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 1967 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															
1965....................	2,949,019	56,110	1,418,648	1,435,989	389	-	-	39	-	-	2,400	1,160	-	33,367	917
1966....................	3,203,996	121,109	1,479,182	1,574,635	425	-	-	230	-	-	700	-	-	25,215	2,500
1967....................	3,022,800	164,505	1,363,400	1,466,295	500	-	-	250	-	-	-	-	-	25,350	2,500
Office of Space Science and Applications															
1965....................	732,362	2,674	2,608	1,462	186,868	99	1,150	34,683	275	10	67,388	199,083	-	107,230	128,832
1966....................	783,237	3,327	14,400	10,607	195,404	-	2,830	37,948	650	5	68,217	179,843	-	106,597	163,409
1967....................	661,400	4,019	15,200	495	189,193	-	3,640	31,463	750	15	35,960	147,371	-	93,146	140,148
Office of Advanced Research and Technology															
1965....................	331,328	-	1,512	28,911	8,517	-	-	19,391	2,333	7,638	34,953	122,084	45,760	31,648	28,581
1966....................	288,596	250	2,355	17,264	9,678	-	-	18,775	6,554	14,919	40,749	69,431	50,218	37,765	20,638
1967....................	278,300	250	3,370	17,496	9,701	-	-	21,455	12,400	7,925	41,127	61,603	48,500	31,833	22,640
Office of Tracking and Data Acquisition															
1965....................	253,236	-	-	2,000	179,252	-	5,100	-	-	1,900	2,200	-	-	7,015	55,769
1966....................	231,065	-	-	1,500	155,950	-	5,835	-	-	1,880	2,000	-	-	10,400	53,500
1967....................	279,300	-	-	1,500	199,600	-	6,400	-	-	2,100	2,100	-	-	12,000	55,600
Office of Technology Utilization and Policy Planning															
1965....................	4,750	-	-	-	-	-	-	-	-	-	-	-	-	4,750	-
1966....................	4,750	-	-	-	-	-	-	-	-	-	-	-	-	4,750	-
1967....................	4,800	-	-	-	-	-	-	-	-	-	-	-	-	4,800	-
Total Budget Plan															
1965....................	4,270,695	58,784	1,422,768	1,468,362	375,026	99	6,250	54,113	2,608	9,548	106,941	322,327	45,760	184,010	214,099
1966....................	4,511,644	124,686	1,495,937	1,604,006	361,457	-	8,665	56,953	7,204	16,804	111,666	249,274	50,218	184,727	240,047
1967....................	4,246,600	168,774	1,381,970	1,485,786	398,994	-	10,040	53,168	13,150	10,040	79,187	208,974	48,500	167,129	220,888

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1967 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 OFFICE1/
OFFICE OF MANNED SPACE FLIGHT, TOTAL	1965	2,949,019	56,110	1,418,648	1,435,989	389	-	-	39	-	-	2,400	1,160	-	33,367	917
	1966	3,203,996	121,109	1,479,182	1,574,635	425	-	-	230	-	-	700	-	-	25,215	2,500
	1967	3,022,800	164,505	1,363,400	1,466,295	500	-	-	250	-	-	[illegible]	-	-	25,350	2,500
Gemini	1965	308,400	-	308,050	-	-	-	-	-	-	-	-	-	-	350	-
	1966	226,611	-	226,211	-	-	-	-	-	-	-	-	-	-	400	-
	1967	40,600	-	40,300	-	-	-	-	-	-	-	-	-	-	300	-
Apollo	1965	2,614,619	55,610	1,100,973	1,430,516	389	-	-	39	-	-	1,200	1,160	-	24,087	645
	1966	2,967,385	120,509	1,249,371	1,569,135	425	-	-	230	-	-	700	-	-	24,515	2,500
	1967	2,974,200	163,905	1,320,500	1,461,795	500	-	-	250	-	-	-	-	-	24,750	2,500
Advanced mission studies	1965	26,000	500	9,625	5,473	-	-	-	-	-	-	1,200	-	-	8,930	272
	1966	10,000	600	3,600	5,500	-	-	-	-	-	-	-	-	-	300	-
	1967	8,000	600	2,600	4,500	-	-	-	-	-	-	-	-	-	300	-
OFFICE OF SPACE SCIENCE AND APPLICATIONS, TOTAL	1965	732,362	2,674	2,608	1,462	186,868	99	1,150	34,683	275	10	67,388	199,083	-	107,230	128,832
	1966	783,237	3,327	14,400	10,607	195,404	-	2,830	37,948	650	5	68,217	179,843	-	106,597	163,409
	1967	661,400	4,019	15,200	495	189,193	-	3,640	31,463	750	15	35,960	147,371	-	93,146	140,148
Physics and astronomy	1965	139,082	-	-	755	110,244	-	1,090	1,557	-	10	2,226	-	-	22,866	334
	1966	143,500	-	-	62	108,498	-	2,550	2,586	-	5	2,272	-	-	27,075	452
	1967	131,400	-	-	25	100,961	-	3,400	2,563	-	15	1,100	-	-	22,836	500
Lunar and planetary exploration	1965	206,027	-	2,608	435	1,267	-	-	15,734	-	-	50,050	97	-	9,256	126,580
	1966	251,337	-	14,400	375	1,164	-	-	12,763	-	-	53,115	-	-	12,913	156,607
	1967	197,900	-	15,200	300	1,200	-	-	7,000	-	-	23,200	-	-	14,300	136,700
Sustaining university program	1965	46,000	-	-	-	-	-	-	-	-	-	-	11	-	45,986	3
	1966	46,000	-	-	-	-	-	-	-	-	-	-	-	-	46,000	-
	1967	41,000	-	-	-	-	-	-	-	-	-	-	-	-	41,000	-
Launch vehicle development	1965	96,500	1,321	-	152	1,557	-	-	-	100	-	735	91,302	-	1,333	-
	1966	55,300	820	-	10,000	250	-	-	-	200	-	570	42,820	-	640	-
	1967	33,700	700	-	-	-	-	-	-	250	-	600	31,550	-	600	-
Launch vehicle procurement	1965	154,487	1,353	-	-	19,496	99	-	-	-	-	13,737	107,673	-	12,129	-
	1966	178,700	2,507	-	-	18,580	-	-	-	-	-	11,600	137,023	-	5,625	3,365
	1967	152,000	3,319	-	-	22,205	-	-	-	-	-	10,400	115,821	-	-	255
Bioscience	1965	28,501	-	-	-	385	-	60	17,392	-	-	-	-	-	9,145	1,519
	1966	36,700	-	-	-	420	-	100	22,599	-	-	30	-	-	11,214	2,337
	1967	35,400	-	-	-	420	-	100	21,900	-	-	30	-	-	10,450	2,500
Meteorological satellites	1965	30,991	-	-	120	29,505	-	-	-	175	-	425	-	-	766	-
	1966	38,900	-	-	170	35,400	-	180	-	450	-	630	-	-	2,070	-
	1967	43,600	-	-	170	39,300	-	140	-	500	-	630		-	2,860	-
Communication and applications technology satellites	1965	30,774	-	-	-	24,414	-	-	-	-	-	215	-	-	5,749	396
	1966	32,800	-	-	-	31,092	-	-	-	-	-	-	-	-	1,060	648
	1967	26,400	-	-	-	25,107	-	-	-	-	-	-	-	-	1,100	193

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1967 ESTIMATES

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

(In thousands of dollars)

PROGRAM		TOTAL	J. K. 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	1965	331,328	-	1,512	28,911	8,517	-	-	19,391	2,333	7,638	34,953	122,084	45,760	31,648	28,581
	1966	288,596	250	2,355	17,264	9,678	-	-	18,775	6,554	14,919	40,749	69,431	50,218	37,765	20,638
	1967	278,300	250	3,370	17,496	9,701	-	-	21,455	12,400	7,925	41,127	61,603	48,500	31,833	22,640
Basic research	1965	21,231	-	-	916	257	-	-	1,966	95	3	1,901	2,234	-	7,503	6,356
	1966	22,000	-	-	815	117	-	-	1,910	595	30	2,119	2,731	-	8,627	5,056
	1967	23,000	-	-	850	120	-	-	2,100	1,000	30	2,200	2,800	-	8,500	5,400
Space vehicle systems	1965	44,193	-	629	16,444	1,231	-	-	3,354	-	1,825	10,594	2,408	-	3,474	4,234
	1966	35,000	-	435	4,201	1,751	-	-	3,076	250	1,010	11,466	3,087	-	6,006	3,718
	1967	36,000	-	670	3,096	2,081	-	-	3,475	250	1,010	14,282	3,223	-	3,713	4,200
Electronics systems	1965	25,622	-	465	3,685	2,967	-	-	3,480	2,178	1,038	6,660	400	-	2,022	2,727
	1966	32,300	-	525	4,003	2,975	-	-	3,718	5,110	698	7,260	539	-	3,906	3,566
	1967	36,800	-	450	4,200	2,960	-	-	4,100	10,000	660	7,420	540	-	3,180	3,290
Human factor systems	1965	13,320	-	365	355	-	-	-	4,233	60	1,750	4,053	232	-	2,172	100
	1966	14,900	-	795	310	25	-	-	5,224	359	1,500	4,246	125	-	2,216	100
	1967	17,000	-	1,100	300	-	-	-	5,830	700	1,250	5,000	-	-	2,820	-
Space power and electric propulsion systems	1965	58,220	-	53	2,415	3,512	-	-	191	-	-	1,324	43,517	-	1,351	5,857
	1966	45,200	-	100	2,010	4,260	-	-	110	50	-	846	28,768	-	4,565	4,491
	1967	42,500	-	650	1,650	3,990	-	-	50	300	-	700	26,065	-	3,045	6,050
Nuclear rockets	1965	57,000	-	-	1,375	-	-	-	-	-	-	-	9,846	45,760	13	6
	1966	58,000	-	-	1,125	-	-	-	-	-	-	-	6,599	50,218	58	-
	1967	53,000	-	-	900	-	-	-	-	-	-	-	3,550	48,500	50	-
Chemical propulsion	1965	76,502	-	-	3,721	550	-	-	-	-	-	1,369	49,588	-	11,973	9,301
	1966	39,700	250	500	4,800	550	-	-	540	-	-	2,877	15,205	-	11,271	3,707
	1967	37,000	250	500	6,500	550	-	-	500	-	-	2,900	12,800	-	9,300	3,700
Aeronautics	1965	35,240	-	-	-	-	-	-	6,167	-	3,022	9,052	13,859	-	3,140	-
	1966	41,496	-	-	-	-	-	-	4,197	190	11,681	11,935	12,377	-	1,116	-
	1967	33,000	-	-	-	-	-	-	5,400	150	4,975	8,625	12,625	-	1,225	-
OFFICE OF TRACKING AND DATA ACQUISITION	1965	253,236	-	-	2,000	179,252	-	5,100	-	-	1,900	2,200	-	-	7,015	55,769
	1966	231,065	-	-	1,500	155,950	-	5,835	-	-	1,880	2,000	-	-	10,400	53,500
	1967	279,300	-	-	1,500	199,600	-	6,400	-	-	2,100	2,100	-	-	12,000	55,600
Tracking and data acquisition	1965	253,236	-	-	2,000	179,252	-	5,100	-	-	1,900	2,200	-	-	7,015	55,769
	1966	231,065	-	-	1,500	155,950	-	5,835	-	-	1,880	2,000	-	-	10,400	53,500
	1967	279,300	-	-	1,500	199,600	-	6,400	-	-	2,100	2,100	-	-	12,000	55,600
OFFICE OF TECHNOLOGY UTILIZATION AND POLICY PLANNING	1965	4,750	-	-	-	-	-	-	-	-	-	-	-	-	4,750	-
	1966	4,750	-	-	-	-	-	-	-	-	-	-	-	-	4,750	-
	1967	4,800	-	-	-	-	-	-	-	-	-	-	-	-	4,800	-
Technology utilization	1965	4,750	-	-	-	-	-	-	-	-	-	-	-	-	4,750	-
	1966	4,750	-	-	-	-	-	-	-	-	-	-	-	-	4,750	-
	1967	4,800	-	-	-	-	-	-	-	-	-	-	-	-	4,800	-
TOTAL BUDGET PLAN	1965	4,270,695	58,784	1,422,768	1,468,362	375,026	99	6,250	54,113	2,608	9,548	106,941	322,327	45,760	184,010	214,099
	1966	4,511,644	124,686	1,495,937	1,604,006	361,457	-	8,665	56,953	7,204	16,804	111,666	249,274	50,218	184,727	240,047
	1967	4,246,600	168,774	1,381,970	1,485,786	398,994	-	10,040	53,168	13,150	10,040	79,187	208,974	48,500	167,129	220,888

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 1967 ESTIMATES

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

Budget Activity	Fiscal Year 1965	Fiscal Year 1966	Fiscal Year 1967
1. Manned Space Flight..........	$199,770,096	$21,401,350	$54,378,000
2. Scientific Investigations in Space..................	8,342,600	7,084,000	6,322,000
3. Space Applications...........	---	---	---
4. Space Technology.............	21,291,000	13,435,000	11,089,000
5. Aircraft Technology..........	3,729,000	682,000	21,011,000
6. Supporting Activities........	27,974,000	16,984,650	8,700,000
Total Budget Plan..........	$261,106,696	$59,587,000	$101,500,000
Financing:			
Appropriation..............	$262,880,500	$60,000,000	$101,500,000
Transferred from (78 Stat. 658) - "Research and development".................	3,545,193	---	---
Appropriation (adjusted).........	266,425,693	60,000,000	101,500,000
Transferred from (78 Stat. 658) - "Research and Development"...........	353,800	---	---
Reprogramming to or from (-) prior year budget plans.....................	-5,672,797	-413,000	---
Total financing of budget plan............	$261,106,696	$59,587,000	$101,500,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1967 ESTIMATES

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

	Fiscal Year 1965	Fiscal Year 1966	Fiscal Year 1967
1. MANNED SPACE FLIGHT.......	$199,770,096	$21,401,350	$54,378,000
John F. Kennedy Space Center, NASA..........	85,044,000	6,895,000	36,497,000
Manned Spacecraft Center	23,907,500	4,180,000	13,800,000
Marshall Space Flight Center................	12,454,096	2,309,450	581,000
Michoud Assembly Facility	6,449,500	284,750	700,000
Mississippi Test Facility..............	58,891,000	1,910,450	1,700,000
Various Locations.......	13,024,000	5,821,700	1,100,000
2. SCIENTIFIC INVESTIGATIONS IN SPACE................	$8,342,600	$7,084,000	$6,322,000
Ames Research Center....	---	2,749,000	---
Goddard Space Flight Center................	605,000	2,400,000	---
Jet Propulsion Laboratory	3,582,000	---	350,000
John F. Kennedy Space Center, NASA..........	2,180,800	887,000	1,379,000
Various Locations.......	275,800	---	4,388,000
Wallops Station.........	1,699,000	1,048,000	205,000
3. SPACE APPLICATIONS........	$ ---	$ ---	$ ---
4. SPACE TECHNOLOGY..........	$21,291,000	$13,435,000	$11,089,000
Ames Research Center....	3,038,000	---	---
Electronics Research Center................	10,000,000	5,000,000	10,000,000
Langley Research Center..	2,540,500	7,568,000	1,089,000
Lewis Research Center...	770,000	867,000	---
Various Locations.......	4,942,500	---	---

	Fiscal Year 1965	Fiscal Year 1966	Fiscal Year 1967
5. AIRCRAFT TECHNOLOGY..........	$3,729,000	$682,000	$21,011,000
Ames Research Center.......	2,630,000	---	---
Langley Research Center....	1,099,000	682,000	5,011,000
Lewis Research Center......	---	---	16,000,000
6. SUPPORTING ACTIVITIES........	$27,974,000	$16,984,650	$8,700,000
Goddard Space Flight Center	1,709,000	---	710,000
John F. Kennedy Space Center, NASA............	1,393,000	---	---
Various Locations..........	14,872,000	14,361,000	990,000
Facility Planning and Design..................	10,000,000	2,623,650	7,000,000
TOTAL PLAN......................	$261,106,696	$59,587,000	$101,500,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

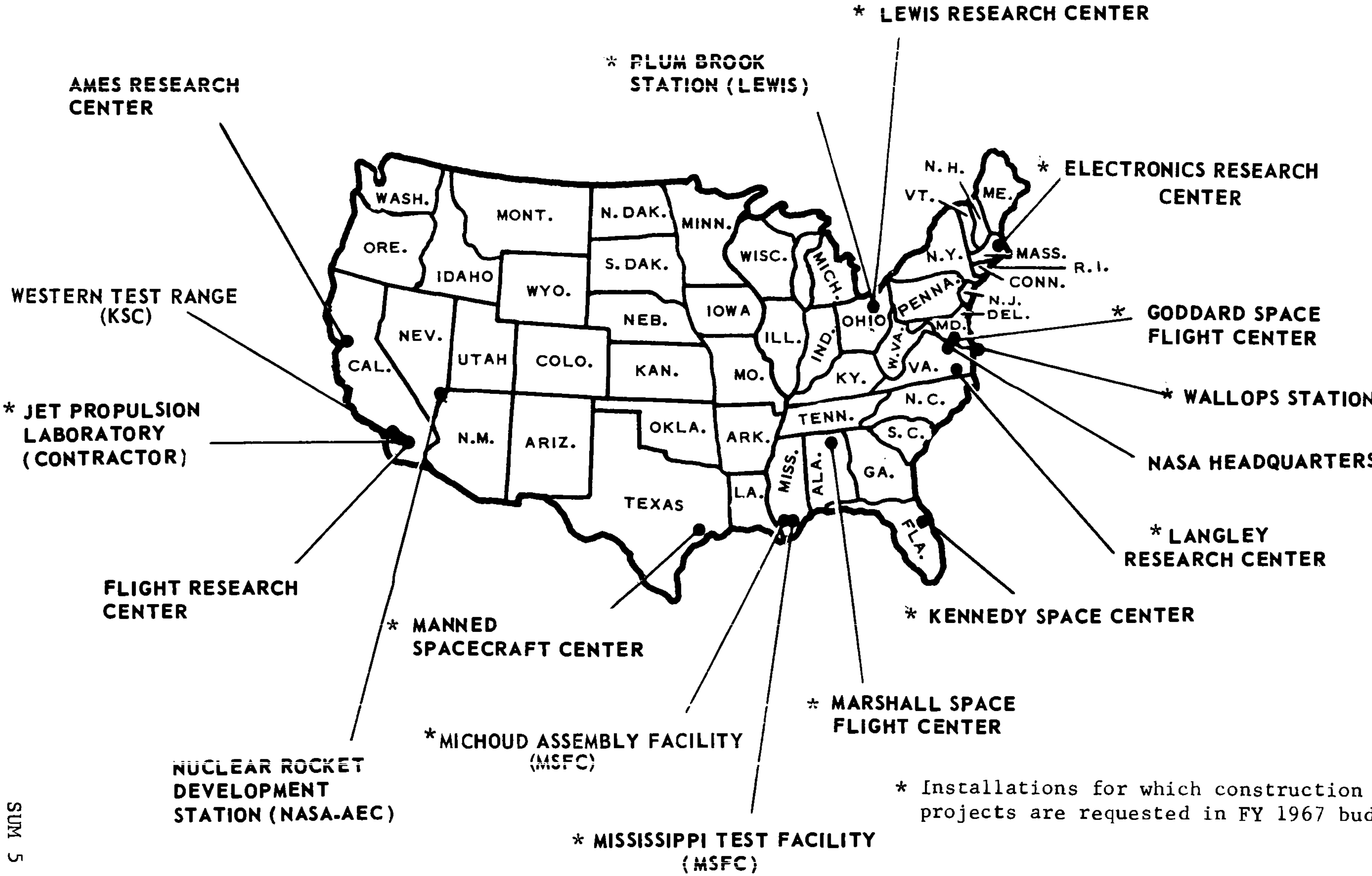
FISCAL YEAR 1967 ESTIMATES

SUMMARY OF CONSTRUCTION OF FACILITIES BUDGET PLAN BY LOCATION

Location	Fiscal Year 1965	Fiscal Year 1966	Fiscal Year 1967
Ames Research Center............	$5,668,000	$2,749,000	$ ---
Electronics Research Center.....	10,000,000	5,000,000	10,000,000
Goddard Space Flight Center.....	2,314,000	2,400,000	710,000
Jet Propulsion Laboratory.......	3,582,000	---	350,000
John F. Kennedy Space Center, NASA.........................	88,617,800	7,782,000	37,876,000
Langley Research Center.........	3,639,500	8,250,000	6,100,000
Lewis Research Center...........	770,000	867,000	16,000,000
Manned Spacecraft Center........	23,907,500	4,180,000	13,800,000
Marshall Space Flight Center....	12,454,096	2,309,450	581,000
Michoud Assembly Facility.......	6,449,500	284,750	700,000
Mississippi Test Facility.......	58,891,000	1,910,450	1,700,000
Various Locations...............	33,114,300	20,182,700	6,478,000
Wallops Station.................	1,699,000	1,048,000	205,000
Facility Planning and Design....	10,000,000	2,623,650	7,000,000
Total Plan....................	$261,106,696	$59,587,000	$101,500,000

The geographic location of NASA installations is shown on the following page. Installations for which construction projects are requested in the fiscal year 1967 budget are identified.

NASA INSTALLATIONS



* Installations for which construction projects are requested in FY 1967 budget.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1967 ESTIMATES

ADMINISTRATIVE OPERATIONS

SUMMARY OF OBLIGATIONS BY INSTALLATION

	Fiscal Year 1965	Fiscal Year 1966	Fiscal Year 1967
MANNED SPACE FLIGHT			
John F. Kennedy Space Center, NASA......................	$52,416,000	$79,723,000	$98,108,000
Manned Spacecraft Center......	91,036,000	87,550,000	98,212,000
Marshall Space Flight Center..	137,787,000	128,260,000	131,934,000
SPACE SCIENCE AND APPLICATIONS			
Goddard Space Flight Center...	92,570,000	64,040,000	71,687,000
Pacific Launch Operations Office.....................	844,000	---	---
Wallops Station...............	10,931,000	9,446,000	10,166,000
ADVANCED RESEARCH AND TECHNOLOGY			
Ames Research Center..........	31,807,000	32,923,000	33,475,000
Electronics Research Center...	3,201,000	6,233,000	15,143,000
Flight Research Center........	10,523,000	9,335,000	9,641,000
Langley Research Center.......	58,998,000	63,006,000	62,587,000
Lewis Research Center.........	68,546,000	67,207,000	66,284,000
Space Nuclear Propulsion Office.....................	1,669,000	1,824,000	1,847,000
SUPPORTING ACTIVITIES			
NASA Headquarters.............	51,516,000	56,286,000	58,667,000
Western Operations Office.....	22,693,000	5,987,000	6,149,000
TOTAL.....................	$634,537,000	$611,820,000	$663,900,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1967 ESTIMATES

ADMINISTRATIVE OPERATIONS

NUMBER OF POSITIONS BY INSTALLATION

	Fiscal Year 1965	Fiscal Year 1966	Fiscal Year 1967
MANNED SPACE FLIGHT			
John F. Kennedy Space Center, NASA	2,491	2,666	2,796
Manned Spacecraft Center	4,431	4,928	4,866
Marshall Space Flight Center	7,754	7,486	7,390
SPACE SCIENCE AND APPLICATIONS			
Goddard Space Flight Center	3,782	3,625	3,807
Pacific Launch Operations Office	22	-0-	-0-
Wallops Station	555	530	530
ADVANCED RESEARCH AND TECHNOLOGY			
Ames Research Center	2,270	2,240	2,211
Electronics Research Center	250	550	1,000
Flight Research Center	669	618	610
Langley Research Center	4,374	4,304	4,249
Lewis Research Center	4,917	4,842	4,779
Space Nuclear Propulsion Office	117	117	115
SUPPORTING OPERATIONS			
NASA Headquarters	2,263	2,227	2,200
Western Operations Office	405	391	386
TOTAL	34,300	34,524	34,939

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1967 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	Western Operations Office	Headquarters
FISCAL YEAR 1965															
Personnel compensation	332,722,000	20,107,000	46,076,000	79,345,000	37,512,000	213,000	4,437,000	21,027,000	1,362,000	6,105,000	39,355,000	46,439,000	1,318,000	4,115,000	25,311,000
Personnel benefits	23,713,000	1,355,000	3,154,000	5,578,000	2,671,000	15,000	305,000	1,549,000	100,000	441,000	2,880,000	3,373,000	94,000	289,000	1,959,000
Travel & transp of pers	20,427,000	2,441,000	4,630,000	3,722,000	2,553,000	38,000	166,000	643,000	118,000	221,000	1,430,000	1,465,000	199,000	247,000	2,556,000
Transportation of things	4,543,000	919,000	864,000	379,000	1,162,000	6,000	113,000	23,000	28,000	20,000	373,000	303,000	4,000	9,000	341,000
Rents, communications, and utilities	46,424,000	3,964,000	7,316,000	10,854,000	7,245,000	41,000	625,000	4,575,000	340,000	393,000	4,984,000	3,839,000	---	349,000	1,899,000
Printing and reproduction	4,174,000	216,000	614,000	1,025,000	398,000	6,000	32,000	27,000	13,000	23,000	175,000	50,000	---	15,000	1,580,000
Other services	74,310,000	14,970,000	11,427,000	18,610,000	5,092,000	42,000	1,001,000	1,611,000	316,000	1,457,000	2,699,000	3,862,000	37,000	522,000	12,654,000
Services of other agencies	10,735,000	3,163,000	743,000	2,542,000	399,000	164,000	77,000	137,000	464,000	37,000	63,000	139,000	17,000	12,000	2,778,000
Supplies and materials	24,553,000	3,534,000	4,282,000	5,820,000	1,927,000	91,000	1,450,000	1,296,000	64,000	422,000	2,681,000	2,435,000	---	51,000	500,000
Equipment	86,370,000	799,000	10,694,000	6,744,000	32,840,000	44,000	2,207,000	608,000	396,000	1,293,000	3,401,000	6,323,000	---	17,085,000	1,936,000
Lands and structures	6,539,000	938,000	1,235,000	1,212,000	771,000	184,000	518,000	311,000	---	101,000	957,000	312,000	---	---	---
Insurance claims and indemnities	27,000	10,000	1,000	6,000	---	---	---	---	---	---	---	2,000	---	---	8,000
Totals	634,537,000	52,416,000	91,036,000	137,787,000	92,570,000	844,000	10,931,000	31,807,000	3,201,000	10,523,000	58,998,000	68,546,000	1,669,000	22,693,000	51,516,000
FISCAL YEAR 1966															
Personnel compensation	355,511,000	28,546,000	49,917,000	80,206,000	38,455,000	---	4,692,000	21,935,000	3,389,000	6,312,000	41,036,000	47,993,000	1,460,000	4,289,000	27,281,000
Personnel benefits	25,299,000	1,930,000	3,368,000	5,558,000	2,737,000	---	333,000	1,584,000	262,000	453,000	2,993,000	3,499,000	106,000	309,000	2,167,000
Travel & transp of pers	20,841,000	2,080,000	4,874,000	3,769,000	2,636,000	---	185,000	676,000	302,000	222,000	1,503,000	1,470,000	200,000	282,000	2,642,000
Transportation of things	4,689,000	862,000	893,000	366,000	1,264,000	---	153,000	25,000	70,000	40,000	370,000	303,000	3,000	45,000	295,000
Rents, communications, and utilities	49,795,000	5,565,000	9,068,000	9,255,000	8,000,000	---	430,000	4,733,000	688,000	317,000	5,607,000	3,389,000	---	402,000	2,341,000
Printing and reproduction	4,615,000	339,000	700,000	1,038,000	240,000	---	35,000	27,000	25,000	20,000	201,000	50,000	---	15,000	1,925,000
Other services	94,231,000	28,315,000	13,199,000	19,106,000	7,102,000	---	1,390,000	1,537,000	610,000	911,000	2,807,000	3,654,000	38,000	514,000	15,048,000
Services of other agencies	13,353,000	6,761,000	612,000	2,632,000	188,000	---	53,000	140,000	258,000	4,000	63,000	139,000	17,000	14,000	2,472,000
Supplies and materials	21,156,000	3,550,000	2,918,000	4,322,000	1,928,000	---	1,250,000	1,148,000	229,000	475,000	2,700,000	2,028,000	---	53,000	555,000
Equipment	16,998,000	818,000	800,000	1,000,000	1,040,000	---	480,000	730,000	400,000	480,000	5,256,000	4,380,000	---	64,000	1,550,000
Lands and structures	5,300,000	947,000	1,200,000	1,000,000	450,000	---	445,000	388,000	---	100,000	470,000	300,000	---	----	---
Insurance claims and indemnities	32,000	10,000	1,000	8,000	---	---	---	---	---	1,000	---	2,000	---	---	10,000
Totals	611,820,000	79,723,000	87,550,000	128,260,000	64,040,000	---	9,446,000	32,923,000	6,233,000	9,335,000	63,006,000	67,207,000	1,824,000	5,987,000	56,286,000
FISCAL YEAR 1967															
Personnel compensation	375,354,000	30,777,000	54,866,000	80,271,000	41,563,000	---	4,865,000	22,572,000	9,012,000	6,510,000	41,999,000	49,064,000	1,483,000	4,426,000	27,946,000
Personnel benefits	27,090,000	2,068,000	3,824,000	5,660,000	2,974,000	---	345,000	1,629,000	687,000	481,000	3,043,000	3,581,000	108,000	317,000	2,373,000
Travel & transp of pers	21,279,000	2,173,000	5,261,000	3,724,000	2,633,000	---	185,000	670,000	347,000	220,000	1,489,000	1,455,000	198,000	282,000	2,642,000
Transportation of things	5,048,000	1,127,000	884,000	366,000	1,325,000	---	124,000	25,000	136,000	40,000	370,000	303,000	3,000	50,000	295,000
Rents, communications, and utilities	56,417,000	7,066,000	9,460,000	10,215,000	9,721,000	---	442,000	5,133,000	1,836,000	270,000	6,035,000	3,449,000	---	402,000	2,390,000
Printing and reproduction	4,916,000	461,000	700,000	1,038,000	250,000	---	35,000	27,000	44,000	20,000	201,000	50,000	---	15,000	2,075,000
Other services	112,317,000	36,756,000	16,804,000	20,429,000	8,360,000	---	1,729,000	1,706,000	1,990,000	989,000	3,319,000	3,656,000	38,000	517,000	16,024,000
Services of other agencies	15,221,000	8,146,000	615,000	2,628,000	170,000	---	65,000	150,000	359,000	4,000	63,000	139,000	17,000	58,000	2,807,000
Supplies and materials	26,122,000	6,594,000	3,350,000	5,397,000	1,929,000	---	1,451,000	1,100,000	412,000	506,000	2,720,000	2,055,000	---	53,000	555,000
Equipment	14,696,000	1,970,000	1,147,000	1,000,000	2,312,000	---	480,000	280,000	320,000	500,000	2,878,000	2,230,000	---	29,000	1,550,000
Land and structures	5,408,000	960,000	1,300,000	1,200,000	450,000	---	445,000	183,000	---	100,000	470,000	300,000	---	---	---
Insurance claims and indemnities	32,000	10,000	1,000	8,000	---	---	---	---	---	1,000	---	2,000	---	---	10,000
Totals	663,900,000	98,108,000	98,212,000	131,934,000	71,687,000	---	10,166,000	33,475,000	15,143,000	9,641,000	62,587,000	66,284,000	1,847,000	6,149,000	58,667,000

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1967 ESTIMATES

COMPUTATION OF PERSONNEL COSTS BY INSTALLATION AND FISCAL YEAR

(In thousands of dollars)

FISCAL YEAR 1965 ACTUAL	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
Personnel Compensation:															
Permanent positions	$325,818	$24,069	$41,391	$73,635	$37,965	$204	$3,862	$21,093	$2,593	$5,689	$38,587	$45,017	$1,419	$26,308	$3,985
Pay above the stated annual rate	1,271	92	159	280	146	1	38	80	10	22	148	173	5	101	15
Lapses (deduct)	-16,039	-5,849	-187	-1,283	-2,100	-14	-112	-638	-1,301	-71	-876	-859	-115	-2,464	-170
Net cost of permanent positions	311,050	18,312	41,363	72,632	36,011	191	3,788	20,535	1,302	5,640	37,859	44,331	1,309	23,945	3,830
Other personnel compensation	22,218	1,795	4,713	6,714	2,046	22	649	492	60	465	1,496	2,108	9	1,366	285
Total personnel compensation	$333,268	$20,107	$46,076	$79,346	$38,057	$213	$4,437	$21,027	$1,362	$6,105	$39,355	$46,439	$1,318	$25,311	$4,115
Reimbursable	546	---	---	1	545	---	---	---	---	---	---	---	---	---	---
NASA funded	332,722	20,107	46,076	79,345	37,512	213	4,437	21,027	1,362	6,105	39,355	46,439	1,318	25,311	4,115
Total personnel benefits	$23,758	$1,355	$3,154	$5,528	$2,716	$15	$305	$1,549	$100	$441	$2,880	$3,373	$94	$1,959	$289
Reimbursable	45	---	---	---	45	---	---	---	---	---	---	---	---	---	---
NASA funded	23,713	1,355	3,154	5,528	2,671	15	305	1,549	100	441	2,880	3,373	94	1,959	289
Total personnel costs	$357,026	$21,462	$49,230	$84,874	$40,773	$228	$4,742	$22,576	$1,462	$6,546	$42,235	$49,812	$1,412	$27,270	$4,404
Reimbursable	591	---	---	1	590	---	---	---	---	---	---	---	---	---	---
NASA funded	356,435	21,462	49,230	84,873	40,183	228	4,742	22,576	1,462	6,546	42,235	49,812	1,412	27,270	4,404
FISCAL YEAR 1966 ESTIMATED															
Personnel Compensation:															
Permanent positions	$353,072	$27,808	$50,226	$76,173	$38,559	---	$4,211	$22,299	$5,919	$5,979	$40,491	$47,854	$1,510	$27,849	$4,193
Pay above the stated annual rate	1,355	107	193	293	148	---	16	84	23	23	156	184	5	107	16
Lapses (deduct)	-20,755	-1,909	-5,793	-2,129	-1,408	---	-106	-997	-2,678	-229	-1,148	-1,900	-64	-2,165	-228
Net cost of permanent positions	333,672	26,006	44,626	74,337	37,299	---	4,121	21,386	3,264	5,773	39,499	46,138	1,451	25,791	3,981
Other personnel compensation	22,471	2,540	5,291	5,869	1,788	---	571	549	125	539	1,537	1,855	9	1,490	308
Total personnel compensation	$356,143	$28,546	$49,917	$80,206	$39,087	---	$4,692	$21,935	$3,389	$6,312	$41,036	$47,993	$1,460	$27,281	$4,289
Reimbursable	632	---	---	---	632	---	---	---	---	---	---	---	---	---	---
NASA funded	355,511	28,546	49,917	80,206	38,455	---	4,692	21,935	3,389	6,312	41,036	47,993	1,460	27,281	4,289
Total personnel benefits	$25,346	$1,930	$3,368	$5,558	$2,784	---	$333	$1,584	$262	$453	$2,993	$3,499	$106	$2,167	$309
Reimbursable	47	---	---	---	47	---	---	---	---	---	---	---	---	---	---
NASA funded	25,299	1,930	3,368	5,558	2,737	---	333	1,584	262	453	2,993	3,499	106	2,167	309
Total personnel costs	$381,489	$30,476	$53,285	$85,764	$41,871	---	$5,025	$23,519	$3,651	$6,765	$44,029	$51,492	$1,566	$29,448	$4,598
Reimbursable	679	---	---	---	679	---	---	---	---	---	---	---	---	---	---
NASA funded	380,810	30,476	53,285	85,764	41,192	---	5,025	23,519	3,651	6,765	44,029	51,492	1,566	29,448	4,598
FISCAL YEAR 1967 ESTIMATED															
Personnel Compensation:															
Permanent positions	$364,599	$29,897	$50,790	$76,720	$41,163	---	$4,315	$22,435	$10,604	$6,009	$40,627	$48,371	$1,501	$27,945	$4,221
Pay above the stated annual rate	1,396	108	196	296	158	---	17	86	40	23	156	186	5	107	16
Lapses (deduct)	-10,644	-1,703	-453	-1,747	-1,100	---	-47	-519	-1,835	-24	-133	-1,399	-32	-1,538	-111
Net cost of permanent positions	355,351	28,302	50,533	75,269	40,221	---	4,285	22,002	8,809	6,008	40,650	47,158	1,474	26,514	4,126
Other personnel compensation	20,568	2,475	4,333	5,002	1,907	---	580	570	203	502	1,349	1,906	9	1,432	300
Total personnel compensation	$375,919	$30,777	$54,866	$80,271	$42,128	---	$4,865	$22,572	$9,012	$6,510	$41,999	$49,064	$1,483	$27,946	$4,426
Reimbursable	565	---	---	---	565	---	---	---	---	---	---	---	---	---	---
NASA funded	375,354	30,777	54,866	80,271	41,563	---	4,865	22,572	9,012	6,510	41,999	49,064	1,483	27,946	4,426
Total personnel benefits	$27,132	$2,068	$3,824	$5,660	$3,016	---	$345	$1,629	$687	$481	$3,043	$3,581	$108	$2,373	$317
Reimbursable	42	---	---	---	42	---	---	---	---	---	---	---	---	---	---
NASA funded	27,090	2,068	3,824	5,660	2,974	---	345	1,629	687	481	3,043	3,581	108	2,373	317
Total personnel costs	$403,051	$32,845	$58,690	$85,931	$45,144	---	$5,210	$24,201	$9,699	$6,991	$45,042	$52,645	$1,591	$30,319	$4,743
Reimbursable	607	---	---	---	607	---	---	---	---	---	---	---	---	---	---
NASA funded	402,444	32,845	58,690	85,931	44,537	---	5,210	24,201	9,699	6,991	45,042	52,645	1,591	30,319	4,743

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1967 ESTIMATES

DISTRIBUTION OF PERSONNEL POSITIONS BY INSTALLATION AND FISCAL YEAR

	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	Western Operations Office
FISCAL YEAR 1965 ACTUAL															
TOTAL EXCEPTED POSITIONS a/	439	16	36	49	36	-	2	26	10	6	31	30	2	191	4
General Schedule Positions:															
GS-16	259	14	20	57	29	-	1	20	-	4	25	23	5	60	1
GS-15	1,756	87	211	409	209	1	4	105	27	15	135	146	18	376	13
GS-14	2,824	204	385	692	389	4	10	154	43	27	236	310	24	300	46
GS-13	4,020	340	639	990	566	1	23	205	34	51	327	582	26	178	58
GS-12	4,080	534	635	1,069	512	5	32	169	21	56	363	504	3	91	86
GS-11	3,653	324	600	861	501	3	40	165	10	70	486	461	3	86	43
GS-10	58	1	-	2	-	-	24	6	-	-	-	16	-	8	1
GS-9	2,449	206	381	359	391	-	49	165	14	41	445	308	-	81	9
GS-8	96	3	2	4	11	-	12	-	-	-	2	21	-	40	1
GS-7	1,552	135	304	300	165	-	36	94	13	21	181	138	1	160	4
GS-6	693	56	57	70	80	1	7	35	2	13	73	57	7	221	14
GS-5	1,776	160	263	361	219	1	41	124	14	19	178	139	13	183	61
GS-4	1,677	136	240	458	182	3	30	115	45	19	145	179	7	80	38
GS-3	1,141	95	166	316	124	-	22	55	11	9	112	143	6	75	7
GS-2	195	5	32	83	22	-	9	4	-	2	6	20	2	10	-
GS-1	28	-	25	1	-	-	-	-	-	-	-	-	-	2	-
TOTAL GENERAL SCHEDULE POSITIONS	26,257	2,300	3,960	6,032	3,400	19	340	1,416	234	347	2,714	3,047	115	1,951	382
TOTAL WAGE BOARD POSITIONS	6,504	112	241	1,429	268	-	176	768	-	252	1,499	1,738	-	21	-
TOTAL PERMANENT POSITIONS	33,200	2,428	4,237	7,510	3,704	19	518	2,210	244	605	4,244	4,815	117	2,163	386
OTHER TEMPORARY POSITIONS	1,100	63	194	244	103	3	12	60	6	64	130	102	-	100	19
GRAND TOTAL POSITIONS - FY 1965	34,300	2,491	4,431	7,754	3,807	22	530	2,270	250	669	4,374	4,917	117	2,263	405
FISCAL YEAR 1966 ESTIMATED															
TOTAL EXCEPTED POSITIONS a/	439	17	36	49	35	-	2	26	10	6	31	30	2	191	4
General Schedule Positions:															
GS-16	293	16	29	61	30	-	1	20	10	3	25	26	6	65	1
GS-15	1,776	85	211	360	205	-	4	120	46	20	156	155	25	377	12
GS-14	2,879	213	404	761	376	-	10	139	73	23	215	301	17	300	47
GS-13	4,567	447	785	1,012	553	-	38	235	79	64	397	672	27	202	56
GS-12	4,370	602	788	1,020	507	-	36	212	44	58	379	513	3	114	94
GS-11	3,925	350	759	806	491	-	44	186	70	65	508	508	1	95	42
GS-10	51	1	-	2	-	-	13	6	-	-	-	21	-	8	-
GS-9	2,391	200	514	340	384	-	51	110	64	39	400	203	-	81	5
GS-8	92	3	2	3	11	-	5	-	-	-	2	23	-	42	1
GS-7	1,382	102	233	275	145	-	36	90	34	25	151	125	2	159	5
GS-6	707	61	60	59	74	-	17	35	4	14	73	64	6	224	16
GS-5	1,824	170	305	355	184	-	55	125	34	16	179	142	13	185	61
GS-4	1,569	132	248	393	169	-	47	108	59	20	139	149	7	59	39
GS-3	1,039	101	168	313	106	-	15	54	23	2	80	133	6	35	3
GS-2	237	15	49	107	39	-	-	1	-	4	-	15	2	5	-
GS-1	44	-	-	42	-	-	-	-	-	-	-	-	-	2	-
TOTAL GENERAL SCHEDULE POSITIONS	27,146	2,498	4,555	5,909	3,274	-	372	1,441	540	353	2,704	3,050	115	1,953	382
TOTAL WAGE BOARD POSITIONS	6,339	105	218	1,359	268	-	144	753	-	245	1,499	1,730	-	18	-
TOTAL PERMANENT POSITIONS	33,924	2,620	4,809	7,317	3,577	-	518	2,220	550	604	4,234	4,810	117	2,162	386
OTHER TEMPORARY POSITIONS	600	46	119	169	48	-	12	20	-	14	70	32	-	65	5
GRAND TOTAL POSITIONS - FY 1966	34,524	2,666	4,928	7,486	3,625	-	530	2,240	550	618	4,304	4,842	117	2,227	391
FISCAL YEAR 1967 ESTIMATED															
TOTAL EXCEPTED POSITIONS a/	439	17	36	49	35	-	2	26	10	6	31	30	2	191	4
General Schedule Positions:															
GS-16	293	16	29	61	30	-	1	20	10	3	25	26	6	65	1
GS-15	1,932	88	219	373	227	-	6	130	77	21	180	175	25	399	12
GS-14	3,158	225	425	801	417	-	13	190	126	22	234	320	17	321	47
GS-13	4,607	472	785	1,000	577	-	38	230	137	63	397	646	26	182	54
GS-12	4,501	662	800	1,012	543	-	37	183	116	58	381	528	3	84	94
GS-11	3,939	367	754	771	537	-	44	180	97	71	506	497	-	75	40
GS-10	50	1	-	2	-	-	13	5		-	-	21	-	8	-
GS-9	2,300	226	474	315	389	-	45	95	88	36	393	153	-	81	5
GS-8	92	3	2	3	11	-	5	-	-	-	2	23	-	42	1
GS-7	1,378	109	179	265	154	-	36	90	97	16	144	122	2	159	5
GS-6	722	67	62	54	70	-	17	33	22	14	73	64	6	224	16
GS-5	1,780	123	310	365	191	-	55	118	61	16	139	144	13	185	60
GS-4	1,548	139	257	328	174	-	47	116	123	20	109	130	7	59	39
GS-3	1,087	105	159	351	108	-	15	53	36	2	77	135	8	35	3
GS-2	233	26	40	99	39	-	-	5	-	4	-	15	-	5	-
GS-1	28	-	-	26	-	-	-	-	-	-	-	-	-	2	-
TOTAL GENERAL SCHEDULE POSITIONS	27,648	2,629	4,495	5,826	3,467	-	372	1,448	990	346	2,660	2,999	113	1,926	377
TOTAL WAGE BOARD POSITIONS	6,252	104	216	1,346	257	-	144	717	-	244	1,488	1,718	-	18	-
TOTAL PERMANENT POSITIONS	34,339	2,750	4,747	7,221	3,759	-	518	2,191	1,000	596	4,179	4,747	115	2,135	381
OTHER TEMPORARY POSITIONS	600	46	119	169	48	-	12	20	-	14	70	32	-	65	5
GRAND TOTAL POSITIONS - FY 1967	34,939	2,796	4,866	7,390	3,807	-	530	2,211	1,000	610	4,249	4,779	115	2,200	386

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 1967 ESTIMATES

ADMINISTRATIVE OPERATIONS

ANALYSIS OF REQUIREMENTS FOR PASSENGER-CARRYING MOTOR VEHICLES

The appropriation language provides for the acquisition of 31 passenger motor vehicles, of which 15 are for augmentation to the fiscal year 1966 ending inventory and 16 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 of the planned acquisitions by class of vehicle in fiscal year 1967 is as follows:

	Total	Medium Sedans	Other Sedans	Station Wagons	Ambulances	Buses
On hand July 1, 1966..	179	1	42	114	11	11
Acquisitions:						
a. By purchase.....	20	-	3	17	-	-
b. By transfer[1/]....	11	-	2	4	2	3
Subtotal..........	31	-	5	21	2	3
(For replacement)...	(16)	(-)	(2)	(14)	(-)	(-)
(Disposed - not replaced)........	(-)	(-)	(-)	(-)	(-)	(-)
On hand June 30, 1967.	194	1	45	121	13	14

1/ During fiscal year 1966 the Research Range at Fort Churchill, Canada, was transferred from the Department of Defense to the National Aeronautics and Space Administration because NASA was the principle user of the facility. Involved in this transfer are 11 vehicles which will augment the NASA passenger-carrying motor vehicle fleet.

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. This research will provide an understanding of phenomena which is necessary for other NASA programs for 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 laboratories 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 applications such as the supersonic transport 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.

The Basic Research Program is concentrated in four disciplinary areas: Fluid Physics, Electrophysics, Materials, and Applied Mathematics.

The understanding and prediction of the tremendous heating loads experienced by space vehicles during reentry into the earth's atmosphere from missions to the moon and beyond has been an important part of the research program in fluid physics. This research, which had been extended to studies involving entry into the atmospheres of other planets, has succeeded in the past year in unifying predictions of frictional heating so that any gas, characteristic of any atmosphere, can be handled by the same simplified analysis. Similar research is being pursued on other gas dynamic aspects of atmosphere entry and will lead to the design of efficient heat protection and atmosphere braking systems for interplanetary spacecraft. Fluid physics research also encompasses fluids having properties very much different from the atmospheric gases, as for example, magnetic liquids. Liquids reacting to magnetic fields may lead to unique space power systems, and provide a means for studying and controlling fluids in "zero gravity" situations.

Electrophysics encompasses theoretical and experimental physics research devoted to exploring and explaining the bulk and atomic behavior of solids, liquids, and gases subjected to gravitational, electric, magnetic, and nuclear force fields. It is designed to increase our understanding of physical phenomena, information which is essential for advances in technology areas such as electronics, space power, and propulsion. For example, an experimental investigation using the nuclear magnetic resonance technique has been under way to determine the presence of hydrogen nuclei in various atoms. The equipment sensitivity has been so improved that extremely small quantities of hydrogen may be recognized. Since hydrogen is a constituent of water, this now becomes a means of determining whether trace amounts of water may be present in rock and soil samples from the moon and planets. The presence of water may indicate the existence of some form of life.

The demands of the manned and unmanned space programs are putting unprecedented requirements on all classes of materials. Designers are calling for lightweight structural materials, chemically stable and radiation resistant coatings, high temperature and high strength materials for propulsion systems, high temperature ablatives for thermal protection, versatile electronic materials, and high temperature bearings and lubricants. New approaches and concepts are required to meet these requirements. The goal of basic materials research is to understand how and why materials can be strengthened by alloying additions and fibrous reinforcements and made resistant to all the components of the space environment. The behavior of well characterized materials in electrical fields is also being studied so that better electronic devices may be developed for space communication and circuitry.

Applied mathematics is concerned with research in mathematical techniques relevant or necessary for application to scientific or technological problems which arise in carrying out any part of the NASA functions. Such mathematical research performed preliminary to the physical operation of which it is an abstract model can usually result in considerable economies of total operation, and often is the only feasible approach to the problem. Recent examples of this have been the successful Ranger and Mariner flights which attained their objectives as scheduled. These results could never have been achieved through non-mathematical experimentation, but had to follow procedures dictated by previous extensive mathematical research.

SUMMARY OF RESOURCES REQUIREMENTS:

	1965	1966	1967
Supporting research and technology...............	$21,231,000	$22,000,000	$23,000,000
Total....................	$21,231,000	$22,000,000	$23,000,000

Distribution of Program Amount by Installation:

	1965	1966	1967
Marshall Space Flight Center..	$916,000	$815,000	$850,000
Goddard Space Flight Center...	257,000	117,000	120,000
Jet Propulsion Laboratory.....	5,792,000	5,056,000	5,400,000
Ames Research Center..........	1,966,000	1,910,000	2,100,000
Electronics Research Center...	95,000	595,000	1,000,000
Flight Research Center........	3,000	30,000	30,000
Langley Research Center.......	1,901,000	2,119,000	2,200,000
Lewis Research Center.........	2,234,000	2,731,000	2,800,000
NASA Headquarters.............	7,503,000	8,627,000	8,500,000
Western Operations Office.....	564,000	---	---

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

	1965	1966	1967
Fluid physics..................	$7,803,000	$8,043,000	$8,200,000
Electrophysics.................	4,039,000	4,404,000	4,800,000
Materials......................	8,034,000	8,193,000	8,500,000
Applied mathematics............	1,355,000	1,360,000	1,500,000
Total........................	$21,231,000	$22,000,000	$23,000,000

Fluid Physics

The efficient design of spacecraft configurations and heat protection systems, of nozzles for air-breathing and rocket fueled propulsion systems, and the ability to solve the communications blackout reentry problem, all depend on a knowledge of non-equilibrium flow processes, i.e., on flows in which the time for temperature-induced chemical reactions occurring in the gas is of the same order as the time for the gas to flow along the body. Thus, an important part of the FY 1967 research program in fluid physics is concerned with the determination of chemical reaction rates in flow situations of interest. These rates will be determined primarily in chemical shock tubes at temperatures up to $15,000^{\circ}$ F, as well as in "in situ" nozzle flows.

Non-equilibrium flows occur in regions of reduced pressure and density or at moderate altitudes. However, at very high altitudes, e.g., at 100 miles and above, the density of air is so low that inter-particle collisions which cause chemical reactions and normal gas-dynamic effects are almost non-existent. This so called "free-molecule" flight regime is of great importance in predicting such phenomena as the drag and heating of satellites, orbital lifetimes of satellites, the heating and thrust loss from control rockets in space, and the contamination of the lunar surface by rocket exhausts. All of these phenomena are directly influenced by the energy and momentum transferred by a particle to a surface during impact, by adhesion to the surface, and by the surface material and surface condition. By means of a laboratory research program, gas-surface interactions will be studied intensively in FY 1967 both theoretically and in molecular-beam devices designed to duplicate the density and energy of space conditions. These studies will lay the foundation and provide the interpretive data for possible future flight experiments to investigate the phenomena with actual satellites.

Another research area that will receive increased attention during the next fiscal year is the flow of "strange fluids", i.e., fluids having viscous, elastic and magnetic properties that differ greatly from those of conventional liquids and gases. These fluids are more than scientific curiosities and are being studied with aerospace applications in mind. Visco-elastic studies include, for example, the flow of blood in parts of the circulatory system, and the fascinating phenomenon of greatly reduced drag of liquid and polymer mixtures when flowing through a channel. Additionally, the physical properties of magneto-fluids are being investigated in order that such fluids can be considered as a base for new space power generating systems.

Considerable progress has been achieved during recent years in developing electromagnetic gas accelerators, demonstrating that electromagnetic interaction on ionized gases may become a powerful investigative technique in future high temperature gas technology. More fundamental research in plasma physics is needed, however, because the properties of plasmas depend sensitively on interactions with electric and magnetic fields, in addition to their dependence on temperature and pressure as in real gas dynamics.

In FY 1967 increased emphasis will be placed on the investigation of plasma properties in their functional relation with system parameters. Chemical phenomena under the extreme (high and low) environments of temperature and pressure will be expanded, as will chemical kinetics as applied to propulsion systems and aerodynamic braking in planetary atmospheres. The classical principles of fluid physics will be utilized to explain fundamental biolcgical and physiological processes to generate new concepts in organic physics.

Electrophysics

The electrophysics program consists of in-house and external experimental and theoretical investigations into the interactions of particles and force fields. The program includes tasks in classical and quantum physics in areas of nuclear, atomic and molecular physics, solid state physics, and theoretical physics.

Research is being conducted on the determination of the behavior of the positron in the earth's gravitational field. A positron, a form of anti-matter, can combine with an electron whereby the pair is annihilated and energy in the form of a gamma ray, that is an electromagnetic wave, is released. Using a preliminary experimental arrangement the lifetime of negative helium ions could be measured. After this feasibility study, a larger experimental apparatus was constructed. This newer equipment is being checked first by measuring well known electrons; then the positrons' gravitational characteristics will be determined. If the experiment is successful, information on possible antigravity in nature will be obtained.

A comprehensive analysis has been made of the scattering of alpha particles (helium) from the nuclei of tin atoms containing even numbers of protons. Such experiments yield information on the excitation of the nucleus and in particular on interactions with individual particles in the nucleus. The results demonstrate that presently known theory adequately describes these experiments. This work is part of a comprehensive program aimed at understanding nuclear interactions and structure.

A much more accurate measurement has been made of the lifetime of the positive pi meson or pion -- a fumdamental particle of nature. The pion is believed to be responsible for binding particles together to form the nuclei of atoms. The lifetime of the free pion is one of its characteristics which determines its ability to perform this function.

In FY 1967 increased effort will be made in nuclear physics research. Experimental and theoretical investigations will be conducted to obtain more detailed information on nucleon-nucleon reactions. The data from this work will contribute to our understanding of collisions between solar protons and materials of the spacecraft structure. The information is needed to improve the design of the shielding material thus preventing radiation damage to equipment on the spacecraft. Furthermore, at the Electronics Research Center, a research program concerned with a better understanding of the fundamental energy exchange processes in crystalline solids will be pursued; and the emission, absorption, and scattering of electromagnetic waves will be studied. Such information provides the base of knowledge required by the Electronics and Control Program to improve reliability and useful life of critical components. It will also lead to better signal sources for space communications.

Materials

Understanding why materials behave as they do in mechanical, chemical, radiation, and thermal environments is the goal of the materials research program. The scope ranges from solid state physics - the nature of solid matter - to the application of such fundamental knowledge to advanced materials for NASA's future missions as well as defining corrective actions for current material problems. For example, the premature failure of titanium oxidizer tanks and titanium structural members may well be avoided as a result of the recently initiated research effort on stress-corrosion cracking. When chosen for use in these applications, it was believed that titanium was immune to stress-corrosion cracking, a kind of unheralded and often catastrophic fracture at normal stresses in certain corrosive environments. Recent failures, however, show that some titanium alloys will crack in nitrogen tetroxide and even in water. Research will be conducted both in-house and by contract to establish the extent and gravity of the problem and to find solutions, both short range and long range.

Another example of basic research motivated by current deficiencies in materials is the research on polymers for use at low temperatures. Glass reinforced propellant tanks require the use of a liner to minimize the loss of hydrogen through the walls of the tank by permeation. Polymeric materials are being studied for such applications; however, they are subject to cracking at low temperatures. Basic studies to understand the relationship between the structure of polymers and their properties at cryogenic temperatures are under way. This understanding should provide the necessary information for synthesizing and processing polymers for use at very low temperatures.

Considerable progress is now being made in obtaining simple and trouble-free lubrication systems for advanced space vehicles. The ideal system would be one in which the bare metals slide upon one another without binding or wearing. It now appears that this is possible if the distribution and arrangement of the metal and impurity atoms is controlled by alloying, mechanical working, and heat treatment. Current research should establish the guidelines to be followed in performing these operations.

Advanced aircraft engines on the other hand can continue to use liquid lubricants provided they are protected from oxidation and thermal decomposition at temperatures several hundred degrees higher than those used in current commercial power plants. Current research at NASA Research Centers and in several research contracts is emphasizing several alternate techniques for preventing degradation. One technique is to use inert gases to protect the lubricant. Another involves the "once through" concept which consists of continuously feeding fresh lubricant into the bearings in a very low but adequate flow rate.

Fundamental research in electronic properties of materials for circuitry in communications devices will be continued. The creation of new electrical devices based upon current understanding of materials behavior is facing diminishing returns. There is, therefore, an urgent need to accelerate the fundamental studies of all material phenomena. Research is being increased both at the Centers as well as on contract to obtain more knowledge of the mechanisms of such phenomena as diffusion, sputtering and electron and ion emission from solids and electron-lattice, and electron-defect interactions in crystals. The role of impurities and alloying additions on semiconductors, electrical insulators and ferroelectric materials is also being pursued.

In FY 1967 the general field of solid state physics will be expanded with particular emphasis on electronic properties. This is a vital area and one in which the Electronics Research Center will contribute heavily.

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.

Research will continue in aerodynamic mathematics for predicting gas flow around or within a body moving at hypersonic speeds, and for determining optimum aerodynamic shapes of aircraft wings and bodies in supersonic and hypersonic air-flows. Gravitational and orbital mathematics will be used to determine more accurately what trajectories could produce a successful lunar orbiting vehicle, as well as to make progress in the continuing problem of more accurate and economical predictions of orbits and positions of earth satellites and other space vehicles. Grants and contracts in mathematical research are also planned for investigation of methods for solving equations of heat-flow in reentering spacecraft, supersonic aircraft, and turbine blades, and for studying programs for optimum performance of aircraft using the calculus of variations. Studies will also continue in the theory of plates and shells of various shapes at various temperatures as a mathematical basis for safe and efficient design of advanced or proposed aeronautical and spacecraft structures.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1967 ESTIMATES

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY SPACE VEHICLE SYSTEMS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The basic objectives of the Space Vehicle Systems program, namely to identify and solve critical design problems associated with space flight and advance the state-of-the-art, require that there be a continual shift in emphasis dictated first by the progress and direction of the overall NASA space program, secondly by the revelation and investigation of new findings and concepts, and also by the necessity for developing immediate solutions to pressing technical problems on current NASA and military space vehicles. Conversely, the program is planned and implemented to provide much of the research that establishes the feasibility and influences the course of the overall NASA space program.

To cope with the technical problems associated with space vehicle launch, ascent through the atmosphere, flight in space, entry, and landing, the program encompasses the technical areas of Aerothermodynamics, Structures, Space Environmental Factors, Design Criteria, and Flight Experiments. The first three, coupled with related Flight Experiments, comprise the backbone of the research and technology effort. The area of Design Criteria represents the effort required to digest the vast quantities of technical information flowing from the research effort and from operational experience and present it in compact, simplified, and authoritative form that can be used by the designer.

In the area of spacecraft aerothermodynamics a highly significant accomplishment was realized during FY 1966 in the second successful Project Fire flight. That experiment determined very accurately the peak heating environment due to both convective and radiative heating processes for a blunt ballistic type of vehicle entering the earth's atmosphere at lunar return speeds of about 37,000 feet per second. The two Project Fire flights have now effectively defined the earth entry heating environment for Apollo. Emphasis will be placed during the coming year on consolidating and building on the new findings of Project Fire to develop improved knowledge of the extreme heating environment associated with entry from planetary flight, involving speeds of 50,000 feet per second and greater. In closely associated research on structures, attention will be directed to advanced ablative thermal protection systems that will be required for such an environment, and work will proceed toward the development of techniques for anchor-point experiments in flight at these extreme speeds which are beyond the reach of laboratory facilities.

Research emphasis in aerothermodynamics and structures will also be directed toward advanced manned space flight in near-earth regions, as exemplified by the lifting-body class of maneuverable entry vehicles. Attention will be focused especially on the flight problems in the critical terminal approach and landing phase using the M-2 and HL-10 test vehicles and on the technology of efficient, readily refurbishable ablatively protected structures. Increased attention will also be given to new concepts of maneuverable entry vehicles that incorporate propulsive lift for terminal descent and landing.

Considerably greater emphasis will be given in FY 1967 to parachute and decelerator technology for several important applications. New developments in steerable parachutes and paragliders with non-rigid structural elements may provide reliable, controlled descent and touchdown capabilities on land for current manned spacecraft types such as Apollo. The thin atmosphere of Mars has placed new demands on parachute technology for lowering instrument payloads to the surface at impact velocities low enough for them to survive and operate. In this application principal needs are for reliable deployment, structural integrity with light weight, and stable descent at the low atmospheric densities anticipated. Flight experiments will be needed to verify ground-based research.

In the areas of space environmental factors and in space structures, several notable accomplishments were made during FY 1966. Major strides were made toward determining the penetrating meteoroid environment in near-earth space through the successful launching of three Pegasus spacecraft by Saturn I launch vehicles. These three large-area spacecraft together with the earlier smaller Explorer XVI and XXIII satellites are providing quantities of statistical meteoroid penetration rate data in structural specimens up to 16 mils in thickness. These data have already been of great value in the Apollo program and will help define the design environment for the Manned Orbiting Laboratory. An essential and closely related part of the meteoroid technology research effort involves the tying together of flight measurements, laboratory impact and penetration measurements, and ground-based observations of natural meteors. A substantially augmented ground-based program is needed and is planned for FY 1967. Additional flight experiments are also needed to extend the thickness range of structural specimens subjected to meteoroid penetration in near-earth orbits and to extend the penetration measurements to the vicinity of Mars and into the asteroid belt where the population of penetrating meteoroids may be much greater than near the earth.

Toward this end research has already produced a notable advance in technology toward the development of the very high quality penetration and impact sensors that will be required.

Research will be continued on the effects of high-energy space radiation on spacecraft materials and components, solar radiation effects and temperature control, the storage of cryogenic liquids such as liquid hydrogen for long periods of time in space, and the behavior and control of fluids in the weightless state.

In launch vehicle aerothermodynamics and structures, technology research will be continued on a wide variety of problems of importance to current types of launch vehicles such as base heating associated with large multiple rocket installations, intense acoustic noise, structural loads, more advanced and efficient structural designs, and dynamics of large space vehicle structures. Special attention will be given to the exceedingly difficult technical problems involved in the recovery and reuse of launch vehicle stages, both from the standpoint of devising techniques for the recovery of existing types of vehicles and from the standpoint of completely different types of advanced vehicles designed from the outset for reuse.

SUMMARY OF RESOURCES REQUIREMENTS:

	1965	1966	1967
Supporting research and technology....................	$25,707,000	$26,000,000	$28,700,000
Project Fire....................	1,811,000	500,000	---
Lifting body flight and landing tests..........................	1,400,000	1,000,000	1,000,000
Scout reentry project............	400,000	3,000,000	4,800,000
Project Pegasus (Saturn-launched meteoroid experiment)..........	13,690,000	2,500,000	---
Small space vehicle flight experiments....................	1,010,000	2,000,000	1,500,000
Scout launched meteoroid experiments....................	175,000	---	---
Total.........................	$44,193,000	$35,000,000	$36,000,000

Distribution of Program Amount by Installation:

	1965	1966	1967
Manned Spacecraft Center.......	$629,000	$435,000	$670,000
Marshall Space Flight Center...	16,444,000	4,201,000	3,096,000
Goddard Space Flight Center....	1,231,000	1,751,000	2,081,000
Jet Propulsion Laboratory......	3,599,400	3,718,000	4,200,000
Ames Research Center...........	3,354,000	3,076,000	3,475,000
Electronics Research Center....	---	250,000	250,000
Flight Research Center.........	1,825,000	1,010,000	1,010,000
Langley Research Center........	10,593,800	11,466,000	14,282,000
Lewis Research Center..........	2,407,831	3,087,000	3,223,000
NASA Headquarters..............	3,473,969	6,006,000	3,713,000
Western Operations Office......	635,000	---	---

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

	1965	1966	1967
Spacecraft aerothermodynamics....	$5,723,000	$6,191,000	$5,346,000
Spacecraft structures............	5,819,000	6,201,000	6,710,000
Launch vehicle aerothermodynamics	1,488,000	855,000	1,300,000
Launch vehicle structures........	3,398,000	2,554,000	3,264,000
Space vehicle environment factors......................	8,039,000	7,974,000	10,805,000
Advanced space vehicle concepts..	606,000	500,000	---
Space vehicle design criteria....	634,000	1,725,000	1,275,000
Total.........................	$25,707,000	$26,000,000	$28,700,000

Spacecraft Aerothermodynamics

Research in spacecraft aerothermodynamics is concerned with atmospheric heating, flight performance, stability, and aerodynamic control associated with hypervelocity entry of vehicles into the atmospheres of the earth and other planets. The program also seeks to devise new concepts of vehicles and flight techniques to enhance our space flight capabilities by sophisticated use of planetary atmospheres for maneuvering and braking. A closely related objective is that of advancing the technology relating to the terminal descent and landing of both manned and unmanned spacecraft.

In addition, the program provides technological support in the solution of specific problems encountered in vehicle development projects of NASA and the military services. The program also provides the institutional support for the Jet Propulsion Laboratory wind tunnels.

A major accomplishment of the past year was the successful flight of Fire II and the analysis of reentry heating data from both flights of Project Fire at speeds of about 37,000 feet per second. The data indicate that at speeds of this magnitude most radiative component of the aerodynamic heating is associated with radiation in the very short wave length ultraviolet part of the energy spectrum. This new finding has already had a significant impact on theoretical and ground-based experimental research. New efforts will be made to understand the exact nature of the physical and chemical processes governing the production and absorption of the radiant energy. Such an understanding is essential to the extension of our knowledge of aerodynamic heating to higher speed regimes of 50,000 feet per second and greater associated with atmospheric entry from planetary flight. Such high speeds are beyond our capacity for direct simulation in the laboratory, hence ground-based research will need support and confirmation by flight experiments which will be directed toward determination of both the heating environment and the performance of thermal protection systems. Since recovery of the experiment payload appears essential, work will be carried out on developing both the flight and recovery techniques for such applications.

An important area to which substantial effort will be directed in FY 1967 is the technology of advanced manned spacecraft having substantial maneuvering capability in the atmosphere. The ability to produce appreciable aerodynamic lift, and the ability to control the amount of lift and drag, promises large benefits, which include: greatly reduced peak g-loads on crew and passengers; widened, less critical entry corridors; greater lateral flight range which provides a larger number of potential landing sites, and thus improved overall operational flexibility; and precision in returning from orbit. With these end objectives in mind, emphasis was placed during the past year on (1) development and construction of the M2-F2 and HL-10 manned low-speed flight research vehicles now entering the flight test phase, (2) laboratory research on the hypersonic performance and heating of the lifting-body vehicles of the M-2/HL-10 class configured to have good flight characteristics at low speeds, (3) generalized mission and preliminary design studies involving lifting-body types of vehicle for guidance of research planning, and (4) preliminary investigation of lifting entry configurations radically different from the M-2 or HL-10. This research will be continued at the Langley and Ames Research Centers in FY 1967. Some of the advanced configurations to be investigated may possess better hypersonic performance than the M-2 or HL-10 class of vehicles, while others may have potentially better airplane type landing capability. Some concepts will incorporate parachute and propulsive lift for soft vertical landing. The Flight Research Center will be heavily involved with the flight test program on the M2-F2 and HL-10 vehicles during FY 1967.

In the area of terminal descent and landing increased emphasis will be given to parachute and decelerator technology with special reference to (1) the soft landing of instrument packages on Mars, (2) terminal descent over land areas with control of the flight path for manned ballistic or semi-ballistic entry vehicles, and (3) recovery of launch vehicle stages. In the Mars landing application, the very thin atmosphere of Mars compared to that of the earth requires the deployment of large lightweight parachutes at relatively high speeds at very low atmospheric densities. Research information is required to assure high reliability of deployment, provide accurate information on aerodynamic forces, and provide for stable descent with the proper terminal or impact velocity. Because of the dynamics involved scaling from small models is difficult and a program of flight tests at relatively large scale is needed to verify and extend ground-based research. Attention will also be given to the aerodynamic problems and performance of high-speed auxiliary deceleration devices, including towed ballutes and inflatable or otherwise extendable skirts, for increasing the frontal area and hence the drag of the basic planetary entry vehicle to increase the transit time through the thin atmosphere and reduce the speed for terminal parachute deployment.

In the applications to manned spacecraft and to booster recovery technology requirements are generally similar, and will involve the study of advanced controllable gliding types of parachute configurations such as the so-called limp paraglider which uses no rigid structural members, and investigation of the deployment of large parachutes beyond the present state-of-the-art for heavy payloads.

Spacecraft Structures

The objective of this program is to identify and solve critical spacecraft structural problems through analytical and experimental research. Major elements of the program include: advanced structural concepts and materials applications, protection against entry heating and space environmental hazards, determination of critical loads and structural response, protection against vibration environments and landing impact, and prolonged storage of cryogenic liquids in space.

In the realm of advanced concepts, requirements for future systems are anticipated, and pertinent advances in structures and materials technology which may have been developed independently are combined to evaluate their feasibility and usefulness in practical applications. A current example is a contract and in-house study of inflatable lunar shelters at the Langley Research Center. Preliminary work has indicated a promising potential that such shelters may provide a shirt-sleeve environment, complete life support and communication facilities, internal temperature control, and meteoroid protection.

Another advanced concept being studied under contract concerns large orbiting antennas for unmanned scientific missions. In this case, requirements from other disciplines associated with radio astronomy are blended with advances in space structures to provide the technology necessary for lightweight, large area antenna systems.

Expanded effort will be directed in FY 1967 to the problems involved with improved structures to withstand atmospheric entry. One area is associated with refurbishable earth entry vehicle structures. As the frequency and magnitude of earth orbital operations increase, economic advantages may be gained by reuse of spacecraft if the critical areas of the structure could be readily restored. Current spacecraft and their heat shields are normally integral structures which do not facilitate repair or replacement of damaged components. Various concepts for providing refurbishment without sacrificing structural efficiency will be investigated.

Another area of emphasis concerns planetary entry structures for use in conjunction with the exploration of Mars. As mentioned previously, current estimates of the Martian atmosphere indicate that the atmospheric pressure is so low compared with that of earth that satisfactory terminal conditions cannot be achieved with conventional vehicles. Consequently, it is necessary to rely on very lightweight vehicles with large frontal areas in order to minimize impact velocity and enhance capsule survival. Research at the Jet Propulsion Laboratory and the Langley Research Center is endeavoring to isolate and resolve the structural problems of such vehicles in order to permit them to be designed with confidence.

Among other important problems, increased emphasis is required during FY 1967 in the area of high frequency vibrations to provide more adequate analytical and experimental techniques for coping with the extremely complex problems encountered in the wide variety of vibration environments encountered by spacecraft. In another area, storage of cryogenic propellants, the technology for tank structures and insulation, is well advanced for short-time storage in launch vehicles. Increased research is required for prolonged storage of cryogenic liquids, such as liquid hydrogen, in spacecraft. Planetary missions will involve storage periods of years rather than hours or days. The significant advantages of liquid hydrogen as a propellant cannot be fully realized unless further advances are made in cryogenic tank structures and thermal protection systems. These investigations at the Lewis Research Center and the Marshall Space Flight Center will be extended in FY 1967.

Launch Vehicle Aerothermodynamics

This program is concerned primarily with heating, acoustic, aerodynamic and recovery problems associated with present and future launch vehicles.

Considerable research has been accomplished on the measurement of temperatures in the base area of both model and full scale clustered rockets to determine the heating caused by the jet exhaust and the burning of entrained gases in the base area of the vehicle. However, a sound understanding of the problem and adequate prediction and control of launch vehicle base heating have been severely hampered by the lack of basic information on the nature of the complex flows in the base region. The situation has been aggravated by inadequate techniques for measuring the flow fields with the accuracies required. An electron gun technique recently developed under the auspices of the Marshall Space Flight Center appears to offer considerable promise for mapping the flow density and temperature in the base region for high altitude flight regimes. In FY 1967 this technique will be employed in several experimental investigations using scaled models of clustered rocket nozzle arrangements. Hopefully, this will lead to improved means of predicting the base temperatures on actual launch vehicles and in controlling the flow to reduce base temperatures in critical hot spots. Also in FY 1967 efforts will be continued to develop techniques applicable to inflight flow measurement on launch vehicles early in the launch trajectory after lift off.

A better understanding of the base flows will likewise generate improved understanding of factors affecting noise pressures in the base region. In FY 1967 research will be augmented at the Marshall Space Flight Center on sound pressures experienced on the vehicle and on the surrounding terrain during operation of large scale clustered rocket motors. Through this research to better understand the noise source, and continued research on atmospheric factors influencing sound propagation, greatly improved accuracy should be possible in predicting sound levels at all distances and azimuths surrounding launch vehicle rocket engine firings for both static tests and actual launches. This will be of considerable value in planning and scheduling engine firings to avoid or reduce disturbances to adjacent communities and nearby buildings, or to alert certain areas where noise levels are expected to be high. Also in FY 1967 research will be emphasized on the substantially magnified sound pressures on launch vehicles in regions of separated flow behind vents and protuberances of various kinds.

The research effort on launch vehicle aerodynamics in FY 1967 will continue to be largely concerned with investigation of specialized problems with existing launch vehicles or those under active development, and with investigation of future launch vehicle concepts, many of which involve recovery. Recovery injects a completely new dimension to the aerodynamics, flight control and heating of launch vehicles, irrespective of whether the recovery mode ranges from that of a first stage landed in the ocean by parachutes, or of a second stage from orbit to a landing on land by lifting surfaces. There are a large number and variety of advanced launch vehicle concepts and recovery modes, many of which have commonality in technology with manned spacecraft as well as hypersonic cruise and supersonic transport aircraft. A modest effort has been expended in FY 1966 to exploit the latter technologies as applied to launch vehicles, while at the same time emphasizing studies to evaluate the many possible concepts, sizes and configurations of future launch vehicles to identify those of greatest interest for concentrated research investigations. This effort will be expanded in FY 1967.

Launch Vehicle Structures

The primary objectives of this program are to explore and evaluate advanced structures and materials concepts for launch vehicles, to provide improved methods for determining the loading and response of vehicle structures, and to develop more reliable means of predicting and confirming the strength of launch vehicles.

Primary structural design conditions for most launch vehicles are associated with atmospheric wind loadings, i.e., ground winds prior to launch and flight winds after launch at altitudes up to about 50,000 feet. Progress is being made at the Ames and Langley Research Centers in experimental studies of ground wind loadings on full scale vehicles for comparison with wind tunnel data, and techniques for simulating atmospheric turbulence in wind tunnel tests are being evaluated. These efforts will continue in FY 1967 with the objective of providing more precise methods which are needed for predicting ground wind loads. The efforts to develop an accurate system for measurement of flight wind conditions have resulted in radar/spherical balloon system now in routine use at the Kennedy and Pacific launch sites. The roughened, two-meter, spherical balloon wind sensor developed at the Marshall Space Flight Center has demonstrated stable ascent through the atmosphere and rapid response characteristics previously unattainable with other techniques.

Without comprehensive detailed design studies, it is often difficult to evaluate the merits of existing or potential advances in structural concepts and materials applications as applied to launch vehicles. Techniques for rapid evaluation of these merits are being investigated under contract. The techniques under study show significant promise for defining the relative payoffs, e.g., weight and cost savings, to be expected from a wide range of advanced structures technology. Such definition will provide guidance for future research which would be applicable either for modification of existing vehicles or for the development of new launch vehicles. Recovery and reuse of launch vehicles create a number of formidable structural/material problems. Although the technology being developed for reusable manned spacecraft will be applicable, certain problems unique to the reuse of the larger and less dense structures of launch vehicles must be studied. Particular attention will be focused during FY 1967 upon substantially different configurations for future generations of launch vehicles.

A general purpose computer program is being developed for the analysis of complex space vehicle structures. This program will be standardized such that it can be used by all of the NASA Centers. It will be available to industry so that the result may improve the structural analysis capability of industry on the whole. It may eliminate also to a large extent the need for special purpose programs that are now constantly under development, and serve as an effective means of communicating structural information between NASA contractors and NASA Centers. Since the program will provide substantial improvement in structural systems analysis, it might be used also by other industries involving structural design. It should be completed and put into general use by the end of FY 1967.

Space Vehicle Environmental Factors

This research program is concerned with the vehicle design problems incurred by the environment of space. The objective of the program is to determine in detail the nature of the space environment from the vehicle design standpoint, to investigate the effects of the environment on spacecraft, and to find solutions for related technical problems. The scope of the research effort includes high energy radiation effects and shielding, the meteoroid environment and impact hazard, thermal radiation and temperature control, high vacuum technology, and the behavior and control of fluids under zero gravity conditions.

Research is being performed to determine radiation effects on engineering properties of sensitive spacecraft materials, devices, and components and to increase the understanding of the basic mechanisms for radiation damage to permit development of improved radiation resistant materials and spacecraft components. Completion of new radiation facilities at the Langley Research Center and the Goddard Space Flight Center will result in increased emphasis on in-house research during FY 1967. The new Space Radiation Effects Laboratory at Langley, operated by the Virginia Associated Research Center under contract to NASA, will become the principal center for NASA experimental research on high energy proton and electron radiation effects. Increased funds are required in FY 1967 for the operational support of the laboratory, as well as for support of increased applied radiation research at Langley. Radiation environmental testing and simulation techniques, and correlation of damage by the various types of radiation will receive increased emphasis at the new Goddard Space Flight Center radiation facility.

In connection with the protection of man and equipment from the effects of high energy radiation in space, theoretical and experimental studies are being performed to provide data on the shielding effectiveness of materials with special emphasis on the secondary radiation produced within the shielding material. A continuing effort in shielding research will be required, with a general increase in research devoted to advanced shielding concepts. Research in an advanced and promising shielding concept which uses a combination of both magnetic and electrostatic forces to deflect charged particles, such as protons and electrons, offers promise of very large savings in shield weight for extended missions.

A broad research program including both laboratory and flight experiments is under way to obtain definitive data on the characteristics of meteoroids and their hazards to spacecraft. A major milestone has been accomplished in the launching of three large area Pegasus meteoroid detection satellites. These spacecraft are providing definitive data in near earth regions on meteoroid penetration of much thicker structural material specimens than any previously flown. However, it is now clear that data on still thicker materials are needed for support of future long duration manned missions where the probability of encountering larger meteoroids is much greater than in short-duration flights. Such measurements must be made with high statistical reliability, and emphasis will be given to the continued development of improved meteoroid flight sensors. In addition to flight experiments, the Harvard College Observatory and Smithsonian Astrophysical Observatory under NASA contract are studying natural meteors entering the earth's atmosphere using radio reflection and optical techniques. Such observational measurements yield data on the near earth meteoroid population for the larger meteoroids. Increased emphasis will be placed in this area of research since an urgent need exists to develop means of correlating these data with the flight measurements of actual meteoroid penetrations to provide design data for the widest possible range of meteoroid sizes. Laboratory research on hyper-velocity impact will also be continued and expanded since this phenomenon must be better understood before the desired correlation can be accomplished with confidence. One of the important and currently uncertain factors involved in impact theory and in correlation of ground observations and flight data is particle density. At the Ames Research Center preliminary laboratory simulations of meteoroid entry into the atmosphere have shown that meteoritic rock undergoes foaming and a radical change of shape at high heating rates. This new finding, which has been injected into the meteor observational program, indicates that present deductions of meteoroid density based on measured meteor velocities and decelerations in the earth's atmosphere may be in error.

Laboratory hypervelocity impact research is still limited by the inability to simulate meteoroid sizes and velocities simultaneously. Continued emphasis will be given to the development of promising techniques for achieving better simulation, along with improvement of present in-house equipment to keep pace with new developments in this area.

The zero gravity fluid behavior program will continue to be concerned primarily with research on fluid dynamics as in fuel tanks under near zero-gravity conditions with particular emphasis on effects of attitude control maneuvers on behavior of the liquid vapor interface, response to outflow disturbances and fluid collection and interface formation times. The results of such research is important to any on-board fluid system. Much of the research in this area will be performed in the new 400-foot drop tower facility at the Lewis Research Center. While similar studies with very small models in the 100-foot Lewis drop tower facility have led to good qualitative understanding of the phenomena involved, the experiments in the new facility will result in data for larger size models giving much greater confidence to extrapolations to full size flight systems.

The exchange of heat to and from vehicles in space is solely by thermal radiation. Since the radiative characteristics of spacecraft surfaces are known to be altered by solar ultraviolet and other space radiations in combination with space vacuum conditions, accurate quantitative temperature predictions for long duration flights are difficult. Present design techniques include iterative or multiple trial processes involving tests in large facilities where adequate simulation of the solar spectrum is difficult. Testing of spacecraft thermal control coatings in space and in the laboratory will continue along with the development of new more stable coatings. Methods will be developed to measure the spectral reflectance of materials over a wide range of conditions, along with the development of new computer programs to apply such data to extensive inter-reflection between surfaces of complex spacecraft shapes. Research on new thermal radiation sources will continue, as will research in the area of thermal scale modeling. The Mariner IV spacecraft configuration was selected for an experimental evaluation of scale modeling techniques. Results obtained in testing of a half-scale thermal model of the Mariner IV have been most encouraging with respect to the application of these techniques which could reduce significantly the future requirements for large solar simulation facilities.

In the testing of spacecraft and materials under simulated combined thermal and vacuum environmental conditions of space, a series of new problems has developed due to an unpredicted contamination of surfaces in vacuum chambers. This contamination produces unwanted changes in the thermal balance of spacecraft under test and adds to the difficulty in analyzing effects due to ultraviolet and other radiations. This and other problems associated with the creation, maintenance and measurement of simulated space vacuum will be under continued study in FY 1967.

Space Vehicle Design Criteria

Space vehicle failures have occurred because of the application of inadequate or inappropriate design conditions or procedures. Moreover, the problem of retrieval of information applicable to the design of future space vehicles continues to grow more complex as the mass of new technical information resulting from research studies, vehicle project development and operating experience increases. The objective of this program is to assist project managers and designers by providing them with technical information suitably filtered from the total mass of data available and arranged in useful forms for uniform application to design. Attainment of this objective entails identification of design problems that must be considered to ensure the flight worthiness of space vehicles, formulation of existing technical information bearing on these problems into authoritative guides to design, dissemination of these guides in an orderly and usable set of design criteria documents to NASA and industry users, and updating as required.

This effort encompasses the preparation of design criteria in the technical areas of environment; structures; propulsion; and stability, guidance and control. The work effort is being carried out at seven of the NASA Centers, at the Jet Propulsion Laboratory, and by contract with several aerospace companies and consulting firms. To provide focal points for detailed control and guidance of the program effort, three of the NASA Centers function as lead Centers: Langley Research Center - Structures Criteria; Lewis Research Center Propulsion Criteria; and Electronics Research Center - Guidance and Control. Fiscal year 1967 funds will provide for continuing contract effort by the lead Centers and other Centers necessary for the timely formulation of design criteria in each technical area where criteria are to be established.

In calendar year 1965 criteria monographs pertaining to solar electromagnetic radiation, buckling of thin-walled cylinders and aerodynamic and ground wind loads were issued to industry and interested government agencies. In addition to the monographs issued, work was continued or initiated on approximately forty-five drafts of planned monographs.

The continuation of this program in FY 1967 should reduce the chances of failure in the future, and ensure an optimum balance between reliability and performance as permitted by the latest available knowledge and experience.

<u>Lifting Body Flight and Landing Tests</u>

	1965	1966	1967
Flight vehicle and support services..	$1,400,000	$1,000,000	$1,000,000

The lifting body class of reentry vehicle configuration has received considerable research attention because of the improved atmospheric maneuvering performance over that of ballistic and semi-ballistic vehicles of the Gemini and Apollo type. This research leads to widened reentry corridors, reduced g-loads on crew and passengers, and greater lateral ranging ability with consequently improved operational flexibility and precision in return from orbit. The lifting body types of vehicle also offer the capability of horizontal landing at prepared land sites.

One of the most important questions with such vehicles is that of terminal approach and landing, investigation of which is the objective of the current flight research project being carried out at the Flight Research Center on the Ames M-2 and Langley HL-10 configurations. These test vehicles were constructed by the Northrop Corporation to NASA specifications. They are built of aluminum using conventional airplane-type construction and adapting off-the-shelf components such as landing gear, control systems, hydraulic systems, ejection seats, etc., and incorporate a ballast feature by which large changes in weight can be made covering a wide range of platform loadings. The M-2 has reached the flight test stage after being thoroughly tested in the Ames 40- x 80- foot wind tunnel. The HL-10, delivered in January 1966, will reach flight readiness in the spring of 1966 after undergoing similar 40- x 80- foot tunnel tests. They will be carried by a B-52 (the same aircraft used for launch of the X-15) to an altitude of 40,000 feet and a speed of about Mach number 0.8 and released to glide back to earth.

The funds in FY 1967 will provide for the continuing aggressive and extensive flight test program, in which both NASA and USAF test pilots will participate, covering a wide range of vehicle loading and operational conditions.

Scout Reentry Project

	1965	1966	1967
Spacecraft and support..............	$400,000	$3,000,000	$4,800,000
Scout (Launch Vehicle Procurement Program).........................	(2,260,000)	(---)	(1,800,000)
Total (including launch vehicles).	($2,660,000)	($3,000,000)	($6,600,000)

The objective of this project is to support the advancement of atmosphere entry technology by performing critical anchor point experiments in hypervelocity reentry flight. Emphasis is on the technologies of aerothermodynamics and high temperature structures and thermal protection systems with the aim of correlating, verifying, and extending research results obtained in laboratory facilities.

In heat shield technology an experiment will be flown to a reentry speed of about 27,000 feet per second to determine the performance of an advanced low-density phenolic nylon heat shield material of particular interest to ballistic and semi-ballistic entry vehicle application. The flight will subject the test heat shield to a high intensity, short duration heat pulse with the objective of verifying the prediction of the performance of the material based on a very thorough laboratory determination of its physical and chemical properties and its performance in arc jet tests.

Further heat shield material experiments are being devised to determine in a similar way the behavior of several promising ablation materials of especial interest for lifting entry vehicle applications. These materials, of which silicone elastomers are one example, have characteristics suited to long duration, relatively low level heating, with short duration high heating rates superimposed during maneuvers. Problems associated with ease of refurbishment are an important consideration, and spacecraft recovery is an essential feature of these flight experiments to study at first hand heat shield damage and its repair.

In the area of aerothermodynamics, two flight experiments will be conducted to provide basic data on the heating rates associated with turbulent boundary layers at high Mach numbers and Reynolds numbers, and to investigate factors which affect transition from laminar to turbulent flow under these conditions. The data are important in predicting heating rates and skin friction on a variety of advanced vehicles, including lifting reentry vehicles, ballistic missiles, hypersonic cruise aircraft and certain classes of reusable launch vehicles. The data cannot be obtained in ground test facilities and anchor point data from flight experiments are needed to resolve disagreements among various theories used to predict turbulent heating rates.

At speeds associated with entry into the atmosphere of Venus and reentry into the earth's atmosphere on return from planetary flight, characteristically 45,000 to 50,000 feet per second and higher, critical flight experiments will be needed to provide anchor point data on both the heating environment and the behavior of thermal protection systems in this extreme heating environment. Such experiments, for which spacecraft recovery is essential, are difficult to devise and will require long lead time for their development. Intermediate steps will be necessary. To this end, configuration and instrumentation concepts will be developed, along with a velocity package, for launch to intermediate reentry speeds of around 36,000 feet per second by Scout launch vehicles.

Small Space Vehicle Flight Experiments

	1965	1966	1967
Spacecraft and support.............	$1,010,000	$2,000,000	$1,500,000

Planetary Entry Technology - One of the most critical problems associated with the exploration of Mars by unmanned spacecraft is that of terminal descent and noncatastrophic landing on the surface. The very low density of the Martian atmosphere will require the use of large, lightweight parachutes that can be deployed with high aerodynamic and structural reliability at relatively high speeds and low dynamic pressures. While several promising parachute concepts have been identified, their opening and structural loading characteristics under the expected conditions have not been established and cannot be established by ground tests alone. The problems will therefore be studied by means of high altitude flight tests under conditions that closely simulate planetary atmospheric conditions. A series of scaled-model tests will be carried out using Nike rocket launch vehicle, coupled closely with larger scale experiments, lofted by balloons and rockets launched at high altitudes.

Heat Shield Materials Technology - As discussed under Scout Reentry Heating Experiments flight measurements of the performance of ablative heat shield materials constitute a continuing program to provide critical anchor point data and to improve understanding of the complex ablative process. The Scout-launched experiments provide data at speeds corresponding to actual spacecraft reentry speeds. A vital link between the Scout experiments and ground-based research is provided by flight tests using the smaller low-cost Pacemaker rocket system to provide flight data at conditions that can be closely approximated in laboratory facilities and therefore afford direct comparison.

An important aspect of the heat shield materials technology program is recovery and examination and analysis of specimens after flight test. Research into recovery concepts and instrumentation aids will be conducted in this program during FY 1967.

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY — ELECTRONICS SYSTEMS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The purpose of the Electronics Systems Program is to insure the availability of electronic technology capable of satisfying the stringent reliability and performance requirements of future space and aeronautical systems and related support functions. The scope of the program extends from conceptual systems research, including performance predictions derived from studies of control and information theory, through the development and evaluation of advanced electronic techniques and components, the elements common to all operating electronic systems. The efforts of this program are motivated by the performance demands of future missions and the operational limitations of today's equipment. Typical general objectives are: (1) attainment of the extended operating lifetimes and reliability requirements of future space missions, and (2) performance and adaptability of instrumentation, communications, data processing, control and guidance subsystems. The program utilizes both analytical and experimental research approaches prosecuted in industrial, university, and government laboratories. Flight experiments are performed, when necessary and prudent, to circumvent the limitations of the earth-bound laboratory research programs.

SUMMARY OF RESOURCES REQUIREMENTS:

	1965	1966	1967
Supporting research and technology...............	$23,222,000	$30,000,000	$34,000,000
Flight projects............	2,400,000	2,300,000	2,800,000
Total....................	$25,622,000	$32,300,000	$36,800,000

Distribution of Program Amount by Installation:

	1965	1966	1967
Manned Spacecraft Center......	$465,000	$525,000	$450,000
Marshall Space Flight Center..	3,685,000	4,003,000	4,200,000
Goddard Space Flight Center...	2,967,000	2,975,000	2,960,000
Jet Propulsion Laboratory.....	2,727,000	3,566,000	3,290,000
Ames Research Center..........	3,480,000	3,718,000	4,100,000
Electronics Research Center...	2,178,000	5,110,000	10,000,000
Flight Research Center........	1,038,000	698,000	660,000
Langley Research Center.......	6,660,000	7,260,000	7,420,000
Lewis Research Center.........	400,000	539,000	540,000
NASA Headquarters.............	2,022,000	3,906,000	3,180,000

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

	1965	1966	1967
Guidance systems...............	$4,523,000	$6,050,000	$6,250,000
Control systems................	5,351,000	6,000,000	6,150,000
Communications.................	4,190,000	4,800,000	5,600,000
Tracking and data acquisition..	2,860,000	3,550,000	3,700,000
Data handling and processing...	3,172,000	3,650,000	4,150,000
Instrumentation................	3,126,000	3,950,000	4,150,000
Electronic techniques and components..................	---	2,000,000	4,000,000
Total.......................	$23,222,000	$30,000,000	$34,000,000

Guidance Systems

Guidance System research and technology efforts are directed toward identifying requirements and characteristics of future space guidance and navigation systems, and developing sensors, components and subsystems capable of attaining advanced performance goals. Systems and trajectory analyses provide the framework for examining sensor, instrumentation and data processing trade-off assessments for future space missions and for the development of guidance equations, navigation logic and advanced systems concepts. From these analyses, the research objectives leading to advanced sensors, reference elements and associated instrumentation components are derived. The program emphasizes research in inertial, optical and electromagnetic phenomena to develop the sensors and techniques directly related to space guidance and navigation.

In the area of inertial guidance components, new activities, designed to improve component performance and reliability, will be concentrated in the Guidance Laboratory at the Electronics Research Center. A typical example of this work is the laser gyro. This device makes use of laser beams to sense inertial quantities; additional research is necessary to realize its operational potential. Proper mixing of gases to control the laser modes of oscillation and the ultimate means for replacing gas lasers with solid state lasers are the areas of endeavor to be explored during the next phase of its development.

In view of the fact that the sun, celestial and planetary bodies provide the primary targets for space navigation and attitude reference, expansion of research on passive electromagnetic sensors, particularly that related to improved detectors, no-moving-part and lightweight tracking devices is planned for this fiscal year, primarily at the Electronics Research Center.

Increased efforts in active radar and laser devices are required to effect future rendezvous and planetary letdown portions of manned and unmanned missions. This area of technology has not heretofore received proper emphasis due to limitations of available personnel and facilities at the Centers. The major increase in this effort will be in the Guidance Laboratory at the Electronics Research Center.

Current and continuing efforts in this program will provide the components and technology necessary to support the development of future guidance and navigation systems. Planned efforts will derive the requirements for advanced research and specify characteristics and components to meet the demands of long term space missions for interplanetary exploration and travel.

Control Systems

The research efforts sponsored by the Control and Stabilization program provide the technological base for future aerospace vehicle control systems. Areas of study include manned and automatic flight control systems, spacecraft attitude stabilization and control, and the development of mathematical tools for system analysis and synthesis. Specific objectives include: more precise mathematical descriptions of manual and automatic control performance, the development and application of modern control theory to future system problems, and the advancement of the state-of-the-art of control and display system components.

During the coming year, intensive efforts will continue in the area of mathematical modeling of both automatic and manual control performance. Past efforts have provided quasilinear descriptions of a pilot's control performance and the techniques capable of limited application. These models have been shown to be valuable in both the analysis and design of vehicle control systems. They have been used in system designs for the supersonic transport, for manually controlled launch vehicles, and for lifting body research vehicles. The efforts in FY 1967 at the Ames Research Center will extend and refine the applications of these techniques, and in addition will concentrate heavily on describing, mathematically, the control function in terms that include decision making, time varying, and adaptive characteristics of the human's control performance.

The effort in the area of system synthesis is illustrated by a problem in optical technology, the pointing of extremely narrow beam laser telescopes. System studies indicate requirements to point these beams with accuracies of up to 0.01 arcseconds of angle, a requirement far exceeding existing control capability. System studies have generated potential means of accomplishing this goal. In the coming year effort will be directed by the Langley Research Center toward the component development necessary to demonstrate the concept feasibility.

During the past year, the component development program efforts have been devoted to advancing the state of the art of display media through the development of X-Y, vertical scale, and alphanumeric electroluminescent displays, and development of electromechanical components such as brushless DC motors, and momentum exchange devices. Other components under development include a display for aircraft zero-zero landing research, an optical system for pilot remote visibility, satellite attitude control hardware, both active and passive, such as nutation dampers and a dual redundant attitude control valve, and television simulation displays. A significant FY 1967 expansion in control components will provide an important payoff in realizing analytical concepts developed over the last few years. The primary expansion is at the Electronics Research Center; other Centers will maintain essentially the same level of effort as in the past.

Communications

The communications subprogram provides a firm technology base upon which to refine present systems and to build future generations of deep space communications systems. Research efforts contributing to this firm technological base are in the microwave, submillimeter and optical frequency domains.

Microwaves

Extremely high data rates (10^7 to 10^{12} bits/sec) are required for real time transmission of high resolution photography and telemetry for scientific purposes from the outer planets. Deep space communication data rate is directly related to the power of the spacecraft transmitter tube, and consequently, our research in microwave tubes for spacecraft is oriented towards higher powered tubes. Mariner IV, using a ten-watt tube, transmitted at 8-1/3 bits/sec from Mars. A 20-watt tube has been developed by Watkins-Johnson for the Langley Research Center. A 1,000-watt tube would improve our communication data rate by 100 times over the Mariner 10-watt tube.

Efforts to be undertaken in FY 1967 at the Electronics Research Center include studies and laboratory experiments to develop the technology required for space-qualified 500-to 1,000-watt tubes for future missions.

Reentry communications is the subject of an intensive research effort. Upon reentering the earth's atmosphere, a spacecraft is enveloped in a plasma sheath which causes a blackout in communications. The Langley Research Center is conducting a Reentry Attenuation Measurements (RAM) flight project to provide basic data concerning the plasma sheath and to test the water injection method of alleviating the effects of the plasma. A further discussion on RAM appears in the Flight Projects section. A major break-through in both understanding and eliminating the effects on communications of plasma is necessary in order to provide reliable communications and tracking for lunar and interplanetary mission reentry velocities of 36,000 to 70,000 feet/sec. Research will continue in this area during FY 1967 at the Langley Research Center with major emphasis on evaluating results of flight data.

Advanced electronics devices which utilize the plasma engulfing the spacecraft are being investigated by the Electronics Research Center for communicating through the blackout period of reentry. Techniques to maintain communications while entering the atmospheres of other planets will also be studied during FY 1967.

Millimeter/Submillimeter

Advances in technology are handicapped by the lack of stable, efficient sources. At the present time deep space communication using these frequencies is not possible. Successful development of suitable sources in this frequency region will make the millimeter-submillimeter region useful for future deep space communications. Research being initiated by the Electronics Research Center should yield this capability in the future. Preliminary studies have shown that atmospheric attenuation in this region may be serious enough to require the use of orbiting relay stations to convert from submillimeter to microwave frequencies for retransmission to the earth station. Results of studies by the Mission Analysis Division concerning efficient, long life orbiting communication relay stations will be used to guide the research effort in FY 1967.

Optical

Electro-optical systems show promise of improving data rate capability from deep space by as much as three orders of magnitude over that possible at microwave frequencies. To realize these high data rates requires considerable improvement in both laser and optical technology. For example, 30 to 60 inch, diffraction-limited, lightweight, space telescopes with surface tolerances of .000002 cm are required for optical communications, but are not in existence today. Studies are under way to select and develop optimum detection techniques for the ground terminal. The Electronics Research Center, for which a Space Optics Laboratory is included in this year's facility request, will be the major research facility for the implementation of the total optical program.

Techniques to remotely monitor and control surface characteristics and the alignment of large primary segmented mirrors in space are under study at the Langley Research Center. The segmented approach to achieving large lightweight diffraction-limited optical telescopes will be applicable to both optical communications and astronomy. This effort will continue in FY 1967.

Tracking and Data Acquisition

Tracking and data acquisition systems capabilities are generally constrained by the physical characteristics of the system components. To provide means of circumventing these limits, research in this program includes: investigations of multiple ground antenna arrays, large lightweight spacecraft antenna development, and optical tracking.

Increased data rates can be achieved by increasing the effective area of ground antennas. Antennas larger than 210 feet are confronted with severe structural, mechanical and cost problems. The alternative of arraying many smaller antennas effectively increases the area while simultaneously reducing structural design and fabrication problems. However, the electronic problem of phase locking low level signals is introduced and must be solved.

Stanford Research Institute, Research Triangle Institute, and Electronic Communications Inc. have completed antenna array studies for the Langley Research Center and for the Goddard Space Flight Center. Experiments are being formulated during this fiscal year for arraying of two 15-foot antennas at the Goddard Space Flight Center to further identify scientific and operational problems peculiar to arrays of this type. These experiments will be undertaken in FY 1967 with major emphasis on the phase locking of the individual signals and the identification of operational problems.

Increasing the size of spacecraft antennas is another approach used for improving data rates, but prelaunch antennas sizes larger than 15 feet are impractical. Therefore, means to erect large antennas in space are being investigated. A nine-foot, deployable antenna developed by Goodyear for the Jet Propulsion Laboratory has been successfully tested and will be used in FY 1967 as a laboratory instrument to further refine deployment techniques. In FY 1967 the Jet Propulsion Laboratory plans to complete a computer program which will allow theoretical evaluation of perturbations and modifications to the antenna reflecting surface. These investigations, augmented by additional studies at the Electronics Research Center, will seek the capability to erect 20 to 30 foot antennas on unmanned spacecraft providing potential data rate improvements of two orders of magnitude over present capabilities.

Additional efforts will be directed towards achieving large apertures at optical frequencies. Tracking and pointing accuracy techniques are problems associated with large ground and airborne optical systems. The Goddard Space Flight Center and the Langley Research Center will continue studying this problem. Tests will be initiated by the Langley Research Center and the Electronics Research Center this fiscal year to determine the atmospheric and space environment effects on coherent optical transmission. These efforts will be continued in FY 1967.

Data Handling and Processing

The rapid evolution of spacecraft technology and the accompanying increase in data gathering capacity of on-board systems continue to tax the data processing capability. Even though significant advances have been made in the technology of both spacecraft and ground data handling techniques and systems, additional research in advanced components and software is required to keep pace with our data sensing ability.

In FY 1967, work at the Goddard Space Flight Center will continue to develop techniques and systems for computer checking of vehicle readiness in the prelaunch phase and to program and monitor launchings from earth, other celestial bodies, or from orbit, including margin testing and prediction of incipient failures; adaptive control of trajectory selection based on predicted partial failure; and continuous assessment of system status. Work in this area has resulted in development of a command and control link which allows more completely automated sequencing and programming of spacecraft checkout, and calibration of scientific experiments. As an example of the growth in the complexity of spacecraft systems and experiments, the

Explorer XVII launched in 1963 had approximately fifteen functions commandable from the ground, while the Radio Astronomy Explorer (RAE) to be launched in 1967 will have over ten thousand.

Advances in ground computer processing of TV pictures from Mars have resulted from past research in this subprogram. Similar efforts have been started in on-board picture storage and compression, and will continue and expand in the next several years.

Investigation of coherent optical phenomena for improvement of data storage and manipulation will be expanded in FY 1967 at the Electronics Research Center.

High capacity on-board data storage devices are required to serve as temporary repositories for the large amounts of data gathered by TV systems. A single high quality TV system may generate several million bits of information each second. Since this far exceeds the capability of present and near future data transmission links at planetary distances, methods are required to store the data until it can be transmitted. The Jet Propulsion Laboratory has demonstrated the feasibility of a small magnetic tape data storage unit which will store one hundred million data bits in several cubic inches. In FY 1967 research will continue to develop a working device as well as to investigate other methods for data storage in devices having no moving parts.

Compression of data aboard a spacecraft is a continuing goal of data processing research required to match the amount of scientific data collected with the current and projected data transmission capability. One such system, developed by the Goddard Space Flight Center for the Interplanetary Monitoring Platform satellite, makes use of the mathematical properties of histograms or bar graphs. Data gathered by particle sensors is coded in a form which can be represented by such a graph. Special on-board computing circuits calculate the pertinent mathematical properties and transmit only these properties to earth. From these properties ground-based computers may then reconstruct the graph. By this process, only one-tenth of the data has to be transmitted.

During FY 1967, emphasis will be placed on perfecting such concepts and extending them to a broader spectrum of experiments.

Instrumentation

The expansion of aerospace scientific knowledge is strongly dependent upon the advancement of instrument technology and the development of new measurement methods. Scientific instruments are essential to sense and measure fundamental astrophysical, engineering and bio-medical parameters.

The principal goals in instrumentation research are to increase accuracy, to extend the measurement range, to improve energy and signal conversion, to reduce size and power consumption, and to eliminate synergistic effects.

Solid-state electronic components have permitted the development of novel circuit designs and new instrument transducers of improved sensitivity. One example is the design of a miniature accelerometer based on semiconductor piezo resistive properties. A theoretical and experimental study of the stress sensitivity and the effect of mechanical strain on semiconductor diodes and transistors, performed by the Research Triangle Institute under the direction of the Langley Research Center, has resulted in the development of a miniature accelerometer with high frequency response and using a unique stress sensitive transistor in the form of a silicon needle. This transducer will find a wide variety of aerospace applications and the principle lends itself to other applications for measuring pressure, stress, and vibration. Further work is required to refine the design of the accelerometer and to eliminate side effects of temperature.

An important feature of aerospace investigations is the acquisition and transmission of pictures. In this process, optical signals are usually converted into electronic signals by means of imaging devices. In an effort to overcome some of the deficiencies of presently used vidicon tubes, micro-miniature techniques are being explored and have made possible the development of a phototransistor sensor. Progress made since last year has led to the design of a small solid-state TV camera using a 50 x 50 matrix of photo-transistors in an area ½" x ½" which operates at low voltage without the complexity of beam scanning. This camera has been developed and demonstrated by Westinghouse, under the direction of the Marshall Space Flight Center. Refinements of the camera to provide more densely spaced sensing elements and permit non-mechanical, opto-electronic coupling into readout electronics require further investigation during FY 1967.

The higher measurement accuracies required for aerospace exploration are limited by the error introduced by the necessary conversion of original analog signals for long distance transmission by digital telemetry. Digital transducers have received increased attention to minimize such errors, to simplify circuitry, and achieve better compatability with digital telemetry.

As an example of current efforts, the Dynamics Research Corporation, under the direction of the Marshall Space Flight Center, has done some preliminary work based on the birefringent behavior of optical media under stress. Polarized light channeled through various optical paths will produce digital outputs which reflect the applied stress in digital form. Such digital sensing devices with no mechanical moving parts, promise to provide considerable system simplification and measurement reliability and are planned to be supported at the Marshall Space Flight Center and expanded at the Electronics Research Center in FY 1967.

Force, pressure, acceleration, and vibration are frequently measured with strain gages made of metal foil strips which change their electrical resistance when their lengths change due to applied stress. Solid-state strain gages have been developed which are many times more sensitive than metal foil gages, but heretofore have been temperature limited. Experiments performed at the Langley Research Center have recently shown that exposure to controlled radiation reduces the temperature sensitivity of certain semiconductor strain gages to a level comparable with metallic foil type gages.

Since their high sensitivity is not affected, strain measurements many times smaller can now be performed under environmental conditions where temperature changes are experienced. Work in FY 1967 is required to increase the range of measurement and to investigate additional materials.

Electronic Techniques and Components

The Electronic Techniques and Components subprogram, first established in FY 1966, is directed to perform the research necessary to determine future requirements to extend the state-of-the-art; and to provide the necessary supporting research and technology for electronic and electromechanical components and their materials. The subprogram supports in-house and contractual research in electronic components, including high temperature and radiation tolerant devices; electromechanical components such as solid-state relay and interconnection concepts; and methods and techniques for qualification and standardization of components designed to explore means for improving and assessing the reliability and quality of materials, parts and devices.

A particularly critical problem in the microelectronics area today is the interconnection and assembly problem. A contracted study has resulted in recommendations for research in this area. The Electronics Research Center will evaluate the results of this study and orient its investigations to those recommendations offering the greatest potential for increased reliability and performance as part of their FY 1967 activities.

Strong emphasis was placed in electronic component research in FY 1966; efforts were centered around high temperature component development and materials technology. These efforts were concentrated at the Electronics Research Center and will be expanded in FY 1967.

The problem of assembling electronic components is of great concern to spacecraft systems and is one of the most important in terms of potential reliability improvement. The Jet Propulsion Laboratory has developed an outstanding capability in new assembly methods for integrated circuits in space applications. In FY 1966, a technique developed at the Jet Propulsion Laboratory was committed for use on the plasma experiment of the Orbiting Geophysical Observatory (OGO-E). As we probe deeper into space with more complex experiments and spacecraft, this problem will be of even greater concern. Additional support in advanced assembly concepts will be required in FY 1967.

Since the near earth radiation environment is now fairly well known, it is important to determine what effects this environment has on electronic circuit devices. A Goddard Space Flight Center sponsored study indicates that state-of-the-art integrated circuits withstand the radiation environment with little degradation. These efforts will be continued in FY 1967 with emphasis on determining the performance capabilities of the newer class of microelectronic devices in the radiation environment.

Since power in spacecraft is at a premium, minimization of power consumption is an important objective. The Langley Research Center has initiated efforts to develop low power logic functions and a differential amplifier in microelectronic form. This effort will continue in FY 1967. The development of computer techniques for use by engineers in analyzing the design and performance of electronic circuits for spacecraft applications will be continued as a means for achieving improved performance and efficiency as well as increased reliability in space systems.

Flight Projects

	1965	1966	1967
Radio Attenuation Measurements (RAM-C)	$900,000	$1,300,000	$1,300,000
Small Flight Projects:			
(SCANNER)	1,500,000	1,000,000	---
(Sextant Experiment)	---	---	500,000
Earth Coverage Horizon Measurement	---	---	1,000,000
Total Flight Projects	$2,400,000	$2,300,000	$2,800,000
Scout (Launch Vehicle Procurement Program)	(---)	(1,400,000)	(800,000)
Total (including Launch Vehicles)	($2,400,000)	($3,700,000)	($3,600,000)

These projects provide the verification of experimental results obtained in laboratory investigations and acquire data essential to the development of advanced sensors and systems of improved performance and reliability. Brief descriptions of these projects are provided in the following paragraphs.

Radio Attenuation Measurements (RAM)

Project RAM was designed to acquire an understanding of the plasma generated by a spacecraft reentering the earth's atmosphere and to determine means of eliminating a communications blackout caused by this plasma.

RAM A and B thus far have shown the relative merits of material addition, magnetic fields, aerodynamic shaping, and higher radio frequencies as methods of overcoming the blackout problem in the velocity range up to 18,000 feet per second.

The major objective of Project RAM C is to obtain reentry communications measurements in the velocity range of 25,000 to 27,000 feet per second. At these velocities the dominant ionization and recombination processes include not only those experienced in the low velocity range of RAM A and B flights, but also processes observable only in the medium and high velocity regimes.

Two flights will be made by the Langley Research Center from Wallops Station. The first, RAM C-A, will test the material addition and X-band telemetry concepts as methods of overcoming the blackout problem. The second, RAM C-B, will be a plasma diagnostic experiment designed to yield measurements of free-electron and ion concentrations at various positions along the spacecraft.

Launches are scheduled in the third quarter of calendar year 1966 for RAM C-A and the first quarter of calendar year 1967 for RAM C-B. Provisions are made for an additional launch for calendar year 1967 in the event the results from the first or second launch make it advisable.

Horizon Definition Research (SCANNER)

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. The project is an extension of current laboratory research on horizon characteristics. Two experiments will be performed by the Langley Research Center from suborbital ballistic trajectories using the Trailblazer II launch vehicle. Flight #1 is scheduled for August 1966 and Flight #2 is scheduled for November 1966.

Sextant Experiment

Simulation studies at the Ames Research Center, which have included participation by Astronauts, have demonstrated the feasibility of making manual sextant sightings for spacecraft navigation. These studies will be extended to experimental manual navigation measurements by Astronauts in manned spacecraft. These experiments will provide knowledge of the effects of the spacecraft environment, including window optical distortion and actual celestial targets, on sighting accuracy capability. The performance will also be directly compared with that of the more sophisticated primary navigation equipment to determine the potential of manual navigation techniques and instruments for primary as well as backup navigation use.

Earth Coverage Horizon Measurement

This project will extend limited measurements attained through Project SCANNER and supporting X-15 flights to a comprehensive measurement of the earth's horizon radiance profile over a broad range of seasonal and climatic variations. Advanced studies have been initiated in FY 1966 to identify suitable flight experiments and techniques. In FY 1967, these studies will be broadened and completed, and the operational requirements for the planned project defined. The Langley Research Center is directing the initial phases of the effort.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1967 ESTIMATES

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 unique environments of space and aeronautical flight; (2) to define the essential requirements for sustaining and protecting man in these environments; (3) to develop the technology necessary to provide suitable life support and protective systems; and (4) to integrate man's capabilities with those of machines to obtain composite systems of superior performance.

The scope, as well as the success, of future manned space missions will depend upon the support and effective utilization of man for extended periods of time. Equally important are man requirements and proper utilization in future aeronautical systems. The understanding of man's performance capability and psychophysiological limitations directly affect design considerations and are essential to insure the effective integration of man as a functional part of the total system. Continuity of effort and timely progress in this program are essential. The increasing priority of certain lagging investigations and technological developments is reflected by the requested funding increases in the various sub-programs.

This program is accomplished through a multi-disciplined approach including researchers in nearly every field of medicine, biology, psychology, engineering, physics and electronics located in NASA centers, Department of Defense aerospace medical facilities, universities and industry generally located throughout the country.

SUMMARY OF RESOURCES REQUIREMENTS:

	1965	1966	1967
Supporting research and technology..................	$12,160,000	$13,000,000	$15,500,000
Small biotechnology flight projects....................	1,160,000	1,900,000	1,500,000
Total......................	$13,320,000	$14,900,000	$17,000,000

Distribution of Program Amount by Installation:

	1965	1966	1967
Manned Spacecraft Center.....	$365,000	$795,000	$1,100,000
Marshall Space Flight Center.	355,000	310,000	300,000
Goddard Space Flight Center..	---	25,000	---
Jet Propulsion Laboratory....	100,000	100,000	---

	1965	1966	1967
Ames Research Center.........	$4,233,000	$5,224,000	$5,830,000
Electronics Research Center..	60,000	359,000	700,000
Flight Research Center.......	1,750,000	1,500,000	1,250,000
Langley Research Center......	4,053,000	4,246,000	5,000,000
Lewis Research Center........	232,000	125,000	---
NASA Headquarters............	2,172,000	2,216,000	2,820,000

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

	1965	1966	1967
Human research and performance.	$3,879,000	$5,102,000	$6,080,000
Life support and protective systems......................	5,503,000	4,496,000	5,800,000
Man-systems integration........	2,121,000	2,902,000	3,120,000
Advanced concepts..............	657,000	500,000	500,000
Total.......................	$12,160,000	$13,000,000	$15,500,000

Human Research and Performance

Long term manned space flight will expose man to environmental conditions quite different from those on earth. The objective of this research is to understand the physiological and psychological reactions of man 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, continuing progress has been made in radiobiology research. The predominating ionizing radiation particles of interest to us in space are protons. Preliminary experiments indicated that at the lethal-dose level, the biological damage mechanism of proton radiation for small animals is somewhat similar to that of gamma radiation. However, additional experiments over many energy levels are required for validation, along with interaction with other parameters such as heat, varied oxygen levels, and vibration. Measurements of dose distribution from the skin inward to a depth of 25 cm with 730 Mev protons shows approximately a 40 percent increase in dose at about 5 cm inside the body. This increase is due to the production of secondary radiation in tissue.

In the area of vestibular research, NASA has a substantial program to investigate the functioning of the primary balance mechanisms, the vestibular organs within the inner ear, and to determine what changes will occur in their functioning under zero-G conditions. The perception of orientation and coordination of body movements occur within the general framework of man's relationship to the force of gravity. Since the interactions between the balance mechanisms and the normal one-G environment are so important, there is a need to know in detail what the results will be when this gravity framework is removed for long periods of time. If it is found that man cannot adapt to long term weightlessness, one engineering solution will be the rotation of the spacecraft. If this is necessary, the effects of different levels of rotation must be known. This is being studied at the Naval Aerospace Medical Institute by exposing both animal and human subjects to various rotating environments and studying the relationships between functional disturbances produced by the varying force fields and vestibular integrity.

A more fundamental approach to this problem is being studied at the Ames Research Center. There NASA is studying the output of a portion of the inner ear in various accelerations. Flight hardware for this experiment to measure this output in an animal in zero-G is nearing completion; it is scheduled for flight on Apollo 205.

Cardiovascular Research

There is concern that in long term space flight, man may suffer a deconditioning of the cardiovascular system. The Ames Research Center is carrying on various research projects in the cardiovascular field in order to determine if deconditioning will occur in stressed conditions. One of the research tasks in this area is concerned with evaluating the changes in the part of the work resulting from changes in gaseous, chemical, and thermal environments. The essence of this work indicates that changes in cardiac performance measured on the isolated heart are small in response to a range of temperatures and changes in oxygen tension which cause serious disturbances to the central nervous system.

Metabolism and Nutrition

Recent manned space flights have indicated that metabolic changes especially dehydration, or possibly alteration of water balance have occurred. The Ames Research Center is carrying on research to determine the basic mechanism of dehydration and at what levels functional deterioration begins. In addition to the above work, Ames is also looking into alteration of the metabolism of fats, carbohydrates and proteins under stressed conditions.

Microbiology

There is a possibility that changes in susceptibility or resistance to infectious agents may occur under those environmental conditions to be found in space travel. A contract was recently granted to the Naval Medical Research Institute in order to conduct work in this area. Animals will be maintained in hypobaric chambers with selected artificial atmospheres, and they will be compared to control groups under normal conditions.

Life Support and Protective Systems

Life Support and Protective Systems are those systems necessary to maintain man in an unstressed condition, sustain human life, and prevent physical injury in the hostile environment of space.

Present spacecraft utilize relatively short duration life support systems in which the food, water and gases for the atmospheres are stored, and the waste is chemically treated and stored. Significant reduction in systems weights, which is essential to the economic feasibility of long duration manned space flight (e.g., to the planets), is possible by developing regenerative systems. Regenerative life support systems will supply man's requirements (food, water, oxygen) by regeneration from his own metabolic and waste products.

The Langley Research Center has developed and has begun testing loosely coupled components of a partially regenerative system in a life support test bed. Oxygen is removed from carbon dioxide, and fresh water from cabin condensation, urine, and wash water. Components will be studied individually as to efficiency, problem areas, and reliability, as well as collectively while sustaining four men for 100 days. Several new approaches to handling the different elements of the regenerative process are being investigated and will be developed into broad based form for study in the test bed.

Two separate contractors are studying, for the Ames Research Center, techniques available for a closed regenerative life support system recycling all elements including food. A breadboard of this system of choice will be contracted for study in FY 1967.

One promising development in advanced space suits is the metal extravehicular suit being developed for the Manned Spacecraft Center under a contract with Litton Industries. The concept uses constant volume joints to increase mobility and eliminate "spring back" effects.

By FY 1967, this metal suit will have reached such a state that additional effort will be needed for the further development and integration of the ancillary equipment with the protective shell, such as thermal control, life support, etc.; with additional effort, these items can be incorporated in suits for test.

Man-Systems Integration

In manned flight systems, mathematical modelling of man and analytical and experimental data on human performance in aircraft and space vehicles are developed, collated and evaluated to provide a basic library of man-machine information for advanced system technology. For manned and unmanned flight systems, the role of man as a major sub-system is studied in the ground support activities as well. Simulation studies are performed to provide design data and to validate design concepts under realistic conditions to further the understanding of the integration of man into aerospace systems.

A typical study involves the use of an advanced design multi-man capsule which will be mounted on the motion generator at Ames. The internal atmospheric environment, rates of acceleration and vibration, seating and working space layouts, and displays and controls will be modifiable to simulate various internal vehicle configurations. This capsule will be used to study the effects of these factors on pilot performance and to define human factors design criteria for aircraft flight control characteristics such as those involved in V/STOL, conventional jet, supersonic and hypersonic transport and private planes. Similar factors will be studied in manned boosters and space vehicles to define the optimal role of man in launch, orbit insertion, rendezvous and docking, mid-course flight, lunar and other extraterrestrial de-orbit and landing.

Another typical study is concerned with astronaut extravehicular activities to determine appropriate tasks for man outside of the space vehicle. His effectiveness in maintenance and repair of vehicles and satellites, transfer of personnel and cargo between vehicles, and assembly and support of large vehicles in space are pacing items for reduced costs and increased reliability of these vehicles. The interaction of space suits, astronaut maneuvering units, and life support systems must be studied to determine design needs.

Substantial reductions in cost and human error can result from studies of optimum crew sizes and task requirements for earth and lunar ground support activities, and orbital launch. Minimum crew skills needed to achieve checkout, launch, and mission control must be determined as soon as possible in order to be available in time to influence planning and design of future systems. The analysis of performance and shelter of astronauts and astronaut scientists on the moon is a continuing effort.

Advanced Concepts

Research on advanced concepts in any field is essential to solving the next generation of problems in a particular 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 following example is representative:

An investigation is being made through the Applied Physics Laboratory of Johns Hopkins University which is exploring advanced non-anthropometric space suit technology utilizing prosthetic type provisions along with the usual space suit arm and glove provisions. Non-conventional propulsion might be feasible as opposed to walking. Conceptual designs which appear feasible and practical will be subjected to further evaluation through components mock-up and testing.

Small Biotechnology Flight Projects

	1965	1966	1967
Small biotechnology flight projects....................	$1,160,000	$1,900,000	$1,500,000

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 example of our current flight experiments is the aircraft pilot's stress study at the Flight Research Center. The aviators are outfitted with the bioinstrumentation for various physiological parameters. The actual collection of the biomedical data to determine baselines of various physiological functions under stress is funded as a flight project.

An example of a flight experiment which requires the space environment and is the outgrowth of laboratory benchwork is an experiment at Ames on the behavior of the otolith organ, the organ of balance located in the inner ear. For this flight experiment, the nerve impulse signals from individual nerve fibers of frog's otolith are tapped. The frog's otolith is similar to man's. The action of the otolith under weightlessness will be measured by recording its nerve impulses to give an indication of the adaptiveness of this organ to weightlessness. This experiment is scheduled for Apollo 205.

An experiment currently being built for the Electronics Research Center for flight on Apollo is a nephelometer to measure the concentrations and size of dust particles in the spacecraft atmosphere under weightlessness.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1967 ESTIMATES

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY

SPACE POWER AND ELECTRIC PROPULSION SYSTEMS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The space power and electric propulsion systems program provides research and technology to evolve new and improved methods of power generation and electric propulsion for space applications. The program includes work aimed at more efficient and practical use of nuclear, solar and chemical energy for the generation and utilization of electric power in space; as well as the development of the technology of electric thrustors powered by either solar or nuclear power systems.

All space vehicles require electric power for operation of such equipment as communications, telemetry, guidance, stabilization and scientific instruments. The power level and duration varies widely (watts to megawatts and hours to years) depending on the purpose of the vehicle, but the trend is toward the higher power levels and longer mission durations. This trend results from the availability of larger launch vehicles such as the Saturn and from the desire to undertake more ambitious programs. All power system experience to date has been at relatively low power levels, less than 1 kilowatt, and the vast majority of applications have involved solar cell and battery systems. This experience has shown that current solar cell and battery systems will require major improvements in performance, particularly at the higher power levels and that advanced systems that are more compact and independent of the sun will be required.

Electric thrustor systems offer promise of significant savings in spacecraft weight, trip time or increased payload. The power required ranges from watts for attitude control systems to megawatts for manned interplanetary propulsion systems. Solar cells appear to be satisfactory power sources for the lower power thrustors. Work is needed on the system aspects of electric thrustors in anticipation of several early applications.

SUMMARY OF RESOURCES REQUIREMENTS:

	1965	1966	1967
Supporting research and technology....................	$36,770,000	$38,200,000	$37,000,000
Space electric rocket test (SERT)	2,300,000	3,000,000	---
SNAP-8 development..............	19,150,000	4,000,000	5,500,000
Total........................	$58,220,000	$45,200,000	$42,500,000

Distribution of Program Amount by Installation:

	1965	1966	1967
Manned Spacecraft Center.......	$53,000	$100,000	$650,000
Marshall Space Flight Center...	2,415,000	2,010,000	1,650,000
Goddard Space Flight Center....	3,512,000	4,260,000	3,990,000
Jet Propulsion Laboratory......	5,607,000	4,491,000	6,050,000
Ames Research Center...........	191,000	110,000	50,000
Electronics Research Center....	---	50,000	300,000
Langley Research Center........	1,324,086	846,000	700,000
Lewis Research Center..........	43,516,700	28,768,000	26,065,000
NASA Headquarters..............	1,351,214	4,565,000	3,045,000
Western Operations Office......	250,000	---	---

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

	1965	1966	1967
Nuclear-electric power...........	$13,106,000	$14,000,000	$13,180,000
Electric propulsion..............	9,919,000	10,000,000	9,850,000
Solar power generation...........	7,911,000	9,050,000	9,000,000
Chemical power generation........	5,834,000	5,150,000	4,970,000
Total........................	$36,770,000	$38,200,000	$37,000,000

Nuclear-Electric Power

The primary objective of the Nuclear Electric Power Generation Technology program is to provide a broad design basis for the energy conversion equipment to be used in the advanced nuclear electric power generating systems needed for future space missions. Close coordination and cooperation is maintained with the reactor technology program of the AEC.

The contractor and in-house effort in the program are concerned with the technology associated with (1) the Rankine cycle alkali metal turbogenerator, (2) thermionic direct conversion, (3) the Brayton gas turbogenerator, and (4) magnetohydrodynamic (MHD) systems. The Rankine cycle and thermionic conversion systems offer the most promise of attaining the light weights needed for electric propulsion systems. The nuclear thermionic concept which is in an early stage of research has few moving parts, and with its inherent redundancy and small radiator area, may ultimately prove to be the better system for many applications. The Brayton cycle conversion system potential advantages and applications are discussed as a part of the solar power section since the same equipment is being investigated for both the solar and nuclear energy sources. MHD conversion systems are of interest as a possible longer range alternate to the high temperature turbine-generator and thermionic approaches.

The Rankine turbogenerator program in FY 1966 obtained much useful information on heat transfer, working fluid properties, cavitation phenomena and high temperature refractory materials. In addition, performance and operating evaluations of such components as the turbine, condenser radiator, pumps, etc., are currently underway and progressing toward the design and fabrication of prototype high temperature components for ground testing. The present component testing is concerned exclusively with lower temperature non-refractory alloy test components. The component test programs will be continued in FY 1967. "Dry" vapor performance testing of the two stage potassium turbine at General Electric will be completed by the end of FY 1966. Facility and test unit construction materials limit operating temperature to a maximum of about 1600°F. A 2000 hour endurance run to evaluate erosion damage is also scheduled to be completed in FY 1966. It is planned to extend endurance testing in FY 1967 to 5000 hours if the test data continue to be favorable. This turbine program will also begin design and fabrication of a three stage turbine unit. Single tube boiling and condensing heat transfer programs are scheduled to be completed in FY 1966. In FY 1967, refractory metal and boiler and flight-type condenser studies will begin.

After extensive studies, an advanced tantalum base alloy, T-111, was selected to be the construction material for a two-phase potassium corrosion loop which will operate at a boiling temperature of 2100°F. The loop components (pump, boiler, condenser, instrumentation) were successfully endurance tested during FY 1966 at rated temperature for 2500 hours as part of a component development and evaluation program. The T-111 loop is scheduled to begin operation in FY 1967 and will be directed toward a 10,000 hour test objective.

During FY 1966, considerable progress was made on determining the suitability for high temperature operation of various electrical insulators, magnetic materials, electrical conductors and bore seal materials. During FY 1967 tests of promising materials will be extended to longer times and higher temperatures, and geometries representative of prototype electrical hardware will be fabricated.

The present phase of the advanced Rankine turbogenerator program has been conducted with stainless steel or superalloy components. Although these alloys simplify test operations considerably, they are useful only to about 1600°F. In FY 1966, a design study of a versatile test rig capable of testing refractory alloy components such as turbines, boilers, condensers, etc., is being performed. Fabrication of the test rig is planned to begin in mid FY 1967. This will enable component tests to be performed at about the 2000°F temperature expected to be required for suitably lightweight systems.

The major technological obstacle associated with the nuclear thermionic conversion approach is the attainment of fuel materials that will be dimensionally stable at the very high temperature (> 3000°F) and uranium fuel burnup conditions required for efficient, long life operation. The AEC and NASA are conducting coordinated nuclear fuel research programs aimed at investigating two broad classes of materials: the uranium oxides at General Electric, Vallecitos, and the uranium carbides at General Atomic. Fuels testing will continue during FY 1967 at the NASA-Plum Brook Test Reactor.

In addition to the fuels research effort, tests of electrically-heated thermionic diodes assembled with fueled or unfueled emitters will continue in FY 1967. During FY 1966, significant improvements in converter operating life continued to be made. However, performance degradation with time remains a problem. Other thermionic research includes investigations of electrical insulator and metal ceramic joining alloys aimed at developing materials and weldments which will maintain satisfactory electrical and structural properties in a nuclear reactor at the high temperatures and for the long periods required. FY 1967 programs will be conducted to further improve diode performance and simplify diode design configurations.

During FY 1965, cold gas tests of radial-flow turbomachinery intended for use at low power levels achieved the high efficiencies that were predicted by design studies. Similar development and test programs on low power axial flow gas cycle turbomachinery are being conducted in FY 1966. The testing of "hot" gas bearing-supported radial and axial flow turbomachinery units will begin in FY 1966 and will be continued in FY 1967. Particular emphasis in this program continues to be on component efficiency and reliability.

The Jet Propulsion Laboratory (JPL) is continuing an analytical and experimental program on a liquid metal magnetohydrodynamic (MHD) conversion system. Basic feasibility of the direct current (DC) generator component of such a system was demonstrated with room temperature test components.

In FY 1967, JPL will investigate alternating current MHD generators. The AC units are theoretically more efficient than the direct current devices and will also reduce the power conditioning requirements to satisfy predicted electrical load requirements. Test programs will continue in FY 1967 which deal with methods of minimizing hydrodynamic losses in other system components such as mixers, two-phase nozzles, separators, diffusers, etc.

Electric Propulsion

The objective of this program is to provide the advanced technology leading to the development of electric thrustor systems for space propulsion. Such thrustor systems when used in conjunction with lightweight solar or nuclear power generation systems for prime propulsion, offer the potential of substantial increases in payload reductions in vehicle weight, or reductions in travel time generally in proportion to the energy requirements of the contemplated missions. Electric thrustor stationkeeping and attitude control systems offer a primary advantage of reduced system weight when compared with conventional chemical thrust systems for long duration applications. These performance improvements result from the high specific impulses developed by electric thrustors which convert electrical energy into kinetic energy of a propellant. However, a major requirement that must be attained for effective application is a capability for thousands of hours of reliable operation. In addition, attainment of high overall thrustor system efficiency is of major importance for prime propulsion applications 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 the propellant atoms (or heavy particles) are electrically charged and then accelerated by an electrostatic field, will continue to receive the major emphasis in FY 1967. Two types, the electron-bombardment and contact ion engines which differ basically in the propellant charging or ionization technique, have made the most progress. In the electron-bombardment thrustor the propellant atom is ionized by electron-collisions. The life of the cathode which produces the necessary electrons is the major factor controlling the life of the thrustor. The cathode life improvement program discussed last year has resulted in a successful 2600 hours test of a cesium thrustor. Further life tests with goals of 3500 and 8000 hours are being conducted in FY 1966. In FY 1967, emphasis will be placed on full system testing including thrustor, feed system and power conditioning. In addition, system interaction problems which become important as thrustor applications increase, such as ion beam impingment on spacecraft structures and radio-frequency interference will also be studied in FY 1967. Since studies of solar-powered mid-course propulsion for planetary missions show potential, these efforts will continue. In addition, scaling of thrustors to the 300 KW size required for future applications will be continued at the Lewis Research Center.

In the contact ion engine, propellant atoms are charged or ionized by coming in contact with a hot material, usually porous tungsten. In order to meet engine life requirements, over 99% of the propellant atoms must be ionized. Previous difficulties in achieving the required ionization at reasonable efficiencies and lifetimes led to a decision to deemphasize contact engine development and concentrate on the ionization problem in FY 1966.

However, techniques of coating porous tungsten with iridium and rhenium were evolved which, on a laboratory scale, show promise of permitting the desired ionization and life expectancy. The performance of these improved ionizers will be evaluated in FY 1967. Progress in thrustor technology has led to an important decision to flight test a small (~15) contact ion thrustor system on the initial Applications Technology Satellites (ATS) in anticipation of using similar systems on the later synchronous gravity-gradient stabilized ATS flights. This first NASA utilization represents an initial and important step in the transition of the status of electric propulsion from an advanced idea to useful applications. Thrust vector control through electrostatic ion beam deflection will be incorporated on similar engines in FY 1967 for evaluation.

A resistojet will also be considered for the ATS. This is one version of an electrothermal engine which accelerates propellant by heating and subsequently expanding the propellant through a conventional converging-diverging nozzle system. System studies have shown the resistojet to be of interest for cancelling aerodynamic drag of large spacecraft such as orbiting laboratories. Research in FY 1967 on this class of device will concentrate on establishing long life and in investigating utilization of waste material (i.e. excess water, etc.) from manned space station life support systems as the propellant. Efforts to evaluate the replacement of the resistojet's electric heater with radioisotope heat sources will also be carried out in FY 1967.

The electromagnetic thrustors, which employ magnetic forces in the development of thrust, offer the promise of superior performance and reduced complexity over the entire range of specific impulse and consequently will receive research emphasis in FY 1967. Efforts will in particular be made to verify the performance of the promising MPD arc jet. Preliminary data of 70% efficiency at a specific impulse of 4000 seconds has been reported. However, the inadequacy of ground facilities to simulate the true space environment causes an uncertainty in these data. A comprehensive effort will be conducted in FY 1967 to eliminate these uncertainties.

Solar Power Generation

Solar photovoltaic cells are relatively low in weight and have proven to be a practical and reliable source of spacecraft electric power at levels up to several hundred watts. However, the availability of the Saturn class of launch vehicles is making possible much larger spacecraft requiring substantially more onboard electric power. During the past year an in-house program was started at the Jet Propulsion Laboratory and the Marshall Space Flight Center, supported by contracted programs at the Boeing Company, the

Ryan Aeronautical Company, and Electro-Optical Systems on the research and technology problems related to very lightweight, kilowatt size solar cell arrays. The investigation of such key problem areas as more economical solar cell fabrication and assembly methods, array packaging and deployment and lightweight structures and folding and unfolding mechanisms will require an increased effort in FY 1967. Although improvements have been achieved, significant weight penalties can still be attributed to the need to protect solar cells from damage by the energetic particle radiation, micrometeoroid and high temperature environments to be encountered by spacecraft operating in space. A continuing effort is needed in these areas, as well as efforts to improve cell efficiency and reduce cell weight.

The output of the array is a direct current (DC) voltage which must be changed (inverted) to alternating current (AC), transformed to higher or lower voltages, regulated, filtered to suppress surges and distributed to the various spacecraft loads. It is essential for the higher power systems that the efficiency of the many electronic components and circuits used for these purposes be improved while maintaining satisfactory reliability.

New work on power transistors to lower saturation resistance and increase current and voltage capabilities is to be undertaken at the Electronics Research Center. Work on integrated circuits at the Marshall Space Flight Center and at the Jet Propulsion Laboratory will be continued with emphasis on higher power handling capability, larger area devices and improved interconnections.

The thermionic conversion of solar thermal energy appears particularly promising as a source of electric power for spacecraft operating near to the Sun. These systems make use of solar concentrators and high temperature thermionic generators which should be relatively unaffected by operation in the high temperature and particle radiation environment near the Sun. Work during the past year has resulted in improvements in thermionic diode operating lifetime, power density, and conversion efficiency. For example, one thermionic converter recently passed 10,000 hours operation and is continuing on test. This is significant in that it is the first such device to demonstrate the possibility of such operating lifetimes. Further improvements are needed in uniformity of converter characteristics and in efficiency and power density, and based on current experience appear possible with additional work. The output voltage per converter ranges between 0.6 and 0.8 volt for operation at 1730°C but by reducing the internal voltage losses could be increased to about 1.2 volts with resulting improvements in conversion efficiency. Further research is planned on the use of surface and plasma additives to reduce the internal losses.

Work is continuing on the Brayton cycle power conversion system technology program initiated in FY 1963, using solar and nuclear power program funds. The use of Brayton cycle conversion systems with solar power sources will minimize solar concentrator size due to the cycle's inherent high efficiency. In a like manner, the use of Brayton equipment with isotope power sources will minimize the amount of scarce and expensive isotope, e.g. Plutonium 238, required. Other significant advantages of importance to both solar and isotope power systems, such as reduced material compatibility problems, and no zero-g problems are derived from the fact that the Brayton cycle uses an inert gas, e.g. argon or neon as the working fluid. The first experimental turbomachinery and heat exchangers have been fabricated, delivered, and are under test at the Lewis Research Center. Cold flow tests have verified design performance. Hot flow tests have not yet been conducted.

Both of the above solar thermal systems (Brayton and thermionic) require focusing concentrators (mirrors) to develop the high temperatures required. The difficulties involved in fabricating large, lightweight mirrors (concentrators) possessing high surface contour accuracies require a continuing effort leading to full size mirrors of 20 to 30 feet diameter weighing less than one pound per square foot (1 lb/ft^2) and having an efficiency of greater than 85% with a concentration ability of over one thousand to one.

Chemical Power Generation

The fuel cell power systems now under development for Gemini and Apollo can be expected to satisfy the need for on-board space electric power for the two-week earth and lunar orbital missions for which they have been designed. With technology improvements the usefullness of these fuel cells can be extended to mission durations of 30 to 45 days. In addition, the first really long duration missions may make use of fuel cells for a total life of 90 days and longer. Thus, there exists a need to extend the present technology objectives from the 400 hour endurance characteristic of Gemini and Apollo to 1000, 2000, and eventually, 3000 hours while maintaining the high reliabilities required for manned missions. Of equal importance is the need to extend standby life, to improve on orbital start and restart capability, and to obtain lightweight, compact systems.

Work on the above problems is continuing using an Allis-Chalmers fuel cell as an experimental system. Experimental modules have been tested at the Manned Spacecraft Center. These breadboard units have been run for more than 1500 hours and have operated well under continuous as well as start-stop conditions.

A reliability test program is needed to obtain parametric design data for operating durations in excess of 3000 hours. Work to further improve efficiency and complete the technology for low-temperature, in-orbit startup is needed. In addition, there is a need to acquire the technology necessary to support the development of larger fuel cell modules in the 3 to 5 kilowatt size.

Primary and secondary (rechargeable) batteries are used for relatively short duration applications, i.e. 34 hour Gemini mission, or in conjunction with solar power systems when the spacecraft is periodically in the dark. To date, spacecraft batteries have been relatively low power devices, which will not be able to satisfy the fast recharge, high power and broad operating temperature range requirements of anticipated missions. Laboratory experiments and ground based system experience indicate that it should be possible to develop satisfactory units. However, such work is not being conducted as part of specific battery development programs in support of approved missions. Therefore, NASA has initiated a research and technology program aimed at improving energy density, cycle life, capacity retention and resistance to high temperature degradation. It is important that this program be strengthened in FY 1967 in order to meet the anticipated needs in the 1970's for larger batteries for orbital, lunar surface and planetary mission applications.

SNAP-8 Development

	1965	1966	1967
Development.......................	$19,150,000	$4,000,000	$5,500,000

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

SNAP-8 is a joint NASA-AEC project with the AEC responsible for the reactor and shield and NASA responsible for the power conversion system and full power system integration. It utilizes a boiling mercury turbogenerator to convert thermal power developed by a compact space reactor into electrical power. The design approach places priority on reliability and ease of development (maximum use of current state-of-the-art) and provides flexibility to adapt to a range of potential missions with a minimum change.

During calendar year 1965, NASA completed testing to determine performance data of the first generation of major power conversion system components -- the system pumps, heat exchange components, and the turbine alternator. The performance was demonstrated to be satisfactory except for the boiler which although performing as required once it reached full thermal power, has been giving erratic superheat performance during initial startup. A boiler re-designed to investigate solutions to this problem is now in test. Endurance development of the components has been started. Single unit endurance times demonstrated to date range from 670 to 2600 hours. As part of the endurance test program, a complete mercury loop was operated for 670 hours, producing electrical power within SNAP-8 specifications. This test was terminated by failure of the first turbine after 830 hours of operation, but mechanical design modifications have now been completed and turbine testing will be resumed shortly. The SNAP-8 reactor completed 12,000 hours of operation, 8,800 of which were at system power and temperature. The reactor is undergoing post-test examination.

During FY 1966, NASA will continue with component performance and endurance development testing and will complete preparations for the test of a first breadboarded power conversion system utilizing FY 1966 funds authorized and appropriated by the Congress.

During FY 1967, development testing of components will be continued and tests of the first power conversion system will be initiated. Supporting technology programs in heat transfer, materials, system dynamics and endurance instrumentation which were delayed by the phase-out operations will be initiated to provide the necessary basis for understanding system behavior and to improve performance as required.

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY — NUCLEAR ROCKETS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The mission of the nuclear rockets program is to provide the necessary research, design, and engineering data, test hardware, and general technology required to develop nuclear rocket systems with power levels, operating times, restart conditions, and specific impulse values suitable for advanced space exploration missions. A program directed to meet these objectives will assure availability of these advanced propulsion systems when they are needed.

Through the use of nuclear rocket propulsion, significant performance advantages accrue to many advanced space missions such as lunar base logistics operations, deep space probing with heavy complex spacecraft, and manned exploration of the planets. A number of studies have been conducted to evaluate the potential of the nuclear rocket in its major applications. For the manned Mars mission, the studies indicated that spacecraft departure weight in earth orbit is substantially less with nuclear rocket propulsion than with chemical propulsion, the weight differences ranging from 1 or 2 million pounds for favorable missions modes and times (low energy requirements) to many millions of pounds for less favorable mission opportunities.

The major areas of effort are the research and engineering of the nuclear reactor, the development of certain non-nuclear components, and the integration of the reactor and non-reactor components into a complete experimental engine system.

The experimental ground test engine system is being investigated to provide an essential understanding of the interaction of components in nuclear rocket engines and of the system performance characteristics. Progress in the technology phase warrants the initiation of specific engine development in FY 1967.

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 Scientic 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.

SUMMARY OF RESOURCES REQUIREMENTS:

	1965	1966	1967
Supporting research and technology	$20,891,000	$21,000,000	$16,900,000
NERVA	35,370,000	36,000,000	33,100,000
NRDS operations	739,000	1,000,000	3,000,000
Total	$57,000,000	$58,000,000	$53,000,000

Distribution of Program Amount by Installation:

	1965	1966	1967
Marshall Space Flight Center	$1,375,000	$1,125,000	$900,000
Jet Propulsion Laboratory	6,000	---	---
Lewis Research Center	9,846,000	6,599,000	3,550,000
Space Nuclear Propulsion Office	45,760,000	50,218,000	48,500,000
NASA Headquarters	13,000	58,000	50,000

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

	1965	1966	1967
Rocket reactor research	$13,069,000	$14,250,000	$11,700,000
Nuclear rocket engine systems	6,269,000	5,150,000	3,950,000
Safety	500,000	500,000	250,000
Vehicle technology	1,053,000	1,100,000	1,000,000
Total	$20,891,000	$21,000,000	$16,900,000

The supporting research and technology (SR&T) effort supplies four basic needs: (1) general supporting research and technological data for current projects; (2) necessary basic technology for the development of future generations of nuclear rocket engines and vehicles; (3) feasibility analyses of advanced nuclear propulsion concepts; and, (4) studies of the special safety problems of nuclear rockets.

Rocket Reactor Research

This activity supports work in two general areas: first in the area of advanced concepts and in the design studies of reactor concepts of interest for future applications; secondly, these funds provide for nozzle and propellant feed systems for use in the ground test of Phoebus 2.

Advanced concept work is concentrated on various types of cavity reactors, in which the fissionable materials are in gaseous, liquid or dust form. Primary in-house capability and research is centered at the Lewis Research Center. Additionally, the capabilities of industry and universities are applied through contracts and research grants. The emphasis is on laboratory research because propulsion systems and large scale experiments cannot yet be defined due to a lack of basic information on feasibility and, in some cases, a lack of basic research data.

NASA funds the development of a liquid hydrogen turbopump feed system to be used in the testing of high-power (Phoebus 2) reactors at the Nuclear Rocket Development Station. This system is based on the liquid hydrogen pumps and turbines developed for the KIWI test series.

Liquid hydrogen regeneratively cooled exhaust nozzles are also required for the Phoebus 2 reactor program conducted by the Los Alamos Scientific Laboratory. Development of such nozzles is underway in a contract let during FY 1965.

Nuclear Rocket Engine Systems

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

Turbomachinery research is directed at the unique problems posed by application to a nuclear rocket engine, and is coordinated with turbomachinery research conducted for advancement of chemical rocket technology.

Another important supporting effort in the nuclear rocket program is provided by the nuclear cold flow rocket engine systems tests conducted by Lewis in the Nuclear Rocket Dynamics and Control Facility. These tests have included the first bootstrap starts of the nuclear rocket engines, and start-up tests in which the turbopump was deliberately run into stall to determine the start-up performance of a nuclear rocket engine under such conditions.

Radiation effects work is conducted at Plum Brook as part of the engine component research work to define the behavior of materials in combined radiation, cryogenic, and vacuum environments. Such information supports all phases of the nuclear rocket program and is essential for the design effort.

The combined environments of radiation, vacuum, extreme temperatures and very high bearing speeds create difficult development problems in regard to bearings, seals and lubrication. An inpile bearing test loop is in operation for research on bearing configurations in a combined radiation and cryogenic environment.

Research continuing through FY 1967 will include work on nozzles for nuclear rocket engines. Analyses and research have been undertaken in areas of refractory metals and coatings, fluid mechanics and heat transfer, stress analysis and thermal fatigue.

In FY 1967 NASA will continue to support, although at a reduced level, the National Bureau of Standards Cryogenic Engineering Laboratory in research and engineering related to the use of liquid hydrogen. While this support has come from the nuclear rocket program, the research has benefited all programs that use liquid hydrogen (e.g., Centaur, Saturn, the J-2 engine, etc.) by supplying basic property data and cryogenic engineering support.

Propellants and pressurants in support of the research and development activities on turbopumps and nozzles for Phoebus reactor tests as well as the Phoebus reactor tests themselves are provided by SR&T funds.

Safety

Safety work is an integral part of the overall nuclear rocket program. It includes effort on hydrogen safety by the Bureau of Mines aimed at unique safety problems associated with handling large quantities of liquid hydrogen in the nuclear radiation environment. Also included is work on evaluation of countermeasure systems to assure safe disposal of nuclear engines and operational safety analyses of nuclear rocket engines.

Vehicle Technology

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

Modular vehicle concepts in which each module includes a nuclear rocket engine and propellant tank has particular attraction since our basic tank/engine design conceivably could satisfy a variety of missions from lunar to planetary stop-over, merely by clustering as necessary the requisite number of essentially identical modules. The modular studies initiated in FY 1965 have defined a configuration in sufficient detail to point out areas requiring advanced technology effort.

In FY 1966 the feasibility of designing and constructing a reasonably close ground test version of a modular tank, which could be used for advanced technology development by means of cold-flow testing is being investigated in depth.

Examples of problem areas requiring advanced technology development include long term storage of liquid hydrogen in space for periods exceeding a half a year, and structural design of tanks for applications requiring assembly into clusters, while in Earth orbit. Investigations in these areas are coordinated with and complement other elements engaged in space vehicle research. In addition, nuclear rocket engine-vehicle interactions, and coupling requirements are also important and will receive continued attention.

NERVA

	1965	1966	1967
Engine systems development........	$5,426,000	$5,600,000	$6,000,000
Component and subsystem development.........................	12,444,000	11,800,000	9,600,000
Ground test and operations support........................	14,572,000	15,100,000	15,000,000
Propellants......................	2,928,000	3,500,000	2,500,000
Total.........................	$35,370,000	$36,000,000	$33,100,000

The objective of the NERVA technology effort is to develop the technology of nuclear rocket engine systems utilizing graphite solid-core reactors. Progress in the graphite reactor program has been very good. The NERVA technology work is conducted principally under a joint AEC-NASA contract by the Aerojet-General Corporation and Westinghouse Electric Corporation. Altitude equivalent performance levels in excess of 750 seconds specific impulse at 55,000 pounds of thrust have been achieved for extended durations.

In view of the reactor progress, increased emphasis is being devoted to the engine system phase. This effort includes the development of critical non-nuclear components, such as the nozzle, turbopump and control system, and the integration of these components with the reactor into meaningful nuclear rocket engine systems tests. It is important to gain a thorough understanding of the interactions of the various components during start-up, full power operation, operation at off-design conditions, and during cool-down periods. With this knowledge we can develop components and systems leading to the development of operational flight engine systems with a high assurance of success.

Engine system work includes investigations of engine system transient start-up 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 are being developed in connection with the engine systems evaluation program, but component development is limited to those major components which strongly influence system performance. Valves and lines are 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 adaptable to "flight" operating conditions.

Significant accomplishments to date in the KIWI and NERVA projects include: reactor start-up and stable operation using liquid hydrogen as a coolant; demonstration of a satisfactory reactor design that avoids the flow-induced vibration previously encountered; successful operation of a single reactor for 16.5 minutes at design conditions; restarting a reactor and achieving design power after a prior run at design power; automatic start-up 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; completion of studies confirming the ability to cluster engines; and the conduct of a Transient-Nuclear-Test with favorable results. Other progress includes improvement in fuel element quality, and advances in nozzle and turbopump technology.

The program calls for the initiation of the NERVA engine development phase in FY 1967. It has been determined that an engine designed for a power level of 4,000 to 5,000 thermal megawatts giving a thrust of about 200,000 to 250,000 pounds could efficiently perform all these missions in which nuclear rockets offer significant advantages. Such an engine system will be based upon the high-power Phoebus 2 reactors technology being developed by the AEC's Los Alamos Scientific Laboratory.

The preceding discussion of NERVA has presented the project from an overall, integrated point of view. The following paragraphs discuss the project from a different viewpoint, that of its major areas of work effort and fund allocation.

Engine Systems Development

The objective of this phase of the NERVA project is to perform the engineering, fabrication, and testing of experimental engine systems. The program includes cold flow tests conducted in a non-nuclear engine simulator as well as hot flow tests conducted with operating reactors. Characteristics evaluated in the cold flow simulator tests include the initial portion of engine start-up with liquid hydrogen, flow stability, flow leakage, system pressure losses, and control response times. During FY 1967, the Cold Flow Development Test System (CFDTS) will be modified to the ground experimental engine (XE) cold flow configuration. The preliminary design and systems analysis of the 200,000 to 250,000 thrust engine will be continued in FY 1967. In addition, effort will be spent on studying concepts for remote removal and installation of the engine from and into the test stand and for remote disassembly and reassembly of components about the engine external shield.

Component and Subsystem Development

Development of components and subsystems include those required for the experimental engine systems and some required for the conduct of reactor experiments. Principal objectives are the development of the liquid hydrogen turbopumps, thrust chamber assembly, and engine controls. During FY 1967, final assembly and shipment of XE-1 components will be accomplished and fabrication and acceptance testing of the thrust chamber assembly of the second experimental engine (XE-2) will be completed. A pressure vessel and a thrust chamber assembly will be fabricated for the engine and the experimental reactor program. In addition, a chamber gas temperature probe will be fabricated and submitted for testing.

Ground Test and Operations Support

Overall, this phase of the project provides remote handling equipment, checkout and test equipment, and maintenance equipment for all test operations, including special test equipment for components associated with the large engine. It also provides certain instrumentation for diagnostic and control purposes, for reliability and quality assurance testing, and for operational safety monitoring. During FY 1967, the design criteria and the design and fabrication of the required transport, handling, hot disassembly and post-operative equipments for the experimental engines will be completed.

The operation and maintenance instructions and acceptance test specification for the experimental engine cold flow support equipment will be formulated. In addition, design and procurement of storage equipment for the various engine and reactor test articles will have been completed during FY 1967. Safety evaluation reports for the experimental engines (XE-1 and XE-2) will be issued and the program comprehensive safety evaluations and reviews and operational safety at the testing station will be continued.

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

	1965	1966	1967
General site support.............	$739,000	$1,000,000	$3,000,000

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.

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. Technical support is not included under this category but is funded from the appropriate project category such as NERVA.

NASA's share of the NRDS Operations costs will increase by an amount of $2,000,000 in FY 1967 over FY 1966. The major reason for this increase is the additional maintenance support required for E-MAD and ETS-1 facilities which will become operational in early 1967. Another element contributing to the increase is the raised level of housekeeping support associated with experimental engine systems testing at NRDS which will be initiated in FY 1967. The first test will be an XE cold flow test scheduled for November 1966 followed by the first XE-1 power test in the summer of 1967.

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 maintaining and operating support facilities and equipment.

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY — CHEMICAL PROPULSION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objective of the chemical propulsion program is to provide a sound base of technology on which to develop propulsion equipment for the National space program missions. This base must cover research examination of fundamental concepts, of engineering data, design, fabrication, and experimental testing to prove that the basic technologies can be integrated to create practical propulsion machinery. In addition, the program supports current mission developments by examining special problems of a research nature.

Chemical propulsion systems are the mainstay of the transportation needs of the space program, notwithstanding the special advantages of nuclear and electrical propulsion. Among their applications are boosters, upper stages and thrust augmentors for launch vehicles, escape stages, lunar and planetary landing modules, and in-orbit maneuver, mid-course correction, attitude control, rendezvous, de-orbit and propellant settling systems for spacecraft. Chemical propulsion is also being applied to personal mobility devices, and future lunar and planetary exploration vehicles. In addition, chemical propellants are used for a variety of auxiliary devices such as ignitors, and stage separation systems. These applications represent a tremendous range of thrust levels, operating times, start and restart conditions, and propellant handling problems. Furthermore, the continued exploration of space will require increased capacity and versatility of these propulsion systems. The program of advanced research and technology to cover this array of applications and operating conditions must strike a balance between these complex requirements and the difficulties of finding practical and reliable solutions and must be managed with perception and perspective with regard to the schedule of potential needs. Such a balanced program will assure continued advancement of the propulsion capabilities of the nation's space program.

The work in chemical propulsion covers both liquid and solid propellant systems, and in fact combinations of the two types, called hybrids. Very advanced engine systems which use atmospheric air during flight through the sensible atmosphere are being examined. The content of the program includes not only the propulsion-oriented basic scientific and disciplinary technologies but in addition brings strong focus on the problems of design methods, fabrication and test procedures, practical operating limitations, and so forth, through tests of quasi-prototype hardware systems. From this work is gained an extremely valuable insight into developmental pitfalls and funding and facility requirements of any new system contemplated. This attempt to bridge the gap between academic research and technology investigations and development is an important and valuable aspect of the chemical propulsion program.

NASA field centers have a profound capability in chemical propulsion with high effectivity in covering the vast array of propulsion component and system types. This work is carried out both in-house by highly talented specialists using unique NASA facilities and by contract with industrial and academic organizations. Such contracts are managed closely by NASA specialists who are well versed in propulsion technology.

The requested funding of the chemical propulsion program in OART has been increased in FY 1967 in anticipation of meeting new requirements for extended orbital and lunar operations, planetary observation and landing missions. This program, which provides the roadbed for NASA space ventures, needs now to lay the groundwork for a new generation of high performance systems that will permit the accomplishment of more ambitious missions with reduction in cost of orbital, lunar and planetary space operations.

SUMMARY OF RESOURCES REQUIREMENTS:

	1965	1966	1967
Supporting research and technology	$24,762,000	$33,500,000	$33,500,000
M-1 engine project	24,910,000	2,000,000	---
Large solid motor project	26,800,000	4,200,000	3,500,000
Small chemical propulsion flight projects	30,000	---	---
Total	$76,502,000	$39,700,000	$37,000,000

Distribution of Program Amount by Installation:

	1965	1966	1967
John F. Kennedy Space Center, NASA	---	$250,000	$250,000
Manned Spacecraft Center	---	500,000	500,000
Marshall Space Flight Center	3,721,000	4,800,000	5,500,000
Goddard Space Flight Center	550,000	550,000	550,000
Jet Propulsion Laboratory	3,858,000	3,707,000	3,700,000
Ames Research Center	---	540,000	500,000
Langley Research Center	1,369,000	2,877,000	2,900,000
Lewis Research Center	49,588,352	15,205,000	12,800,000
NASA Headquarters	11,972,422	11,271,000	9,300,000
Western Operations Office	5,443,226	---	---

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

	1965	1966	1967
Liquid Rocket Research and Advanced Technology...........	$11,500,000	$12,720,000	$12,700,000
Liquid Rocket Experimental Engineering..................	6,075,000	12,235,000	12,250,000
Solid Rocket Research and Advanced Technology...........	4,995,000	5,045,000	5,050,000
Solid Rocket Experimental Engineering..................	2,192,000	3,500,000	3,500,000
Total........................	$24,762,000	$33,500,000	$33,500,000

Liquid Rocket Research and Advanced Technology

This area of broadly based research-technology is applicable to all chemical propulsion and is therefore of major significance in the program. It encompasses studies of future requirements, conceptual work on engine cycles and systems to meet these requirements, examination of combustion processes and instabilities, investigation of disciplinary engineering areas such as pump design and related hydrodynamic behavior, examination of new materials and methods of fabrication, development of new instrumentation or testing techniques, compilation of engineering information for design, data tables, etc. This work, covered by nearly 200 tasks, provides the technological base needed for design and fabrication of new chemical propulsion systems.

Component and materials investigations include valves, seals, connectors, refractory materials, fibers, and resins. New oxidizers and fuels in gelled and in slush form are being characterized. A screening and development program has been under way for catalysts to use in liquid hydrogen-liquid oxygen engines as the primary method of ignition. The initial results have led to consideration for J-2 engines.

The alloys of pyrolytic graphite utilizing zirconium and hafnium are being manufactured by new processes which are the result of exploratory work supported by this office. Prior manufacturing processes were not rigorous enough nor could they be controlled to the degree needed for making the alloy form. Further, alloys of hafnium/tantalum have been manufactured under sponsorship of NASA by the Illinois Institute of Technology Research. These materials are the forerunners of a new class of metal alloys which will be applicable in the high temperature environment. The breadth of use can be from aircraft turbo-machines to higher temperature rocket engines to the external structure of hypersonic aircraft. The basic metallurgical technology is thereby adding to the industrial capability of the nation.

Combustion instability has been a continuous problem of the liquid rocket. Part of the problem has been in relating the theoretical parameters to designs of hardware. This impasse is being attacked by a concentrated and continuing effort. Engine dynamics, instability and propellant pumping also are being investigated. The realm of work is broad-based, incorporating basic work in fluid mechanics and aerothermochemistry, materials, and design technology.

The potential of thrust vector control, using the fluid amplifier, is being assessed for large engines. The system utilizes hot gas bled from the combustion chamber and injected into the exit nozzle to create shock patterns, thus applying a side thrust to the vehicle.

A typical supporting research problem is that of leakage detection. The purpose of work on this problem is to establish and document all modern methods and new laboratory methods into a standard. This standard will utilize correct technical language, leakage units, and operating procedures applicable to the field. This Leakage Detection Manual will be distributed throughout NASA, the Department of Defense, and the aerospace industry. The basic method, although the manual is not yet complete, is presently being used in the Surveyor program.

Liquid Rocket Experimental Engineering

The liquid rocket experimental engineering program is divided into three major categories: launch vehicle systems, space propulsion systems, and auxiliary propulsion systems.

Launch Vehicle Systems - Advanced engine concepts which offer greater performance capability than typical current engines have been under investigation at low funding levels in the broad-based chemical propulsion research technology program. Two major concepts have emerged. The first concept involves combustion at high pressures. This allows greater expansion in a conventional nozzle within a limited envelope. The second concept uses a so-called plug nozzle, again providing greater expansion within a limited volume but at lower combustion pressures. Although these concepts represent rather different technical approaches, either has the prospect of significant increases in performance capability when compared to current engines.

The diverse technologies of each concept will be explored with scale model hardware. Testing of various components such as pumps, injectors, combustion chambers and nozzles and the assembly of these components for a breadboard engine test will demonstrate the concepts under study to provide design information for advanced engine developments of the 1970's. The scale of these breadboard demonstrations will be such that the hardware concepts may also be employed to uprate Saturn vehicles. Modular concepts are under study which would allow use of a building block approach for application of a common module to several vehicle sizes with considerable reduction in development cost.

This activity supersedes and benefits from the M-1 engine project. As it became evident that post-Saturn vehicles would not be required until later than had been anticipated when the M-1 was initiated, the M-1 program was first rescheduled at a reduced funding level. The project is now being terminated in favor of the technological investigations of higher performing advanced oxygen-hydrogen engines for the large launch vehicles. Before termination of the M-1 engine program operational tests of large scale engine components, including the oxygen-hydrogen turbopump assemblies and the full scale combustion chamber, will provide scaling correlation factors that will apply to the development of large advanced engines of the future.

Experimental engineering work to be conducted in the next few years will begin with expansion of the effort now underway in high pressure pumping. Design studies for this fiscal year will define other components so that work on high pressure and toroidal or annular combustion devices, aerodynamically augmented plug nozzles, thrust vector control, etc., may be initiated. By the turn of the decade, a sound basis is expected for specifying a new generation of high performance engine systems.

Space Propulsion Systems - Solar probes, delivery of satellite spacecraft to earth orbit, and planetary orbiting and landing missions impose unique requirements on the propulsion system designed to perform these missions. Some of these are long-term missions requiring six months or more for a one-way trip. Most require very high energy release. Further, the acceleration that must be imparted to a space payload places a premium on the performance of the spacecraft system itself. Obviously, it is desirable to invest as little weight in propulsion systems as possible in order to maximize the real payload. The propellant performance aspects include not only high thrust per unit mass burning rate of propellants but also spontaneous ignitability, and for landing maneuvers, throttling capability.

The high energy deep-cryogenic fluorine-hydrogen propellant combination is attractive for upper stage vehicles where storage time requirements are not extensive. Work with these propellants is continuing with RL10 engines toward demonstrating the performance capabilities of a pump-fed engine configuration. Significant performance improvements are being measured in the current test program following modifications of flight weight engine components originally designed for oxygen-hydrogen service.

Attention is also being given the fluorine propellant feed system area through a program recently initiated to provide engineering criteria for the design, fabrication, inspection and servicing of fluorine feed system components such as flow lines, control valves and regulating equipment. Such system criteria will serve as a model for criteria applying to other fluorine containing oxidizers. For extended-time-in-space missions such as the planetary missions, extended Earth-orbit missions, lunar extended-stay-time missions, and planetary missions, there is a requirement for propulsion systems of low weight using high performing propellants that can be stored in the space environment for extended time with minimum evaporative loss. To enhance space storability, it is desirable to use oxidizer and fuel propellants with a common liquid range at temperatures where heat gains or losses are minimal.

High propellant bulk density is desirable to reduce the surface of tanks exposed to radiation and to meteoroid impact and to minimize the insulation required. The class of propellants that most nearly satisfies the requirements includes oxygen-difluoride (OF_2) or mixtures of oxygen and fluorine (FLOX) as oxidizers; high performance fuels with similar liquid ranges include liquified petroleum gases (LPG) and diborane (B_2H_6). While these propellants exhibit lower specific impulse than combinations such as O_2H_2 or F_2-H_2, the much higher bulk densities (liquid hydrogen has a density about 7% that of water) and overlapping liquid ranges are advantageous.

The space storable class of propellants involves very energetic oxidizers which burn at exhaust temperatures between 7000 and 8000^{o}F, significantly higher than propellants currently in use. This fact poses a serious technical problem since cooling at such exhaust temperatures is difficult, particularly for the relatively small propulsion systems visualized for long-term missions in the next decade. There are a number of technical problems to be solved. Cooling techniques and materials of construction will be developed that will contain these high temperature combustion products. An OF_2-MMH program has been initiated to investigate the general cooling problem represented by this class of propellants. Problems of using oxygen difluoride in combination with liquified petroleum gases in a pressure-fed proplusion system application are being identified. A program to demonstrate the capabilities of a pump-fed engine utilizing these space storable propellants will be pursued in FY 1967. These programs will provide vehicle designers with information needed to assess realistically the potential capabilities of propulsion systems of this type and to lay the engineering foundation needed to promote orderly development in the future.

The majority of spacecraft systems currently under development use earth storable propellants, i.e. those normally liquid on earth. Less complex equipment associated with these systems would enhance mission reliability and result in significant weight savings, which translate directly to increased payload. Part of the space propulsion effort is directed towards this purpose. It is anticipated that many of the hardware design improvements will also be applicable to those systems employing more advanced propellant combinations.

Auxiliary Propulsion Systems - These systems embrace three categories of liquid propellants: monopropellants, earth storables, and cryogenics. In the monopropellant area research with a spontaneous catalyst is being put into practice with specifications for catalyst production, hydrazine rocket engine design, test program of flight type hardware, and a design handbook for engine development. Earth storable work includes continuation of engine designs for greatly extended life capability over the engines now in spacecraft use.

In FY 1966 a project was initiated to demonstrate techniques for using boil-off or direct propellant supply from tankage of advanced oxygen-hydrogen stages to provide auxiliary propulsion requirements. In FY 1967 breadboard hardware will be built and tested to demonstrate the expected higher performance and better system capability.

Solid Rocket Research and Advanced Technology

By virtue of reliable performance, intrinsic simplicity, compactness, ease of handling, ruggedness and early availability, the use of current and advanced state-of-the-art solid propellant motors for space flight propulsion can provide booster and spacecraft operations at reduced cost. Exploiting the unique advantages of solid-propellant motors will enhance the early and econcmic accomplishment of NASA space missions.

The Solid Propulsion Technology program is designed to provide the technology base for producing flexible and reliable solid and hybrid propulsion of high performance. Such an objective, of course, must be supported by competency maintained on a long range basis, particularly in the fundamental areas. Program flexibility is provided to allow pursuit of promising new concepts as they appear.

High performance solid propellants are now becoming operationally available. Such propellants are characterized by high flame temperatures, complex combustion, and in some cases, poorly defined physical and chemical properties. Efforts are being made to better understand the fundamental problems and to define the kinetics of decomposition, chemical erosivity, instability characteristics, propellant and metal combustion processes, two-phase flow behavior, sensitivity, processing characteristics, and others. In addition, there are a number of pressing technical requirements, for example: command stop, start, and thrust variation in solid propellant space motors which will receive research emphasis. Examination will be made of techniques for nondestructive testing to assure structural integrity of the propellant itself in the large rocket motors projected for the future. Further supporting research and technology to the Large Solid Motor Project will be required.

Hybrid systems offer advantages for certain missions. Problems in the application of hybrid propellant systems must be resolved before these systems can receive consideration for use.

Solid Rocket Experimental Engineering

This activity covers motors in three categories: launch vehicle, spacecraft, and auxiliary.

Launch Vehicle Motors - Launch vehicle motors are characterized by high thrust, long burning time, and large size. Diameters may be greater than 20 feet, and lengths may exceed 100 feet. Thrust levels for this class of motor are in the multimillion-pound region; burn times are generally two minutes or longer. This class of motor finds application primarily as first stage boosters of launch vehicles. The great weight and cost of these vehicles call for the most reliable propellants and materials. The major test work on 260" diameter, high-thrust motors is supported under the Large Solid Motor Project, but three important related programs are pursued under the experimental motor program.

The first is to devise instruments and systems for warning of potential failure in solid propulsion systems used for manned vehicles; instrumentation for interpreting the warning signals; and methods for terminating or reducing thrust, so that, if necessary, a safe escape could be made by astronauts. In prior years, a burn-through detection method was invented, and quench of combustion was demonstrated in a medium size motor. In FY 1967, the program will reach the point of system engineering for integration into the motor processing and checkout complex, and this system will be tested in realistic sub-scale motors, possibly of 120" diameter.

Second, a basic requirement for showing feasibility of the high-thrust motors is demonstration of vector control (steering systems). Initially, the program to do this establishes the design of prototype systems, including components such as hydraulic actuators and power supplies, so that a quantitative evaluation of competing systems can be made. This has been done for the secondary liquid injection system and is in process for an advanced flexible nozzle concept. Work will be done on those systems or components which are most attractive on the basis of reliability and cost effectiveness, by demonstration in motor tests in the size range of 15-25 inch diameter nozzles.

Third, methods for recovery and re-use of large motors are under investigation with the objectives of establishing designs and materials for nozzles, insulation and motor cases, so that multiple use can be made of each, and for establishing techniques for recovering, refurbishing and re-qualifying the major components of large solid propellant motors. The justification for the effort grows from the large unit cost of the components of large motors. Anaylsis indicates that more than 60% of the cost of large solid systems is represented by non-expended components, potentially re-usable. Recovery will be facilitated by the sturdy structures of large solid motors; metal thickness ranges from 3/4" to 2½"; ablative materials are 2" to 3" thick.

The work in prior fiscal years has concentrated on analysis, small motor testing, and dynamic modeling of water impact stresses. In fiscal year 1967, effort will involve test operation of cold-flow and hot-flow laboratory models; water impact testing of model motors, and assessment of the effects of water exposure on nozzle, case and insulation materials.

Sounding rockets are another class of launch vehicle motors for which appreciable improvement can result from technology investigations. Effort in FY 1967 will start work on motors incorporating new propellants and advanced structures. The designs will be governed by the goals of low cost, high reliability, and simplicity of use, rather than high specific impulse or high mass fraction. Two different classes of motor will be investigated, one for small meteorological sounding rockets, one for higher probe missions.

Spacecraft Motors - Solid motors for spacecraft application are generally of intermediate thrust, weight, and dimensions. In general, they are characterized by sophisticated designs and will make use of new high energy propellants. These motors are used primarily in the upper stages of small launch vehicles, or for deep-space, volume-limited missions. They are storable in space over extended periods of time, and require few subsystems or auxiliary components to be developed.

The high performance system engineering program is investigating prototype motors with new high energy propellants and novel structural concepts. System definition studies of the most desirable concepts were completed in prior years and the process of motor manufacture and test will begin in FY 1967. This will also require the manufacture of relatively large amounts of new propellants. The test program will determine the effects of ignition at simulated altitude, the effects of space environment, and burning characteristics under spinning condition, in addition to the usual tests of propellant and structure.

Variable motors offer potential in special missions such as spacecraft landing, orbit injection or payload attitude control and maneuvering. They are characterized by greater mechanical complexity than the non-variable solid rocket motor, and as a result, they require appreciable development of structures and control.

The major effort on controllable motors is a program on hybrid propulsion engineering (a hybrid motor uses a liquid oxidizer and a solid fuel).

In Fiscal Year 1967, the engineering, fabrication and test program will continue with demonstrations of injector designs and material, nozzle and motor case design; solid propellant processing methods and quality control, and combustion dynamics and efficiency under start and stop transients.

Auxiliary Motors - The auxiliary motor class is represented by retro, ullage and emergency escape motors, whose primary requirement is a high degree of reliability and safety. This class of motors is well established in NASA programs, fulfilling a requirement that cannot be efficiently met by liquid propellant rockets.

System studies of advanced concepts have been made to define the materials, designs and operational characteristics which have potential for major gains in reliability, performance, and cost effectiveness. Motor test programs started in FY 1966 will continue in FY 1967. The primary costs will be for manufacture and test of motors which may contain a few hundred pounds of propellant (retro and ullage motors), to a few thousand pounds of propellant (escape motors). Novel concepts of reinforcement to obtain high strength in thin-wall grains may be introduced. Reliability will be established through test firing under all environmental extremes. Finally, the program will attempt to establish a relatively few designs which can be used for many vehicles and missions.

Large Solid Motor Project

	1965	1966	1967
Large solid motor project......	$26,800,000	$4,200,000	$3,500,000

The objective of the large solid motor project is to establish the practicality of very large solid propellant rocket motors by demonstrating technology and manufacturing methods and by providing estimates of their cost and reliability.

This project was initiated in June, 1963, when, with NASA coordination, the Air Force let contracts to fabricate and test 260" diameter solid motors.

Acting on a DOD request, the NASA agreed to fund the program in FY 1965, and in March of 1965 assumed complete responsibility for the program.

In February, 1965, the first major test under the program was successfully carried out. A 156" diameter subscale motor delivered over three million pounds of thrust and burned for about one minute. The next test was the static firing of the first 260" diameter motor in September, 1965. The test was successful in all respects. The average thrust was over 3,000,000 pounds and a peak of more than 3,500,000 pounds was attained.

In FY 1965 NASA allocated $13.0 million to continue the contracts originally funded by DOD. The President's FY 1966 Budget did not provide funds to complete the contracted effort. After careful analysis of the possible alternatives, it was decided that maximum benefit to the government would result from completion of the technical effort, and in March of 1965, the NASA reprogrammed $13.8 million of FY 1965 funds for this purpose. Congressional action on the FY 1966 budget included the addition of a $6.2 million authorization for the continuation of large motor work beyond the program then current.

The next objective of the program will be to investigate and test additional motor features which will be necessary for vehicle stage applications. Of particular importance are the establishment of an efficient and reliable thrust vector control system and development of failure warning and combustion termination systems. Subscale tests with 156" diameter motors will be made prior to integration of such advanced components into 260" motor firings.

The ultimate objective of this program will be the fabrication and test firing of 260" motors generating a thrust level of about 7,000,000 pounds for two minutes, complete with all the basic design features necessary for vehicle application. This would allow subsequent initiation of a motor development program for any appropriate NASA vehicle program with high confidence in its design, fabrication procedures, performance capability, and cost.

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY — AERONAUTICS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION

The primary role of the Aeronautics program is to improve the efficiency, utility, and safety of aircraft. General objectives are:

1. To provide leadership in the generation of advanced aircraft concepts.
2. To seek technological advances needed to develop superior aircraft.
3. To supply industry with advanced data for the design of new aircraft.

The scope of the NASA aeronautical research program includes work in aerodynamics, structures, materials, air breathing propulsion, operational aspects, including safety and noise, and pilot and aircraft integration. Studies in these areas point to the most profitable paths for 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 all appeared several years ago as NASA research concepts having great promise. 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 1967 will include studies directed toward improvement of subsonic aircraft; 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; 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 testpilot proficiency aircraft considered necessary to carry out and support the aeronautics effort are included under this program.

SUMMARY OF RESOURCES REQUIREMENTS:

	1965	1966	1967
Supporting research and technology	$ 8,163,000	$10,261,000	$ 9,000,000
X-15 research aircraft	1,425,000	883,000	900,000
Supersonic transport	19,953,000	14,056,000	14,100,000
V/STOL aircraft	2,987,000	2,000,000	5,000,000
Hypersonic ramjet experiment...	2,712,000	5,000,000	2,000,000
XB-70 flight research program..	---	9,296,000	2,000,000
Total	$35,240,000	$41,496,000	$33,000,000

Distribution of Program Amount by Installation:

	1965	1966	1967
Ames Research Center	$ 6,167,000	$ 4,197,000	$ 5,400,000
Electronics Research Center..	---	190,000	150,000
Flight Research Center........	3,022,000	11,681,000	4,975,000
Langley Research Center......	9,052,000	11,935,000	8,625,000
Lewis Research Center........	13,859,000	12,377,000	12,625,000
NASA Headquarters	3,140,000	1,116,000	1,225,000

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

	1965	1966	1967
Aircraft aerodynamics..........	$ 1,307,000	$ 2,277,000	$ 1,600,000
Aircraft loads and structures..	2,021,000	2,000,000	1,500,000
Air breathing propulsion.......	2,027,000	2,250,000	3,000,000
Aircraft operating problems....	2,808,000	3,734,000	2,900,000
Total	$ 8,163,000	$10,261,000	$ 9,000,000

Aircraft Aerodynamics

Research on the aerodynamics of aircraft is a continuing program toward improvement of flight in the atmosphere. Generally, the problems are those of maximizing aerodynamic efficiency, achieving satisfactory levels of aerodynamic stability, and insuring adequate aerodynamic control over wider ranges of operating conditions.

For subsonic aircraft, further improvements in cruise performance, i.e., improvement in transonic drag rise characteristics, and reduction of boundary layer losses, of second-generation jet transports and new V/STOL types will be sought. Investigation of the stability and control for these types of aircraft will be continued.

For supersonic aircraft, aerodynamic research on transport configurations will be continued to improve the technology to extend the operating range of efficient supersonic vehicles and to improve sonic boom characteristics. Basic studies of configuration improvements and boundary layer phenomena at supersonic speeds will be conducted. A basic investigation of the stability and control of maneuverable missiles will be continued.

The difficulty of the aerodynamic problems of flight increases greatly at hypersonic speeds and altitudes, and increased research effort will be directed to the aerodynamics of aircraft shapes at Mach numbers above 4 or 5. This research is necessary to provide basic information for conceptual studies and performance predictions of future hypersonic cruise vehicles and recoverable reusable boosters. It will consist of investigation of flow fields, boundary layer development, skin friction, and heat transfer for winged configurations that include such practical features as air inlets and stabilizing surfaces. The dynamic stability and control requirements of hypersonic aircraft concepts will also be investigated.

The take-off and landing characteristics of advanced supersonic and promising hypersonic aircraft configurations will be assessed in large-scale wind tunnels. The trim, speed stability, and lateral-directional characteristics of various classes of aircraft with powered-lift systems for STOL operation will be further explored and design criteria for control systems in this mode of operation will be better established.

The funds requested are for contract studies, materials, models, and special instrumentation utilized in the in-house research. They include provision for wind tunnel support of projected NASA flight research programs, Department of Defense development of advanced aircraft and missiles systems, and aircraft related projects of other agencies of the government such as the Federal Aviation Agency

Aircraft Loads and Structures

A high degree of reliability and integrity is demanded of the airplane structure by the operators and users which include the military services and traveling public. Limitations of weight preclude the attainment of this reliability except to a limited degree by duplication of structural elements or by designing to low working stresses. The over-all objective of structures research is to achieve these dual and conflicting requirements of high efficiency with great integrity.

An accurate knowledge of the loads imposed on the structures is of course required for the attainment of these requirements. The important load sources are atmospheric turbulence, airplane maneuvers, landing and take-off and cabin pressurization. A research effort is being maintained to update and improve the definition of the structural loads in keeping with introduction of more advanced aircraft and changes in types of operation. The heating cycles associated with supersonic flight introduce further complexities in that this heating produces stresses in the structure which add to or subtract from the stresses due to loads and, therefore, must be accounted for in design. Current and planned research includes analytical studies aimed at development of procedures for inclusion of thermal stresses in structural design and experimental evaluation of thermal effects using the X-15 research airplane and the XB-70.

An improvement in structural efficiency can be obtained, particularly for high strength materials, by the use of sandwich type structures in which the conventional sheet and stringer is replaced by two thin sheets on each side of a low density core. The attachment of the face sheets to the core by welding or gluing has presented serious manufacturing and cost problems. As a result of the development of improved plastics in recent years a particularly promising structural concept is the use of glass fiber fabric or metal sandwich in which these newer plastics are used as the bonding agent. Research is being undertaken to evaluate these new materials in structural concepts under realistic environments.

Exploratory research will continue on promising structural concepts which may have merit for use in a hydrogen fueled hypersonic airplane. Formidable structural problems are involved in such an aircraft as a consequence of aerodynamic heating. The current experimental and analytical research represents an initial effort of a relatively long range program which will ultimately serve as the basis for an efficient and reliable long range hypersonic airplane.

Air Breathing Propulsion

Research in this program is directed toward increasing the performance of current and future aircraft through improvement in airbreathing engine components such as inlets, compressors, combustors, turbines, nozzles and materials to provide higher ratios of thrust-to-engine-weight, higher ratios of thrust-to-engine-volume, and lower specific fuel consumption. The research effort in this area also includes research on engine controls, lubricants and fuels and the interaction effects of the propulsion system components on one another and of the propulsion system on the aircraft.

Research on subsonic vehicle concepts including V/STOL aircraft is being continued. Studies of the interaction of internal and external flows on the thrust and drag of various inlet and afterbody nozzle combinations will continue. One phase of this program is related to the increased net thrust obtainable with properly designed and positioned afterbody fairings. Basic studies emphasizing research leading to engines having high ratios of thrust-to-weight and thrust-to-volume for V/STOL application is planned. The V/STOL propulsion work is funded under the V/STOL project although the results are generally applicable to other subsonic vehicles.

The supersonic propulsion system effort is directed toward the better understanding of the operation of supersonic inlets, inlet distortion, and compressor stall, and includes basic research studies of boundary-shock interaction in regions of adverse pressure gradients as well as in the transonic throat region. Much of the propulsion research results in the supersonic speed regime are directed to the supersonic transport since this vehicle requires a technically advanced propulsion system in terms of efficiency in performance and weight as well as high reliability and long life. The work directed to the problems of the supersonic transport, although just as applicable to military vehicles, is described and funded under the Supersonic Transport project. A substantial effort can also be anticipated to aid the military services in the wind tunnel support of specific advanced aircraft and missile propulsion systems.

The effort devoted to hypersonic propulsion systems contains inlet research to determine the fundamental effects of such parameters as wall cooling, leading edge blunting, and fuel injection on the system performance. Since the supersonic combustion ramjet engine offers considerable promise at speeds above Mach 7, basic studies will be conducted to improve the understanding of supersonic mixing and diffusion, ignition delay and combustion, and dissociation and recombination. The work described under the Hypersonic Ramjet Experiment project will provide research information from a complete ramjet system as part of this over-all program. Adequate facilities are not now available for propulsion research, therefore, development will be undertaken of a new facility which will permit much needed propulsion research to be conducted.

Aircraft Operating Problems

Research in this area is directed toward improving flight safety and increasing the operational flexibility of current and proposed aircraft. Research in the fields of sonic boom and aircraft noise are also included in this program.

Piloted simulators and analytical techniques will be used to continue studies of the effects of atmospheric turbulence and the influence of aircraft structural flexibility on the pilot's ability to control the over-all system within aircraft operational constraints. Piloted simulators will also be used to determine the instrument displays and piloting techniques required to cope with large amplitude airplane oscillations and a variable stability airplane will be flown in rough air to evaluate stability and control characteristics and piloting techniques for rough air flight. The feasibility of several techniques to detect clear air turbulence (for example, lasers, passive optical and microwave devices) will be investigated.

The jet engine noise problem is being given a high priority with a continuing effort underway to obtain fundamental information on the generation and propagation of noise from exhaust jets and the compressor and fan components of jet engines, leading to the design of acceptably quiet propulsion systems. Flight tests using steep approach techniques will be continued to determine the maximum operational glide slope for a variety of transport airplanes in connection with landing approach noise abatement procedures and the related problem of aircraft safety during such steep descents.

The greatest unknown factors with regard to the propagation of sonic boom pressure waves are those associated with the effects of various atmospheric variables such as temperature, turbulence, wind shears and humidity. These factors will be studied in an accelerated program which will also include the response of building structures, humans, and window glass to sonic boom pressure waves of various shapes and magnitude. The XB-70 will be utilized to determine the effects of aircraft size and weight on sonic boom generation.

Turbojet aircraft are still encountering serious difficulties in steering during taxiing and in stopping on wet runways. Studies are underway at the Langley Landing Loads Track to investigate the effects of various runway surface additives and tire trends on braking friction, and in FY 1967 these studies will be continued under full-scale operational conditions. Full-scale tests will also be made to determine the benefits, and information for the practical design, of an air jet ahead of the tire to clear away water and slush as a follow-up to the present exploratory studies.

A general purpose airborne simulator (a modified Jet-Star aircraft) will be used in flight tests to investigate the stability, control and performance characteristics of a variety of advanced design airplanes, such as the supersonic transport, and aerospace vehicles.

Preliminary work will be performed leading to a flight research program utilizing the F-111 airplane. The flight program will provide information on aerodynamic load and structural temperature distributions, aeroelastic effects, and handling qualities of a full-scale variable-sweep aircraft configuration.

X-15 Research Aircraft

	1965	1966	1967
Aerodynamics	$18,000	$267,000	$160,000
Loads and structures	15,000	10,000	215,000
Propulsion	---	---	---
Operating problems	1,392,000	606,000	525,000
Total	$1,425,000	$883,000	$900,000

The X-15 research program, conducted in cooperation with the Department of Defense, is providing data on manned, maneuverable hypersonic flight. During the course of the flight test program, through calendar year 1965, more than 150 flights have been made, including more than 115 flights at speeds greater than a Mach number of 4. Of these flights, more than 75 have been made at Mach numbers above 5.

The X-15 remains the only research capability in the world for 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.

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; high-speed high-altitude photography and stellar ultraviolet radiation has been performed using the X-15 as a carrier vehicle.

In six and one-half years of flight test, from June 1959 to December 1965, the X-15 program not only has contributed to the increased confidence of designers of current high-performance aircraft, but has focused attention on the areas which required additional research. The future program will be directed toward these areas, to provide information for the next logical step in our flight research program which is manned, maneuverable hypersonic cruise flight.

Supersonic Transport

	1965	1966	1967
Aerodynamics	$640,000	$880,000	$1,300,000
Loads and structures	214,000	110,000	700,000
Propulsion	14,270,000	11,501,000	11,100,000
Operating problems	4,829,000	1,565,000	1,000,000
Total	$19,953,000	$14,056,000	$14,100,000

NASA's research effort and support for the national supersonic transport (SST) program will continue in FY 1967 at about the same level as in FY 1966, but with a substantial shift in emphasis. The Federal Aviation Agency and its contractors will by then be carrying the major activity in prototype configuration development, structural design, and development of the first-generation engines. NASA will maintain a major effort on advanced propulsion systems and materials for advanced engines, expand its operational research, carry major responsibility in noise and sonic boom research and make available its unique facilities and technical resources as needed during prototype development.

A large part of the requested funds will be used in the field of propulsion for continuing contract research on engine components and materials started in FY 1965 and 1966. In FY 1967, however, the contracted research program will be reduced and at the same time, the in-house effort will be increased to provide research information required for second-generation SST engine development.

Compressor and fan component research will be directed toward reduced weight and increased performance through utilization of such concepts as supersonic inflow compressors and variable geometry features. Turbine studies will be toward more effective cooling and stress alleviation techniques; promising configurations of rotating elements will be fabricated and evaluated experimentally. Combustor research will include consideration of advanced annular and swirl-type combustor cans, as well as integration of combustor and turbine stator to permit increased turbine inlet temperatures. Lubrication systems, lubricants, bearings, and seals research will also investigate various means of increasing operating temperatures, with emphasis on increasing the fatigue life of the bearings themselves.

Inlet research will be continued to provide design information applicable to both two-dimensional and three-dimensional types. Inlet-engine flow dynamics and inlet control systems will receive particular attention. Because of the large effect of exit nozzle performance on over-all flight efficiency, the effort in this area will be increased to determine performance limits and to find more effective methods for nozzle cooling.

The engine materials research will be aimed generally at metals with higher heat capability and longer fatigue life. Chromium, nickel and cobalt alloys will be investigated along with coatings to eliminate oxidation at higher operating temperatures. Methods for exploiting metal phase change and superalloy purification will be explored to achieve the long life desired in a commercial supersonic transport engine.

In the field of airframe structures, structural dynamics problems such as vibration and flutter will receive increased emphasis. Studies will be continued on establishing the characteristics of appropriate titanium alloys and other materials under realistic loads and temperature environments for the SST.

In the supersonic transport operating problems field simulation and flight studies will be made of the low-speed approach and landing problems of proposed configurations to define the ranges of airplane characteristics acceptable to the pilot and to devise means of achieving these characteristics. Following further definition of the handling qualities requirements for normal operating conditions for low-speed approach, additional restraints of adverse weather operation will be considered by analysis and ground simulation.

In the field of airframe aerodynamics, the optimization of performance, stability, and control characteristics over the entire operating speed range of the SST will be pursued. This continuing effort will be closely associated with the wind tunnel and related investigations carried out in the development of the SST prototypes, and with parallel investigations of sonic boom generation and propagation.

V/STOL Aircraft

	1965	1966	1967
Aerodynamics	$1,533,000	$740,000	$1,600,000
Loads and structures	99,000	8,000	200,000
Propulsion	449,000	314,000	1,000,000
Operating problems	906,000	938,000	2,200,000
Total	$2,987,000	$2,000,000	$5,000,000

A major part of the increase in funding in FY 1967 will result from studies of a new VTOL research airplane capable of providing more accurate information on the influence of all-weather landing operation capability on the design of high-performance tactical V/STOL types. A feasibility study will be initiated to determine the characteristics required of such a research airplane and to identify existing conventional high-performance aircraft which could be modified to provide the vehicle needed. Wind tunnel studies will be undertaken to determine the effectiveness of the modifications proposed. Actual modification of the existing vehicle, which the Air Force has agreed to provide from its inventory, may begin. Related flight studies of the requirements for pilot displays to effect safely such VTOL all-weather landing operation, begun in FY 1966, will continue using the NASA Bell 204B helicopter; a flight investigation of an advanced landing approach aid for STOL aircraft, recently initiated using a conventional transport airplane, will be extended in FY 1967 to more realistic approach conditions following procurement of a suitable STOL aircraft.

A substantial increase in effort is expected on short-haul (primarily commercial) transport research, based in large part on anticipated recommendations made as a result of current NASA-sponsored feasibility studies by three U.S. aircraft manufacturers. This research will include wind tunnel investigations, simulation, and flight studies.

Other wind tunnel research studies will continue aimed at providing basic information on such effects as aerodynamic interference and hot gas ingestion for representative military fighter and transport V/STOL configurations. Basic propulsion studies will be increased substantially, emphasizing research leading to engines having high ratios of thrust-to-weight and thrust-to-volume.

Flight and simulator research will also continue to provide more detailed information on the design requirements for satisfactory handling qualities of V/STOL aircraft, including helicopters. In addition to the NC-130C boundary layer control STOL aircraft and the X-14A and YHC-1A variable-stability VTOL research aircraft, the new X-22A tilt-duct and XV-5A fan-in-wing VTOL airplanes will be utilized to provide information on more realistic configurations and to provide correlation with wind tunnel and simulator predictions.

Based in part on requirements of the military services, it is planned that the wind tunnel and flight effort on compound helicopters started in 1966 will be increased; such programs will usually be conducted jointly with the services. Specific evaluation of structural dynamics and handling quality advantages or problems associated with the promising hingeless rotor concept will continue using the NASA XH-51N research helicopter.

Hypersonic Ramjet Experiment

	1965	1966	1967
Propulsion	\$2,712,000	\$5,000,000	\$2,000,000

A feasibility study and design competition is nearing completion between the Garrett Corporation, the General Electric Corporation, and the Marquardt Corporation, to determine an optimum configuration for a liquid hydrogen fueled ramjet engine capable of being operated between Mach 3 and 8. In this speed regime, using a convertible combustion arrangement, both subsonic and supersonic combustion systems can be studied.

Upon completion of the current phase I studies, an evaluation will be made to select one or more of the study phase contractors to continue with detailed design, experimental wind tunnel verification, fabrication, and proof test of the selected concepts. This second phase of the program is expected to require 29 months for completion.

Since the research ramjet must be designed for the most severe anticipated operating conditions, structures must be capable of withstanding stagnation pressures approaching 5,000 psi and active cooling concepts must be devised to maintain structural integrity at stagnation temperatures of 4,700°F.

XB-70/SST Flight Research Project

	1965	1966	1967
Aerodynamics	---	$5,146,000	---
Loads and structures	---	600,000	---
Propulsion	---	850,000	---
Operating problems	---	2,700,000	$2,000,000
Total	---	$9,296,000	$2,000,000

NASA, by virtue of its statutory responsibility for aeronautical research and technology within the United States Government, has the responsibility to provide the research information and advanced technology needed for design, development contruction, and flight test of the prototype supersonic transport.

The use of the USAF XB-70 aircraft as a research tool will be supported jointly by the USAF and NASA. It will provide NASA with the ability to validate its basic aerodynamic theories and experimental results obtained in ground facilities to account for, as examples, effects of vehicle size (Reynolds Number) 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 and will continue to be the subject of major research efforts in analysis and ground based facilities; the XB-70 program will provide vital guidance and assessment of the soundness of these programs, assuring that major programs such as the supersonic transport will proceed on a sound basis.

The NASA portion of the XB-70 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, consisted of continuation and expansion of the initial program and the initiation of research which could not be accommodated during the initial 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, which will be greatly accelerated in FY 1967, NASA will fund the costs associated with NASA's research program utilizing the XB-70 aircraft.

This program is obtaining results which are important 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 NASA 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 describe plans and related funding requirements to continue the Tracking and Data Acquisition program in each of these areas during FY 1967.

SUMMARY OF RESOURCES REQUIREMENTS:

	1965	1966	1967
Operations......................	$95,254,000	$129,600,000	$199,000,000
Equipment.......................	144,482,000	87,665,000	66,500,000
Supporting research and technology..................	13,500,000	13,800,000	13,800,000
Total........................	$253,236,000	$231,065,000	$279,300,000

Distribution of Program Amount by Installation:

	1965	1966	1967
Marshall Space Flight Center..	$2,000,000	$1,500,000	$1,500,000
Goddard Space Flight Center...	179,252,000	155,950,000	199,600,000
Jet Propulsion Laboratory.....	55,769,000	53,500,000	55,600,000
Wallops Station...............	5,100,000	5,835,000	6,400,000
Flight Research Center........	1,900,000	1,880,000	2,100,000
Langley Research Center.......	2,200,000	2,000,000	2,100,000
NASA Headquarters.............	7,015,000	10,400,000	12,000,000

BASIS OF FUND REQUIREMENTS:

Operations

	1965	1966	1967
Manned space flight network.....	$23,118,000	$37,000,000	$60,000,000
Satellite network...............	25,063,000	29,000,000	33,700,000
Deep space network..............	19,040,000	26,500,000	32,800,000
Other instrumentation...........	5,930,000	6,600,000	7,000,000
Communications..................	17,478,000	24,000,000	57,000,000
Data processing.................	4,625,000	6,500,000	8,500,000
Total........................	$95,254,000	$129,600,000	$199,000,000

Manned Space Flight Network Operations

The Manned Space Flight Network, originally configured to support the Mercury program, is now actively supporting the Gemini missions. The network for Gemini support consists of seven primary land stations located at Cape Kennedy, Florida; Bermuda; Grand Canary Island; 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 located at Kano, Nigeria; Tananarive, Madagascar; Canton Island; Point Arguello, California; White Sands, New Mexico; and Eglin Air Force Base, Florida.

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 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 stations with 30-foot antennas, three stations with 85-foot antennas, one transportable station with a 30-foot antenna, five ships, eight instrumented aircraft, and three Deep Space Network stations with 85-foot antennas for backup during lunar missions. Staffing of stations and training of operating personnel are well under way to assure that the network will be ready to support Apollo missions beginning in early 1966.

A significant increase in operations costs will occur in FY 1967 as the network will be required to support both the Gemini program and increased activity in the Apollo program. Approximately one-half of the increase will be for the operation and maintenance of the Apollo instrumentation ships and aircraft which are under the responsibility of the National Range Division of the Department of Defense. Also in FY 1967, most of the new stations being constructed for support of the Apollo program will become operational. At existing stations, manning levels will increase due to Gemini/Apollo flight activity and the more advanced equipment required for the Apollo program. Additional funds will also be required for computer programming, network engineering, and logistic support associated with the new equipments and the increasing level of flight activity.

Satellite Network Operations

The Satellite Network includes the electronic stations of the Space Tracking and Data Acquisition Network (STADAN) managed by the Goddard Space Flight Center, and the 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.

The STADAN stations operate on a 24-hour day, seven-days per week basis. The workload of the network will continue to increase in FY 1967. Not only will more satellites be supported, but they will be more complex and carry more experiments which will result in an even greater increase in the control functions and data output to be handled by the stations. Impacting the workload in FY 1967 will be initial flights of the Applications Technology Satellite and the Biosatellite projects, and additional flights of the Orbiting Geophysical Observatory, the Orbiting Astronomical Observatory, and the Orbiting Solar Observatory.

Increased operational costs in FY 1967 are due to the higher staffing levels and logistic support required to meet the greater workload and to operate facilities which are being installed at Goldstone, California; Rosman, North Carolina; and Toowoomba, Australia for support of the Applications Technology Satellite project.

Deep Space Network Operations

The Deep Space Network's primary function is to provide tracking and data acquisition support for unmanned lunar and planetary space flight. 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 as required, transmits commands to the spacecraft to execute the above functions, and records the scientific data which are acquired from the spacecraft. Three stations in the network, one each in Australia, Spain, and California, will provide a backup capability for the Apollo manned lunar missions.

The control center for the Deep Space Network is the Space Flight Operations Facility (SFOF) located at the Jet Propulsion Laboratory in Pasadena, California. The SFOF 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 flight missions of the Lunar Orbiter, Surveyor, and Pioneer projects will continue through FY 1967. In addition, a Venus fly-by mission is scheduled for launch in late FY 1967. To meet the flight schedule, the Deep Space Network and the SFOF must support two or more missions simultaneously.

At the beginning of FY 1967, the Deep Space Network will consist of two operational 85-foot antenna facilities, S-band equipped, at each of the three longitudinal locations required to maintain continuous surveillance of a lunar or planetary mission. Staffing at all stations will increase to meet flight mission requirements. Stations with heavy workloads will require additional work shifts. The prototype 210-foot antenna facility at Goldstone will become operational during the first part of FY 1967, and will require single-shift staffing. The SFOF also will require additional staffing and computer capacity to handle the projected workload in FY 1967.

Other Instrumentation Operations

Instrumentation systems are operated in support of sounding rocket programs conducted at 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 provided 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. Funds required in FY 1967 reflect approximate costs which are being experienced in the current year with a slight increase for additional engineering effort needed in the areas of data analysis and computation, instrumentation development, trajectory determination and impact prediction, and quality assurance.

Effective January 1, 1966, management responsibility for the Fort Churchill facility was transferred from the U.S. Air Force to the National Research Council of Canada. Instrumentation at Fort Churchill is contractor operated and is funded jointly by the National Research Council and NASA as a cooperative effort. Costs to NASA will continue in FY 1967 at about the same level as 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 1967 will be the Lunar Lander Research Vehicle, the Lifting Reentry Research Vehicle, the space sciences experiment program using the X-15, the XB-70 flight program, and various small aircraft research projects including the studies on laminar flow.

Communications Operations

NASA's tracking stations and control centers are linked together by a single operational communications system operated by the Goddard Space Flight Center. Communications switching centers have been established at major locations such as Goddard, London, and Australia, to maximize circuit sharing. Requirements in most cases are being met by providing alternate voice/data circuits instead of straight voice circuits, thereby reducing the total number of circuits needed.

In the early Mercury missions, considerable reliance was placed on high frequency radio communications. As a result, network communications were limited and not of satisfactory reliability. Although this situation has improved with Gemini, it is still not possible to transmit sufficient voice, telemetry, and tracking data from remote stations to the Mission Control Center or to provide sufficient reliable voice up-data and commands from the Control Center to the spacecraft in real time.

In the Apollo program, the increased complexity of the missions and the number of vehicles to be supported have dictated the requirement for vesting complete responsibility for real-time mission control directly in a centrally located facility. To achieve the required centralized control, the remote sites must have sufficient communications with the central facility in terms of both reliability and capacity to provide flight control functions through remote operation from the central location.

The FY 1967 budget reflects the cost of providing the quality and volume of communications service necessary to meet the requirements of the Apollo program. Communications requirements will be met through the leasing of services provided by communications satellites as well as through conventional circuits. Communications service via satellite will be provided to six tracking stations: Carnarvon, Australia; Canary Island; Ascension; and the three Apollo insertion/injection ships. Fiscal year 1967 also reflects the cost of leasing the approximately seventy voice/data circuits, twenty-four teletype circuits, and two wideband channels required for Apollo.

Data Processing Operations

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 are the primary objective of the spacecraft missions which are undertaken to explore and understand space.

The increased number of spacecraft to be supported in FY 1967, in conjunction with the greater number of experiments carried per satellite, particularly in the observatory satellites, will result in a large increase in the telemetry data processing workload. Funds also will be required in FY 1967 to handle the projected increases in computer programming and orbital computations associated with such complex upcoming projects as the Orbiting Astronomical Observatory.

Equipment

	1965	1966	1967
Manned space flight network.....	$98,348,000	$50,300,000	$26,500,000
Satellite network...............	17,995,000	15,800,000	14,500,000
Deep space network..............	15,168,000	9,900,000	10,500,000
Other instrumentation...........	4,300,000	4,065,000	4,500,000
Communications..................	4,755,000	5,100,000	7,500,000
Data processing.................	3,916,000	2,500,000	3,000,000
Total........................	$144,482,000	$87,665,000	$66,500,000

Manned Space Flight Network Equipment

The Manned Space Flight Network is now supporting the Gemini Program in the areas of tracking, telemetry, command, and communications. Procurement and manufacture of equipment needed to meet the greatly increased requirements for support of the Apollo Saturn IB and Saturn V programs were initiated in FY 1964 and continued in FY 1965 and 1966. Funds are required in FY 1967 to incorporate additional capabilities in the network for support of the Apollo lunar missions and to meet costs of installing equipment at the stations and integrating hardware and facilities as a compatible, unified network.

The augmentation of the network for Apollo 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 are continuing efforts.

During the past year, the Air Force negotiated and awarded the contract for modification and equipping of the eight Apollo/Range Instrumentation Aircraft. These aircraft, initially authorized in FY 1965, will provide voice communications with the astronauts and telemetry coverage during injection of the Apollo spacecraft into the translunar trajectory and during the reentry into the earth's atmosphere. The negotiated value of the contract is substantially greater than forecast. The FY 1967 budget includes funds to cover the additional costs of this contract.

Fiscal year 1967 funds are also required for additions to the memory capacity of the on-site data processing equipment. A review of flight control, command, and display requirements has indicated that the memory capacity must be expanded by 50 per cent to cover the rendezvous, lunar landing, and Earth return phases of the lunar missions. Equipment and modifications to provide the necessary augmentation of memory capacity will be incorporated at 13 land stations for Apollo support.

Equipment must be added to the existing network control centers to enable operational control of the network during non-mission periods and simulations, and to provide the capability to assess network performance during mission periods. Funds required in FY 1967 are primarily for equipment to be installed for Apollo support in the Manned Space Flight Network control center at the Goddard Space Flight Center.

A review of airfield capability by the Air Force has indicated that additions and modifications to certain existing commercial airfields will be required in support of the eight Apollo Range Instrumentation Aircraft. A detailed on-site survey by the Air Force is underway to determine the extent of modifications required at several locations. Fiscal year 1967 funds will be required for these additions and modifications.

During FY 1967, facilties will be completed and equipment will be installed in nearly all of the network stations. Costs arising directly from this effort are those for systems engineering; for the shipment of equipment to the network stations; for the provision of network descriptive documentation, specifications, and manuals; for the provision of standard test equipment; and for the establishment of spare parts inventories needed to preclude long periods of station downtime during mission periods.

Satellite Network Equipment

During the past several years, the primary objective of the Satellite Network equipment program has been to achieve a general purpose capability which will meet the more complex support requirements of the advanced scientific and applications satellites, and at the same time accommodate the increasing workload on the network. The FY 1967 program represents a continuation of equipment augmentations and modifications which were initiated in prior years to meet this objective. It also includes funds for improvements, replacements, and recurring support items required to maintain the general purpose capability.

Fiscal year 1967 funds are required to complete modifications of the Range and Range Rate tracking systems at four operational sites. Initiated in FY 1966, these modifications involve a frequency change and improvements to incorporate greater systems performance gain.

For several years, a long range program has been under way to augment the network with high performance telemetry and command links to meet the expanding workload. In FY 1967, additional receivers, phase demodulators, and recording equipment will be procured to provide the number of telemetry links needed for the projected workload. Existing telemetry links will be improved by replacing mechanical polarization switches with more reliable solid-state components. Telemetry equipment also will be procured for the new 40-foot antenna facility in Alaska.

Command links procured with prior years funds have been used extensively, and certain deficiencies have been identified which necessitate corrective action to minimize operational complications and to prevent excessive maintenance. Included in the FY 1967 program are the replacement of tube transmitters with solid-state transmitters, replacement of the rim-mounted command antennas on the 40-foot and 85-foot dishes with smaller and more reliable antennas, and the replacement of existing command encoders at selected stations with a more flexible programmable encoder.

In FY 1967, new consoles will be provided at selected stations to centralize the switching of subsystems such as receivers, data handling equipment, tape recorders, command generators, and transmitters. Centralized control is necessary to minimize station turn-around time between passes and to allow the most efficient use of the expanding capability of network stations. This equipment will permit the station controller to select the configuration of subsystems necessary to support a given mission and to monitor remotely the operational performance of these subsystems.

Certain projects to be supported by the Satellite Network have specialized requirements which cannot be fulfilled by the general purpose network equipment. Fiscal year 1967 funds are required for equipment supplements at Alaska and Rosman for Nimbus B support and for modifications to the wideband telecommunications system. Funds are also needed for integration of the Applications Technology Satellite ground support equipment procured in FY 1965 and 1966.

The Satellite Network control center at the Goddard Space Flight Center must be adapted to meet the requirements of flight projects. In FY 1967, equipment additions will be necessary to support the Nimbus B mission and minor equipment modifications will be required for follow-on missions of the Orbiting Geophysical Observatory, the Orbiting Astronomical Observatory, and the Explorer series.

To maintain the capability of the network, a continuing test, calibration, and checkout program is required. FY 1967 funds will be used for replacement of the large dish optical calibration system with a more reliable and heavier duty unit. Additional quality assurance equipment will be procured for testing of ground systems under simulated operating conditions. Field calibration equipment with a near-real-time capability for analyzing antenna pattern measurement data also will be procured. At the present time, the antenna measurement data are returned to Goddard for analysis resulting in substantial delays in determining antenna anomalies.

Funds are required on a recurring basis for the repair and modification of facilities to sustain current operations and to improve network performance and reliability. In FY 1967, modification of some station facilities will be necessary to house equipment additions. Also required are funds for cabling, augmentation of station power systems, modification of air-conditioning systems, and facility repairs at the stations. Funds for procurement of spares and replacement parts also are included in the FY 1967 request.

Deep Space Network Equipment

The FY 1967 Deep Space Network equipment program will be directed toward assuring the capability of the network to meet the period of peak loading which is scheduled to occur in calendar year 1967. In addition, a program of required engineering changes, modifications, equipment replacement, and spares provisioning will be conducted to assure the required level of network performance and system reliability.

The major item of the Deep Space Network equipment cost in FY 1967 will be for station monitoring and control equipment. The purpose of this program is to implement a single standardized set of equipment at each site which will serve the needs of multiple flight programs. FY 1967 funds are required for modification of control and monitoring consoles to handle digital formats, and for procurement of communications buffers and line printers for all sites. These modifications, along with prior year equipment purchases, will provide a capability for continuous, semi-automatic monitoring of equipment performance at each station. It also will provide real-time data on the operational status of each station to the Space Flight Operations Facility so that the necessary decisions can be made and corrective action initiated when required.

Low speed electric motors to drive the 85-foot antennas automatically at a sidereal rate will be procured in FY 1967 for the operational antennas. This drive is required for long periods of spacecraft coverage at planetary distances when the rotation of the Earth in relation to the spacecraft is extremely slow.

The Deep Space Network standard configuration includes a 10 kilowatt transmitter at each operational site. The only high power transmitter in the network is located at the Goldstone Venus research and development station. During the later months of the Mariner flight to Mars, this transmitter insured a reliable up-link between the ground and the spacecraft. It is planned to incorporate a high power transmitter capability at the 210-foot antenna facility at Goldstone. This requires an augmented power supply which will be procured with FY 1967 funds.

Support of both manned and unmanned flights by the Deep Space Network requires receiver compatibility with the Manned Space Flight Network. Improvements and modifications which have been made in the receiver systems for manned flight support must be incorporated into the Deep Space Network. These modifications will lessen the time required for checkout, signal acquisition, and frequency changeover and will provide for a wider tuning range.

The FY 1967 program includes funds for general purpose support which is required to sustain current operations and to improve network performance and reliability. Included are such items as generators, power system modifications, microwave modifications, calibration and test equipment, interface and integration equipment, intrasite communications, and cabling.

Fiscal year 1967 funds are required to continue modifications of the Space Flight Operations Facility for multiple mission support. This Control Center also will be provided with a capability for participation as an integral network element during mission simulations. Through such participation, the SFOF can determine network readiness for mission support and assess the level of performance to be expected. In addition, a capability will be provided for training of personnel at stations and the SFOF, thus improving the reliability of the entire network.

Other Instrumentation Equipment

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.

During FY 1967, the Flight Research Center will continue to update the telemetry systems of the Aerodynamic Test Range. Equipment which was purchased for the Edwards site in FY 1966 will be installed and made operational. Similar equipment will be procured and installed at the Ely station. Display systems will be updated to meet program requirements. The radar at the Edwards site will be outfitted with a solid-state precision data system in order to decrease maintenance time.

At Wallops Station, funds will be required in FY 1967 to update the telemetry system on the 60-foot antenna, to modify surplus Department of Defense radars to meet NASA's requirements, and to modify and integrate range control systems. Funds are also included for the procurement of non-recoverable hardware required in support of the various missions.

Communications Equipment

Funds for FY 1967 reflect the continuation of a planned program to install switching equipment at major communication focal points. With the buildup of the Madrid complex, a solid-state switch will be installed to maximize circuit sharing and to handle the high speed data transmissions required by Apollo. A solid-state switch will also be installed at the Jet Propulsion Laboratory (JPL) to handle the high speed data from the Deep Space Network, and to interconnect circuits with Goddard Space Flight Center.

Funds will also be required in FY 1967 to provide a line concentration switch at Guam in support of Apollo and for major modification of the switching capability at Goddard to accommodate the increasing flow of communications. Expansions of the switching units at London, Canberra, and Hawaii will be required to handle the high speed data transmissions associated with Apollo.

Other modifications planned in FY 1967 include an upgrading of the Goddard and JPL teletype and voice systems. Recurring equipment items which are necessary to maintain and update existing systems will also be required. These include signal generators, modulating and demodulating devices, high frequency radio data modems, data quality monitors, data detection and error correction equipment, and distortion measuring units.

Data Processing Equipment

The operational data processing equipment will continuously require minor redesign, modification, and improvement as well as normal maintenance and repair. Although the data processing lines are made as flexible as possible, modifications must be made to the lines to satisfy requirements of new programs as the lifetimes and data transmissions of older satellites terminate. Funds in FY 1967 will continue to provide the components for these modifications and improvements.

In FY 1967, an additional line of the high capacity Phase II Satellite Telemetry Automatic Reduction System (STARS) is to be procured by the Goddard Space Flight Center. This line is needed to meet the data processing requirements of the Nimbus B and the Applications Technology Satellite, and to serve as backup to other lines which will be loaded to capacity by such high data rate satellites as the Orbiting Geophysical Observatory (OGO), Polar Orbiting Geophysical Observatory (POGO), the Orbiting Astronomical Observatory (OAO), and the Interplanetary Monitoring Platform (IMP).

Additional telemetry reduction and processing equipment is needed to provide flexible, high speed reduction of data for quick-look analysis by experimenters. This is of increasing importance as spacecraft become more complex and have the capability of operating in various modes. This requires that decisions be made in monitoring experiments and in the data rates to be used. A flexible, high speed reduction capability provides, in rapid fashion, the information necessary to make these decisions.

Test equipment, spares, and replacements are needed to maintain the various data processing lines. All equipment must be maintained at peak operating levels to insure maximum data usage and operating efficiency.

Supporting Research and Technology

	1965	1966	1967
New systems....................	$1,580,000	$1,160,000	$500,000
Integrated systems analysis, development, and test.........	3,025,000	2,690,000	3,500,000
Antenna subsystems..............	2,511,000	2,150,000	1,600,000
Receiver and transmitter subsystems....................	2,674,000	2,700,000	2,300,000
Data handling and control.......	1,729,000	2,400,000	2,100,000
Data processing and reduction...	780,000	1,220,000	2,100,000
Spacecraft subsystems...........	1,201,000	1,480,000	1,700,000
Total........................	$13,500,000	$13,800,000	$13,800,000

Supporting Research and Technology (SR&T) is the activity whereby technology of advanced systems, components and techniques is developed 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.

With the trend toward complex, long-duration flight projects, the FY 1967 SR&T program will place greater emphasis on improvements for increasing the reliability and lifetime of existing systems and for determining techniques for efficient utilization of these systems to meet upcoming requirements. The SR&T program is organized into seven functional areas of effort which are described below.

New Systems

Effort will begin in FY 1967 on aircraft-based optical and infrared tracking instrumentation systems which will be required in support of future NASA flight research programs, particularly atmospheric reentry projects. Field test and evaluation of the Airborne Range and Orbit Determination (AROD) system and the S-band interferometer will be concluded with FY 1966 funding.

Integrated Systems Analysis, Development, and Test

With network operations becoming a major expense, the effectiveness of present and planned operational techniques must be closely examined and evaluated. This program will use the method that has proved effective for equipping the networks, that is, using experimental sites to ensure rapid transition from concept to laboratory model to field implementation. Areas to be investigated in FY 1967 include training, simulation, and means of assuring reliable support during critical phases of a mission such as the Mars encounter.

Antenna Subsystems

As workload and mission complexity continue to increase, there is a correspondingly greater dependence upon antenna system reliability since a backup capability does not exist at most stations. Consequently, antenna subsystem design for servo drives, antenna structures, and wideband feeds, must incorporate the latest improvements in the state-of-the-art. In recent years, numerous mathematical tools have been developed which are valuable in designing antenna subsystems. Because of the existence of detailed mathematical models of the critical parts of the system, the 210-foot Advanced Antenna System (AAS) at Goldstone, California, was successfully built to performance specifications within the original budget and schedule estimates. In FY 1967, actual operational tests of the AAS will be employed to evaluate and refine the mathematical elements which were used in its design.

Receiver and Transmitter Subsystems

In FY 1967, the receiver effort will consist primarily of development of a broader data bandwidth capacity as well as automatic radio frequency control for pre-tracking calibration, signal acquisition, and actual mission tracking. Increasing the bandwidth of some of the current receivers is necessary to accommodate the support requirements of long-duration manned Earth orbital missions. Automatic radio frequency control is the first of a series of alternatives being evaluated that show promise of providing partial automation of ground equipment for some of the critical control functions.

In the area of transmitter subsystems, effort will continue on improving the reliability of a 100 to 400 kilowatt power amplifier.

Data Handling and Control

Future spacecraft missions will be characterized by increasing complexity and long duration. This requires that the networks have increased operational flexibility and improved system reliability. Operational flexibility is becoming particularly critical in such areas as antenna redirection, frequency changing, and shifting to different demodulation formats. One of the areas to be investigated in FY 1967 will be the use of computer-to-computer control to achieve greater flexibility with existing station equipment. Critical parameters of station status which are monitored during actual missions will be analyzed, and preliminary definitions will be developed for adapting computers to the various tasks.

Data Processing and Reduction

Effort in this area is directed toward more efficient methods of processing, reducing, and displaying extremely large volumes of scientific data which are gathered, usually in magnetic tape form, from the many satellites and spacecraft in the NASA programs.

In FY 1967, a study will be initiated to determine to what extent the techniques developed for the Satellite Telemetry Automatic Reduction System (STARS) can be applied to meet future real-time mission control needs during flight. The initial step will consist of processing selected data immediately so that a limited number of critical decisions can be made by the experimenter in near-real-time.

Spacecraft Subsystems

Spaceborne electronic equipments are closely mated in capabilities with equipment used for the tracking and data acquisition networks. The advancement of component technology and technology for applying information theory is making possible appreciable increases in overall support capability through improvements in spacecraft subsystems.

In FY 1967, a standard solid-state telemetry transmitter operating at 136 megacycles will be developed which is suitable for use in a variety of small spacecraft. Over approximately a three year period, a family of standard, reliable, solid-state transmitters will be developed which can be applied to a wide variety of NASA programs.

Investigation of on-board data handling techniques will continue. In FY 1967, a study will be made to define on-board data handling systems using previously developed logic modules and memory units.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1967 ESTIMATES

OFFICE OF TECHNOLOGY UTILIZATION

TECHNOLOGY UTILIZATION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The primary objective of the Technology Utilization program is to provide for the widest practicable and appropriate dissemination to industry of information concerning NASA activities and results which appear to have industrial applications potential. 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:

	1965	1966	1967
Identification....................	$1,235,000	$1,220,000	$1,165,000
Evaluation.......................	645,000	680,000	650,000
Dissemination....................	1,970,000	2,000,000	2,085,000
Analysis.........................	900,000	850,000	900,000
Total..........................	$4,750,000	$4,750,000	$4,800,000

Distribution of Program Amount by Installation:

	1965	1966	1967
NASA Headquarters...............	$4,750,000	$4,750,000	$4,800,000

BASIS OF FUND REQUIREMENTS:

Identification

The Identification effort is carried out by NASA personnel; specialists from research institutes, universities and industry; and, by scientists and engineers working for NASA and NASA contractors. These personnel search for ideas, innovations, processes and techniques which appear to have potential for non-aerospace application and report them quickly to NASA Headquarters. These reports are now coming in at the rate of 1,200 per year and with the present emphasis on the implementation of the New Technology Reporting Clause in NASA contracts the rate of reporting is expected to increase. The identification effort also includes the identification of incremental advances in technology. Research institutes, universities and private companies identify these incremental advances in technology by reviewing broad areas of space research and developing state-of-the-art summaries, called Technology Surveys. During FY 1965, contracts for 12 surveys were negotiated. This program will be continued at about the same level during FY 1966 and FY 1967.

Evaluation

The technical information reported to Headquarters is forwarded to a group of Research Institutes and evaluated for novelty, technical feasibility and relevance to non-aerospace industry. A preliminary review is conducted by the Illinois Institute of Technology Research Institute. Innovations of merit are then evaluated in detail by that Institute and one of four other contractors: Arthur D. Little, Batelle Memorial Institute, Stanford Research Institute, and Southwest Research Institute. The product of this evaluation is a flow of new items, processes and techniques having non-aerospace potential. These processes are then made available in one of several publications: Tech Briefs, Technology Utilization Notes, or Technology Utilization Handbooks. Tech Briefs are one to two page bulletins about innovations, published in this format in order that the new developments may reach the potential user as quickly as possible. The Technology Utilization Reports, Notes and Handbooks are more comprehensive publications resulting from in-depth evaluations by research contractors and preparation of more complete information on the subjects covered. Although the current emphasis on new technology reporting is expected to increase the rate of documents coming into the system, the funding requested for FY 1967 will permit continuation of this evaluation effort at about the same level as for FY 1966 and FY 1965.

Dissemination

Dissemination activities are focused on exploiting the normal channels of communication that are in existence or which can be developed. Two general techniques of dissemination are employed. The first is by mailing lists consisting of over 8,000 industrial companies and individuals who receive information in some cases on all Technology Utilization publications, and in others only those in their technical areas of interest. The second form of dissemination is through experimental regional dissemination centers. The first experimental regional program was established in January, 1962, with the Midwest Research Institute (MRI) at Kansas City, Missouri. MRI has employed a broad, generalized approach in disseminating ideas and innovations to over 1,000 industrial firms in the Midwest area. During FY 1967, MRI will continue the basic program and develop new programs for working more closely with the Midwestern industry on a problem solving basis, using computer support from the Aerospace Research Applications Center (ARAC) at Indiana University. This center was established in January, 1963. It offers three basic services: (1) Industrial Applications Service, a weekly dissemination to companies of the Technology Utilization publications with follow-up applications engineering service, (2) Selective Dissemination Service, a bi-weekly computer read-out of the new additions to the NASA magnetic tapes to provide companies with current announcements of items coming into the information system; and, (3) Retrospective Search Service, which are responses to special technical questions, accomplished by computer searching of the entire file of NASA documents (now totalling approximately 200,000 items). During FY 1964 and FY 1965, six Centers in addition to MRI and ARAC were established. These are at Wayne State University (Detroit); the University of Pittsburgh; University of Maryland; Southeastern State College at Durant, Oklahoma; the North Carolina Science and Technology Research Center; and the University of New Mexico. These Centers are serving over 120 member companies with more than 3,000 firms receiving some degree of service. Fiscal year 1967 funds will be used to support current programs at these Centers with appropriate modifications and improvements; and also provide support for several pilot projects with other agencies. In addition, two new experimental dissemination centers are planned.

Analysis

In recognition of the much broader impact of NASA programs than simply that of a major one in advancing science and technology, support is given to a study program to analyze the impact of the space program on the regional and local economy, and on industries, private institutions and different types of manpower. The principal aim here is to have researchers assist in characterizing NASA's impact as it has affected their regions and to develop analyses which lead to consideration of improved policies within the constraints of existing legislation. Under one grant, for example, a study is being made of the distribution of subcontracts under the Gemini program, regional differences in the distribution of NASA and the other Federal expenditures, the role of Defense/Space programs in the national economy, and the supply and demand for scientific manpower. These and similar studies will be conducted during FY 1967 to enhance NASA's understanding of the implications of the space program.

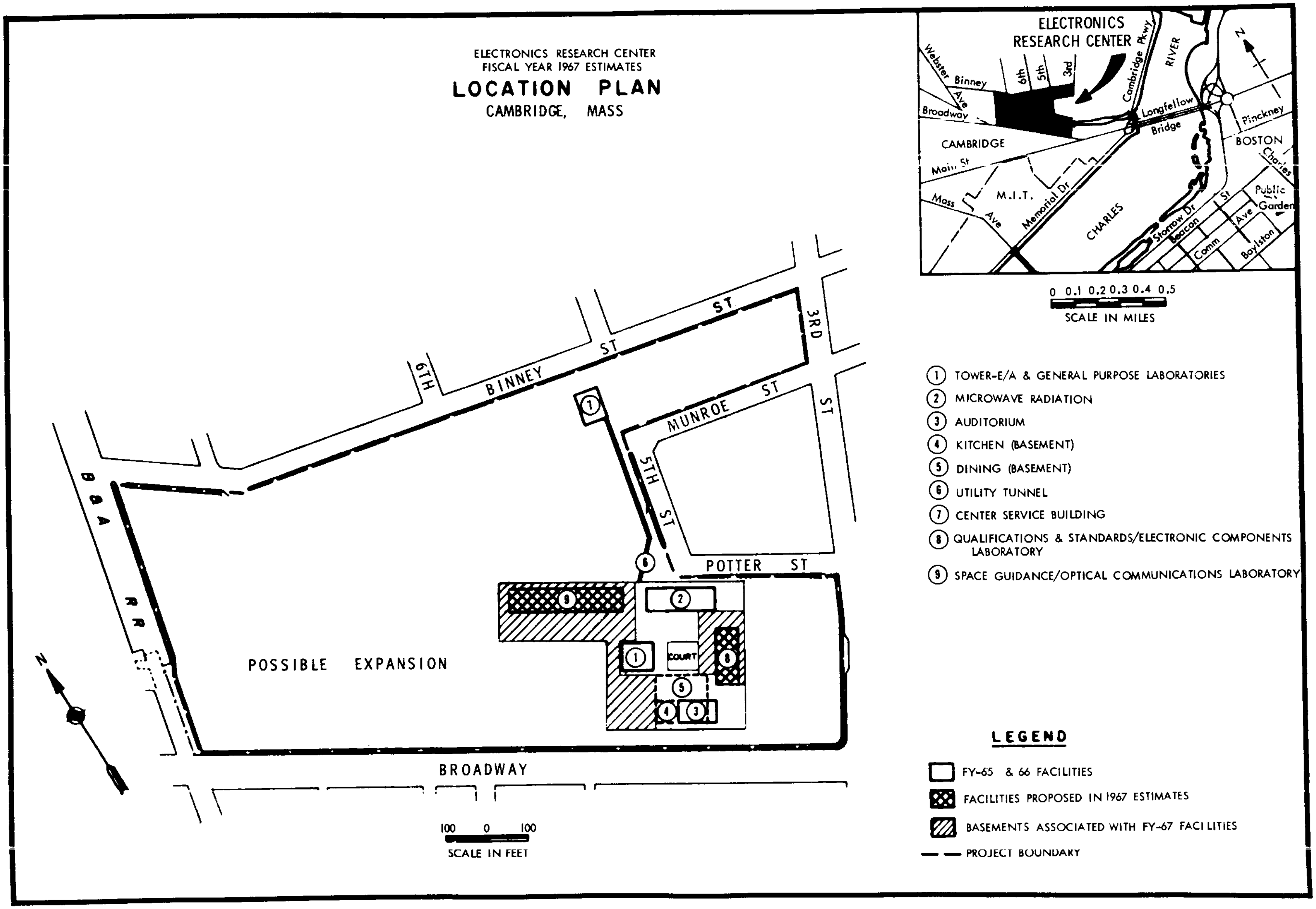
A recognition of the need to solve critical management problems and possibly to develop wholly new techniques for managing such a large and complex research and development enterprise as the NASA led to the support of study areas that include the organization and management of large R&D projects, the diversified roles of the research director, the government-industry contracting system, conditions under which the transfer of new technology takes place in the economy, and top level policy and decision-making in large R&D organizations. During FY 1967 NASA will continue to support a modest program of research on such management problems, the solution of which will promote increased management efficiency both within the agency and within those industries with whom NASA has contacts.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1967 ESTIMATES

ELECTRONICS RESEARCH CENTER


ELECTRONICS RESEARCH CENTER
FISCAL YEAR 1967 ESTIMATES
LOCATION PLAN
CAMBRIDGE, MASS
ELECTRONICS RESEARCH CENTER
Webster Ave
Binney
6th
5th
3rd
Cambridge Pkwy
RIVER
Broadway
Longfellow Bridge
Pinckney
CAMBRIDGE
BOSTON
Main St
Charles
M.I.T.
Mass Ave
Memorial Dr
CHARLES
Storrow Dr
Beacon St
Comm Ave
Boylston
Public Garden
N
0 0.1 0.2 0.3 0.4 0.5
SCALE IN MILES
BINNEY ST
6TH
3RD
MUNROE ST
ST
5TH ST
POTTER ST
B & A RR
POSSIBLE EXPANSION
COURT
BROADWAY
N
100 0 100
SCALE IN FEET
1 TOWER-E/A & GENERAL PURPOSE LABORATORIES
2 MICROWAVE RADIATION
3 AUDITORIUM
4 KITCHEN (BASEMENT)
5 DINING (BASEMENT)
6 UTILITY TUNNEL
7 CENTER SERVICE BUILDING
8 QUALIFICATIONS & STANDARDS/ELECTRONIC COMPONENTS LABORATORY
9 SPACE GUIDANCE/OPTICAL COMMUNICATIONS LABORATORY
LEGEND
FY-65 & 66 FACILITIES
FACILITIES PROPOSED IN 1967 ESTIMATES
BASEMENTS ASSOCIATED WITH FY-67 FACILITIES
PROJECT BOUNDARY

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

INSTALLATION SUMMARY
CONSTRUCTION OF FACILITIES
FISCAL YEAR 1967 BUDGET ESTIMATES

(Dollars in thousands)

NASA INSTALLATION	COGNIZANT PROGRAM OFFICE FOR INSTALLATION	LOCATION OF INSTALLATION	COUNTY	NEAREST CITY
Electronics Research Center	Advanced Research & Technology	Cambridge Massachusetts	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 1965	FY 1966	FY 1967
NASA PERSONNEL *(End of Year)*	250	550	1000
CONTRACTOR AND OTHER PERSONNEL	-0-	-0-	40
TOTAL ALL PERSONNEL	250	550	1040

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, 1965)*	$ -

PROJECT LINE ITEM	COGNIZANT OFFICE	FY 1963 THRU CURRENT YEAR	FY 1967 *(Estimated)*	FUTURE YEARS *(Estimated)*	TOTAL ALL YEARS *(Estimated)*
Space Guidance/Optical Communications Laboratory	ART	624	4,954	-	5,578
Qualifications and Standards/Electronic Components Laboratory	ART	140	3,046	-	3,186
Center Support Facilities (Phase III)	ART	130	2,000	-	2,130
ALL OTHER PROJECTS		18,006			
TOTALS		18,900	10,000		

NASA FORM 1029 (REV. JUN 65) PREVIOUS EDITIONS ARE OBSOLETE.

* *Includes work in process.*

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1967 ESTIMATES

SPACE GUIDANCE/OPTICAL COMMUNICATIONS
SPECIAL PURPOSE 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 1966 and Prior Years	$624,000
FY 1967 Estimate	4,954,000
Total Funding Through FY 1967	$5,578,000

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$3,200,000
4-story laboratory building	Sq. Ft.	72,464	$33.98	2,462,000
Special construction	Sq. Ft.	72,464	10.18	738,000
Equipment				$1,754,000
Space Guidance Lab:				
Inertial test equipment	LS	---	235,300	235,300
Special instrumentation	LS	---	110,600	110,600
Optical devices	LS	---	346,200	346,200
Analysis equipment	LS	---	99,100	99,100
Electronic support equipment	LS	---	124,600	124,600

	Unit of Measure	Quantity	Unit Cost	Total Cost
Precision machinery equipment	LS	---	$42,300	$42,300
Instrumentation assembly equipment	LS	---	32,900	32,900
Optical Communications Lab:				
Optical transmission equipment	LS	---	239,300	239,300
Optical reception equipment	LS	---	277,600	277,600
Optical analysis equipment	LS	---	153,600	153,600
Optics preparation and material equipment	LS	---	92,500	92,500
Design	---	---	---	---
Fallout Shelter	---	---	---	-0-
		TOTAL		$4,954,000

PROJECT PURPOSE:

This project will provide laboratory facilities and special equipment for conducting research on space guidance and optical communications systems.

PROJECT DESCRIPTION:

This Special Purpose Laboratory is a four story building housing special research equipment for the Space Guidance and Optical Communications Laboratory functions. The basement, which extends under the podium level providing 26,900 square feet, will provide ground level support for heavy equipment and equipment requiring vibration-free mounting and extra height of more than twelve feet. The podium level and two upper floors, each with 15,200 square feet, will provide space for special research equipment of lesser building tolerances than that which is closely associated with the equipment installed at ground level. Space is provided for utility lines and local utility equipment items such as pumps, vacuum devices, fans, heat transfer units, electrical transformers, converters, regulators, etc., necessary to provide the special environment required for this research.

Laboratory equipment will be provided in the Space Guidance space to analyze, test, simulate and generate concepts, techniques and elements for future space navigation and guidance systems. Specialized test devices will include equipment for sensing and generating velocities, accelerations, angular rates, gravity forces, and inertial references and will include 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.

Optical Communications portion of the building will contain special purpose equipment for the measurement, analysis, generation and reception of optical energy in the 100 Angstroms to 100 microns wave length region. 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:

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

Current space guidance systems were originally developed for aircraft and ballistic missiles which required very high accuracy for short duration flights. 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 highly reliable, lightweight systems capable of operating for extremely long periods without serious degradation of performance.

The Space Optics Laboratory will conduct research on optical radiation sources and components, data transmission and recovery techniques, and propagation phenomena.

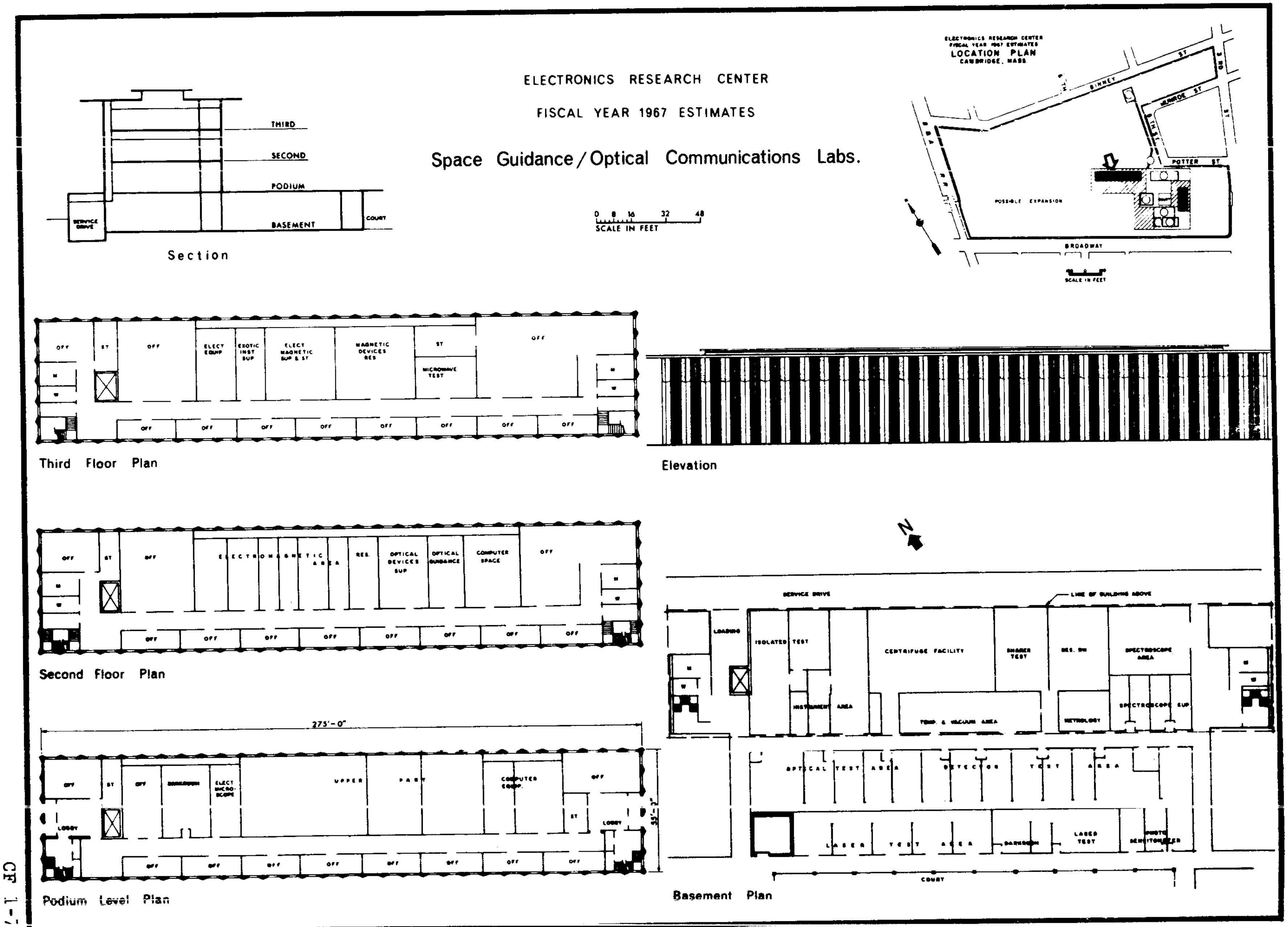
The emergence of the laser indicates that the wavelength band between 100 Angstroms and 100 microns offers an impressive potential for the solution of problems related to space exploration. Applications of optical concepts include communication, guidance and control, and computers and displays. Few of these concepts have progressed beyond basic research. The need for a better understanding of the related 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 sensitivity 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 a billionth of a second 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 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 spectra 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 spectra of space background radiation and stray light 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 communications 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. It is believed that in 1975 a bit rate of one hundred million bits per second will be required over distances of several astronomical units and that optical means show promise in filling this requirement. In addition, 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, reliable, optical components for 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 1967 ESTIMATES
Space Guidance / Optical Communications Labs.
THIRD
SECOND
PODIUM
BASEMENT
SERVICE DRIVE
COURT
Section
0 8 16 32 48
SCALE IN FEET
LOCATION PLAN
CAMBRIDGE, MASS.
BINNEY ST
POTTER ST
BROADWAY
POSSIBLE EXPANSION
SCALE IN FEET
OFF
ST
ELECT EQUIP
EXOTIC INST SUP
ELECT MAGNETIC SUP & ST
MAGNETIC DEVICES RES
MICROWAVE TEST
Third Floor Plan
Elevation
ELECTROMAGNETIC AREA
RES.
OPTICAL DEVICES SUP
OPTICAL GUIDANCE
COMPUTER SPACE
Second Floor Plan
N
SERVICE DRIVE
LINE OF BUILDING ABOVE
LOADING
ISOLATED TEST
CENTRIFUGE FACILITY
SHAKER TEST
RES. SH
SPECTROSCOPE AREA
INSTRUMENT AREA
TEMP. & VACUUM AREA
METROLOGY
SPECTROSCOPE SUP
OPTICAL TEST AREA
DETECTOR TEST AREA
LASER TEST AREA
DARKROOM
LASER TEST
PHOTO SENSITOMETER
COURT
Basement Plan
275'-0"
ELECT MICRO-SCOPE
UPPER PART
COMPUTER EQUIP.
LOBBY
55'-2"
Podium Level Plan

CF 1-7

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1967 ESTIMATES

QUALIFICATIONS AND STANDARDS/ELECTRONIC COMPONENTS SPECIAL PURPOSE 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 1966 and Prior Years	$140,000
FY 1967 Estimate	3,046,000
Total Funding Through FY 1967	$3,186,000

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$1,945,000
Building	Sq. Ft.	38,600	$33.16	1,280,000
Special construction	Sq. Ft.	38,600	17.22	665,000
Equipment				$1,101,000
Qualifications and standards environmental test equipment	LS	---	898,000	898,000
Electronic components lab-special lab equipment	LS	---	203,000	203,000
Design	---	---	---	---

	Unit of Measure	Quantity	Unit Cost	Total Cost
Fallout Shelter	---	---	---	-0-
		TOTAL		$3,046,000

PROJECT PURPOSE:

This project will provide the laboratory facilities and special purpose equipment for research in new electronic components and the standards by which to qualify them.

PROJECT DESCRIPTION:

This Special Purpose Laboratory Building will house in its four levels (Basement, Podium, 2nd and 3rd Floors) a variety of special research equipment and will provide working space for a number of personnel who will support the objectives of the Qualifications and Standards Laboratory and the Electronic Components Laboratory, both subdivisions of the Component Technology Division. The ground level (Basement) comprises 14,400 square feet of floor space in which will be located most of the equipment with unusual building design characteristics (i.e., greater than normal floor loads, specialized foundations, vibration isolation mounts and clear ceiling heights in excess of twelve feet). The podium (1st Floor) level consists of 8,000 square feet and will contain, like the 2nd and 3rd floors, a portion of the special laboratory areas for fabrication and modification of experimental electronic models and some of the research office spaces. The 2nd and 3rd floors each contain 8,000 square feet which will be devoted to the special laboratory areas with lesser load and clear height requirements as well as a number of research work spaces. The building will be of permanent type construction and will contain the necessary utility lines and equipments such as fans, pumps, electrical transformers, converter/regulators as required to provide the specialized environmental requirements of these laboratory areas.

PROJECT JUSTIFICATION:

The Electronic Components Laboratory is needed to provide facilities for increasing basic knowledge and for advancing technology in the area of electronic components in order to provide the necessary capability for meeting the electronic components requirements for successful accomplishment of NASA space missions. Advanced research will be carried out in the fields of solid state, low temperatures, quantum electronics, high temperatures, and mechanical and metallurgical studies. Materials research will be performed in semi-conductors, magnetics, dielectric materials evaluation, and radioisotopes and radiation. Microelectronic research will include thin films, microelectronic techniques and molecular electronics. Physical electronics research will include electron emission studies, plasma research and surface studies. A capability is needed for advanced development of semiconductor devices, tubes, electromechanical devices, and optical and display devices. This facility is needed to provide special purpose laboratory space and research equipment to carry out the necessary in-house portion of the electronic components research program.

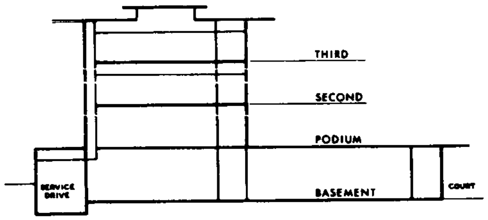
The Qualifications and Standards Laboratory will provide space and equipment to permit the staff to conduct component qualification testing and to establish electronic design and fabrication standards. The standards established by this laboratory will materially reduce the complications and unnecessarily high development costs which result when space systems are to be assembled from electronic components obtained from a large number of developers and suppliers, all working to different basic fabrication and reliability qualification standards. This laboratory will be the NASA focal point for promulgation of space electronic component qualifications and standards. These qualifications and standards will also be supplemented with laboratory developed qualified parts lists, calibration methods and procedures and environmental test criteria which will be invaluable to other groups within the Center, other NASA Centers, other government agencies and interested industrial and university groups.

ESTIMATED FUTURE YEAR FUNDING FOR THIS PROJECT: None

ELECTRONICS RESEARCH CENTER

FISCAL YEAR 1967 ESTIMATES

Qualifications & Standards / Electronics Components Labs.



Section

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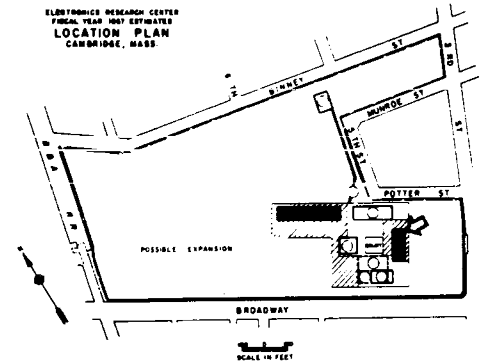
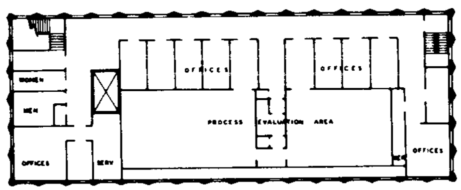
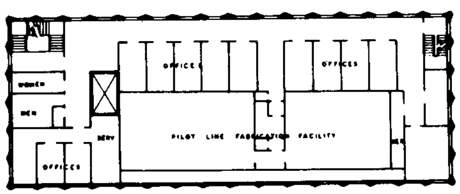
SCALE IN FEET

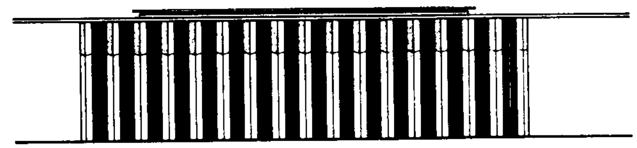




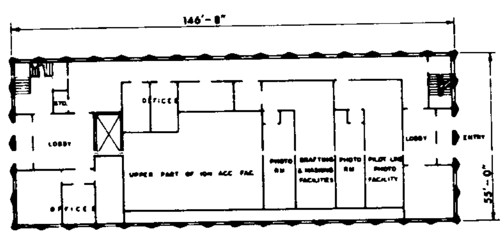
Third Floor Plan



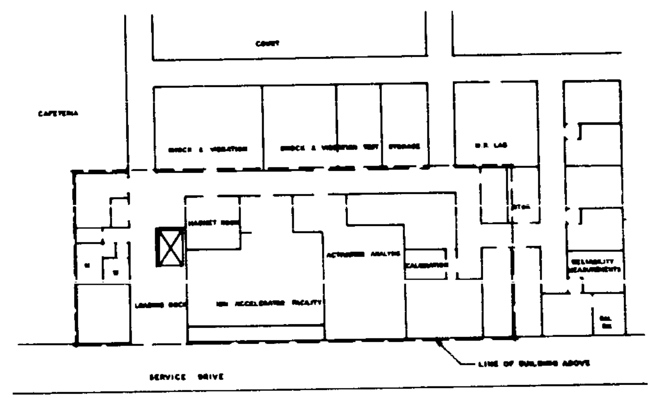
Elevation



Second Floor Plan



Podium Level Plan



Basement Plan

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1967 ESTIMATES

CENTER SUPPORT FACILITIES

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 1966 and Prior Years	$130,000
FY 1967 Estimate	2,000,000
Total Funding Through FY 1967	$2,130,000

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$2,000,000
Basement mechanical spaces and equipment	Sq. Ft.	9,000	$38.24	344,000
Support shops in basement area	Sq. Ft.	14,000	36.07	505,000
Corridors and courts below podium	LS	---	155,000	155,000
Covered service drive	Sq. Ft.	9,000	34.57	311,000
Utilities	LS	---	590,000	590,000
Site preparation	LS	---	95,000	95,000
Equipment	---	---	---	---
Design	---	---	---	---
Fallout Shelter	---	---	---	-0-
		TOTAL		$2,000,000

PROJECT PURPOSE:

This project will provide essential support utilities for the Electronics Research Center Laboratory Facilities requested for FY 1967.

PROJECT DESCRIPTION:

The project provides for all utilities and facilities beyond and under the building lines including the Podium which is not provided by the building construction. It provides for the extension of utility lines from those installed under prior year programs and new utility services from outside lines of the City and Public Utilities. The project also includes space and mechanical and electrical equipment in 9,000 square feet of mechanical equipment rooms located between the laboratory buildings beneath the podium and provides for covered corridors and open courts connecting the laboratories. Site improvements consist of grading and landscaping of areas exterior to the FY 1967 portion of the complex. Extension of the exterior perimeter Service Drive is provided for access to the new laboratory facilities and for providing covered utility line distribution spaces.

PROJECT JUSTIFICATION:

These Center Support Facilities are required to operate individual laboratories of the Electronics Research Center requested in the FY 1967 budget. Without these necessary utility supports the laboratories will not function.

ESTIMATED FUTURE YEAR FUNDING FOR THIS PROJECT: None

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

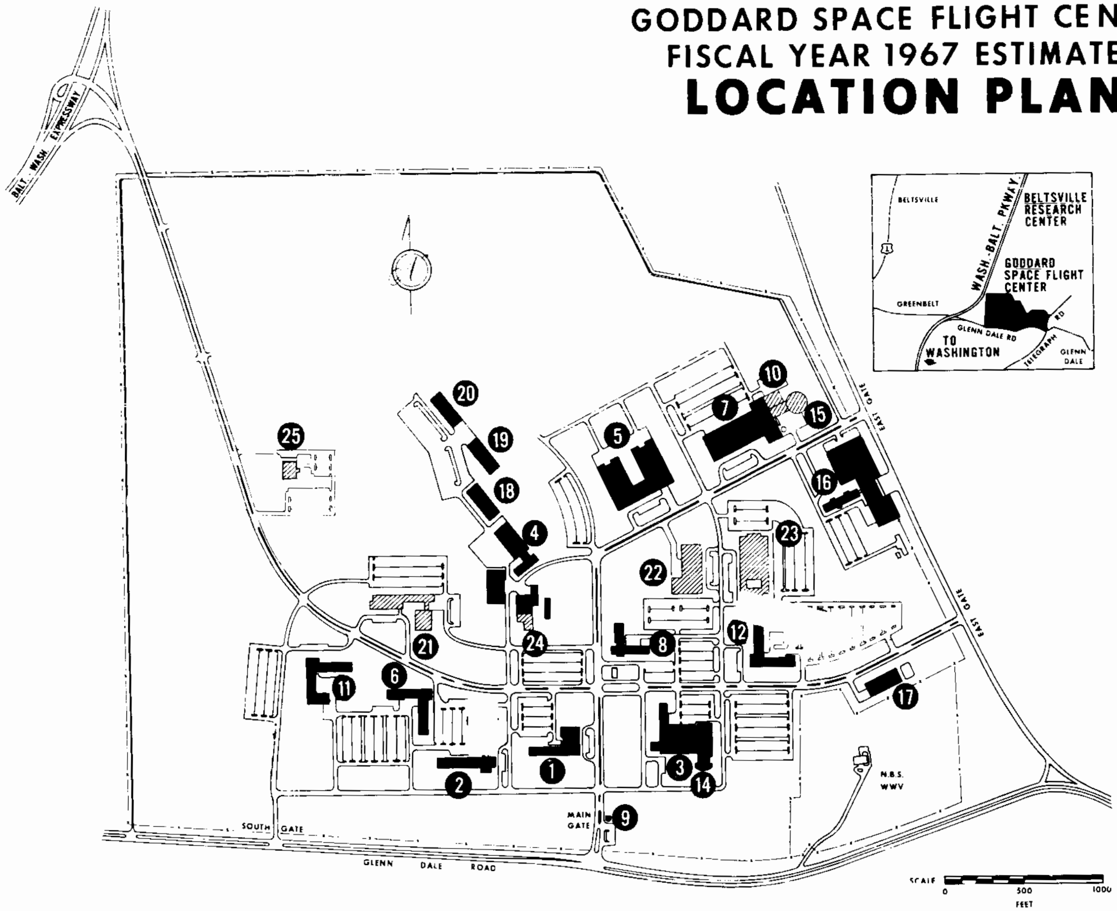
FISCAL YEAR 1967 ESTIMATES

GODDARD SPACE FLIGHT CENTER

GODDARD SPACE FLIGHT CENTER

FISCAL YEAR 1967 ESTIMATES

LOCATION PLAN



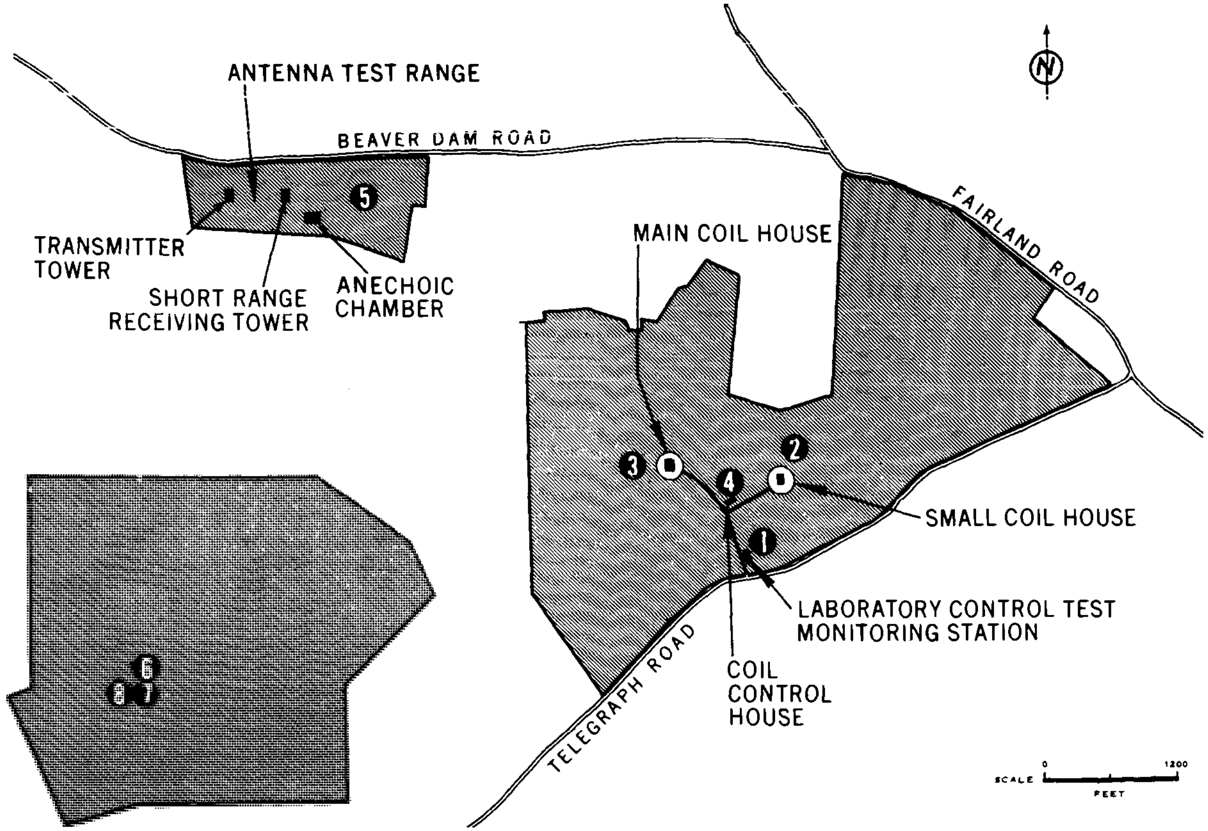
1. SPACE PROJECTS BUILDING
2. RESEARCH PROJECTS LABORATORY
3. CENTRAL FLIGHT CONTROL AND RANGE OPERATIONS LABORATORY
4. BOILER HOUSE AND ELECTRIC SUBSTATION
5. INSTRUMENT CONSTRUCTION AND INSTALLATION LABORATORY
6. SPACE SCIENCES LABORATORY
7. PAYLOAD TESTING FACILITY
8. SATELLITE SYSTEMS LABORATORY
9. GATE HOUSE
10. ENVIRONMENTAL TESTING LABORATORY
11. APPLIED SCIENCES LABORATORY
12. TRACKING AND TELEMETRY LABORATORY
14. SPACECRAFT OPERATIONS FACILITY
15. LAUNCH PHASE SIMULATOR
16. DEVELOPMENT OPERATIONS BUILDING
17. MULTI-PURPOSE BUILDING
18. MULTI-PURPOSE BUILDING
19. MULTI-PURPOSE BUILDING
20. MULTI-PURPOSE BUILDING
21. METEOROLOGICAL SYSTEMS DEVELOPMENT LABORATORY
22. MECHANICAL TEST FACILITY AND QUALITY ASSURANCE LABORATORY
23. DATA INTERPRETATION LABORATORY
24. ADDITION TO CENTRAL HEATING AND REFRIGERATION PLANT
25. NASA SPACE SCIENCE DATA CENTER

EXISTING FACILITIES

FACILITIES UNDER CONSTRUCTION

GODDARD SPACE FLIGHT CENTER
FISCAL YEAR 1967 ESTIMATES

REMOTE SITE AREAS



1 2 MAGNETIC FIELDS COMPONENT TEST FACILITY
3 4 ATTITUDE CONTROL TEST FACILITY
5 ANTENNA TEST RANGE
6 STADAN ENGINEERING & REAL TIME STATION
7 MANNED SPACE FLIGHT TRAINING FACILITY
8 40-FOOT ANTENNA TEST BED

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

INSTALLATION SUMMARY
CONSTRUCTION OF FACILITIES
FISCAL YEAR 19 67 BUDGET ESTIMATES

(Dollars in thousands)

NASA INSTALLATION	COGNIZANT PROGRAM OFFICE FOR INSTALLATION	LOCATION OF INSTALLATION	COUNTY	NEAREST CITY
Goddard Space Flight Center	Space Science and Applications	Greenbelt, Maryland	Prince George's	Greenbelt, Maryland

INSTALLATION MISSION

This Center is responsible for complete development of unmanned sounding rockets and orbiting spacecraft experiments in basic and applied science. The work covers scientific satellites, and communications and weather satellites which orbit in cislunar space (region between the earth and the moon). In addition, the Center manages NASA's Delta rocket and two world-wide tracking, data acquisition and data reduction networks.

PERSONNEL STRENGTH	FY 1965	FY 1966	FY 1967
NASA PERSONNEL *(End of Year)*	3782	3625	3807
CONTRACTOR AND OTHER PERSONNEL	2306	2712	2869
TOTAL ALL PERSONNEL	6088	6337	6676

LAND	NO. ACRES
NASA-OWNED	554
OTHER GOVERNMENT AGENCY-OWNED	650
NON-FEDERAL *(Leases, easements)*	3
TOTAL LAND	1,207
TOTAL CAPITAL INVESTMENT* *(Including NASA-Owned Land) (as of June 30, 1965)*	$ 197,236.0

PROJECT LINE ITEM	COGNIZANT OFFICE	FY 1959 THRU CURRENT YEAR	FY 19 67 *(Estimated)*	FUTURE YEARS *(Estimated)*	TOTAL ALL YEARS *(Estimated)*
Forty-Foot Antenna Test Bed	TDA	10.0	710.0	-	720.0
ALL OTHER PROJECTS		82,227.6			
TOTALS		82,237.6	710.0		

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* *Includes work in process.*

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1967 ESTIMATES

FORTY-FOOT ANTENNA TEST BED

SPACE TRACKING AND DATA ACQUISITION NETWORK (STADAN)

AUTHORIZATION LINE ITEM: Goddard Space Flight Center

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

LOCATION OF PROJECT: Greenbelt, Prince Georges County, Maryland

COGNIZANT NASA INSTALLATION: Goddard Space Flight Center

TYPE OF CONSTRUCTION PROJECT: New

FUNDING:

FY 1966 and Prior Years	$10,000
FY 1967 Estimate	710,000
Total Funding Through FY 1967	$720,000

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$120,000
Operations building addition	Sq. Ft.	1,700	$36.47	62,000
Raised floor system	Sq. Ft.	1,700	5.31	9,000
Servo-mechanical system and shelter	LS	---	2,000	2,000
Antenna and tower foundation	LS	---	14,000	14,000
Roads and walks	Sq. Yd.	1,580	8.22	13,000
Utilities	LS	---	17,000	17,000
Site preparation	Acre	6.5	462.00	3,000

	Unit of Measure	Quantity	Unit Cost	Total Cost
Equipment				$590,000
Antenna mount, reflector, and (2) collimation towers	LS	---	$300,000	300,000
Drive and servo-system	LS	---	200,000	200,000
Installation and testing	LS	---	90,000	90,000
Design	---	---	---	---
Fallout Shelter (Not feasible)	---	---	---	None
		TOTAL		$710,000

PROJECT PURPOSE:

The proposed project will provide Goddard Space Flight Center with a 40-foot antenna test bed for field tests and evaluations of improved data acquisition and control systems prior to their integration into the STADAN Network, and for testing of spacecraft RF compatibility with ground data acquisition and tracking systems.

PROJECT DESCRIPTION:

This project proposes the construction and erection of a 40-foot antenna test bed to be located at the STADAN Engineering and Test Facility site, which is adjacent to the Goddard Space Flight Center. The project includes an addition of seventeen hundred (1,700) square feet of operations area with raised floor system, on the northeast side of the STADAN Engineering and Test Facility. Included also are antenna and collimation tower foundations, a servo-mechanical system with shelter for the antenna, two collimation towers, an electrical distribution system for the antenna and collimation towers, site preparation, and roads. Existing utilities will be extended as required. The equipment to be installed consists of an antenna mount and reflector and an antenna drive and servo-system.

Prototype electronic systems (such as antenna feeds, parametric amplifiers, tracking receivers, time standard, etc.) from prior year SRT programs will be used to equip this 40-foot antenna data acquisition test bed for operational test capacility.

PROJECT JUSTIFICATION:

A 40-foot antenna test bed facility is required at Goddard Space Flight Center to make fundamental measurements of antenna structural parameters and antenna control systems, to perform complete integration and testing of new ground systems, to qualify the overall spacecraft/ground data acquisition system, and to evaluate the systems post-launch.

This facility will permit meaningful antenna structural and control system evaluations and tests on a full scale antenna and associated subsystems. Developments of improved data acquisition subsystems are needed in the STADAN Network to keep abreast of new concepts. Before new systems can be put in the network they must be thoroughly tested under simulated operational conditions in the field. It is not possible to do this testing at STADAN stations because of the operational workload at the stations. The 40-foot antenna test bed will allow a direct operational simulation of STADAN 40-foot antenna performance.

The second requirement for the 40-foot antenna at Goddard is to test spacecraft RF compatibility with ground data acquisition and tracking systems, and to acquire critical real-time data from satellites, including failure situations, where fast reaction is essential. Compatibility testing should be conducted at Goddard during the environmental test phase.

The combination of the developmental test requirements and the spacecraft test and support requirements makes it mandatory to have a 40-foot antenna data acquisition test bed facility at Goddard.

ESTIMATED FUTURE YEAR FUNDING FOR THIS PROJECT: None

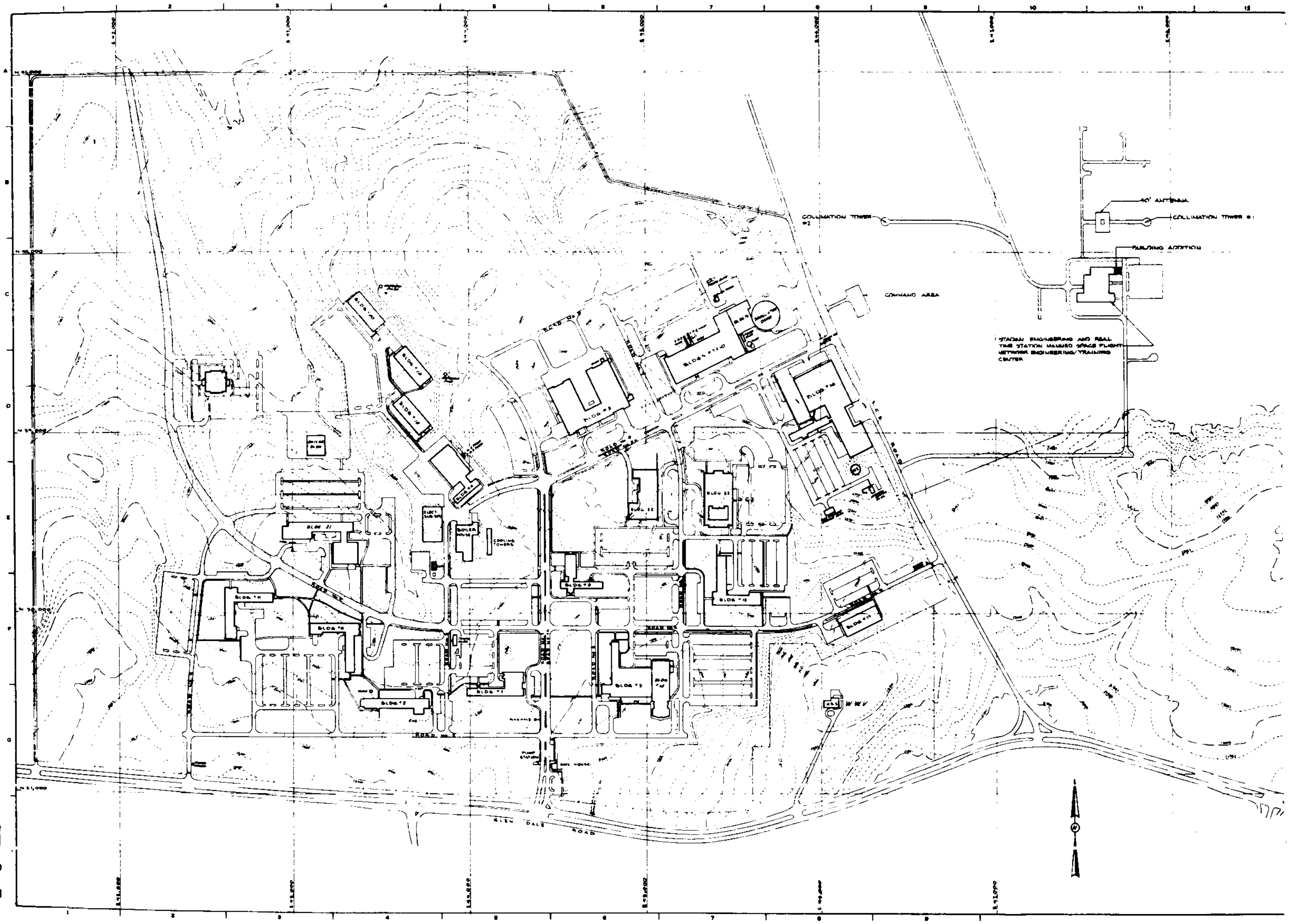
40-FOOT ANTENNA TEST BED

NATIONAL AERONAUTICS & SPACE ADMINISTRATION

GODDARD SPACE FLIGHT CENTER

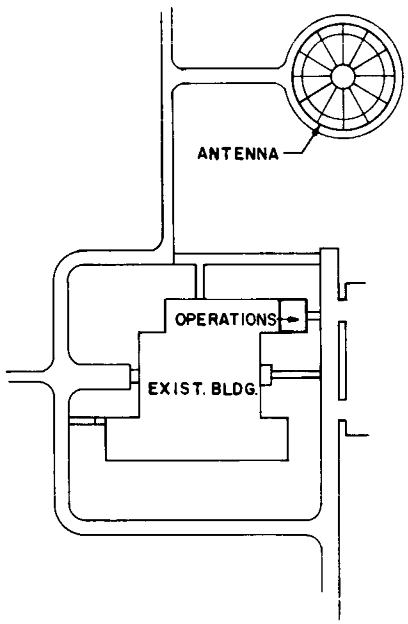
GREENBELT, MARYLAND

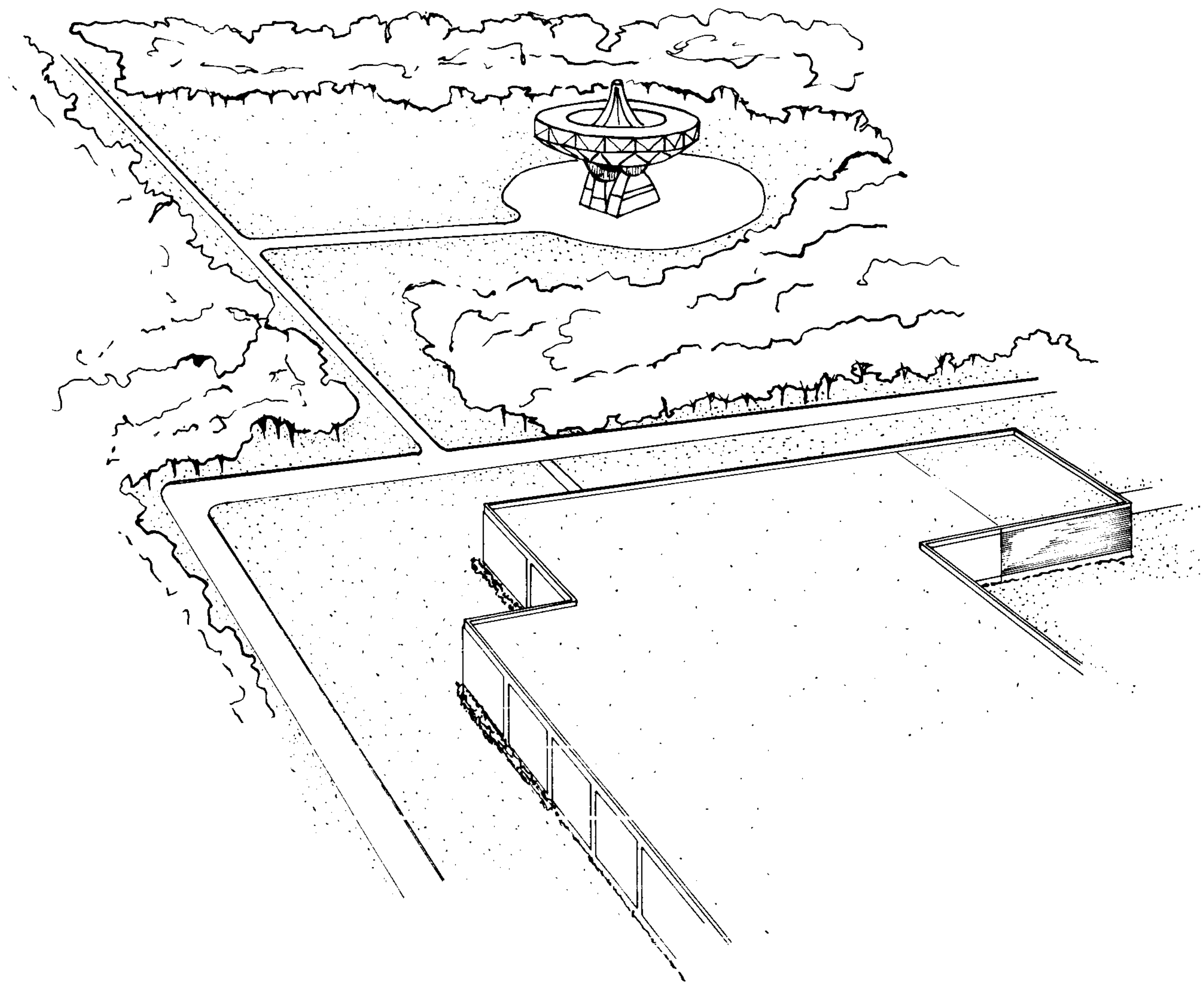
SITE LOCATION PLAN



GODDARD SPACE FLIGHT CENTER
FISCAL YEAR 1967 ESTIMATES

FORTY FOOT ANTENNA TEST BED





NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

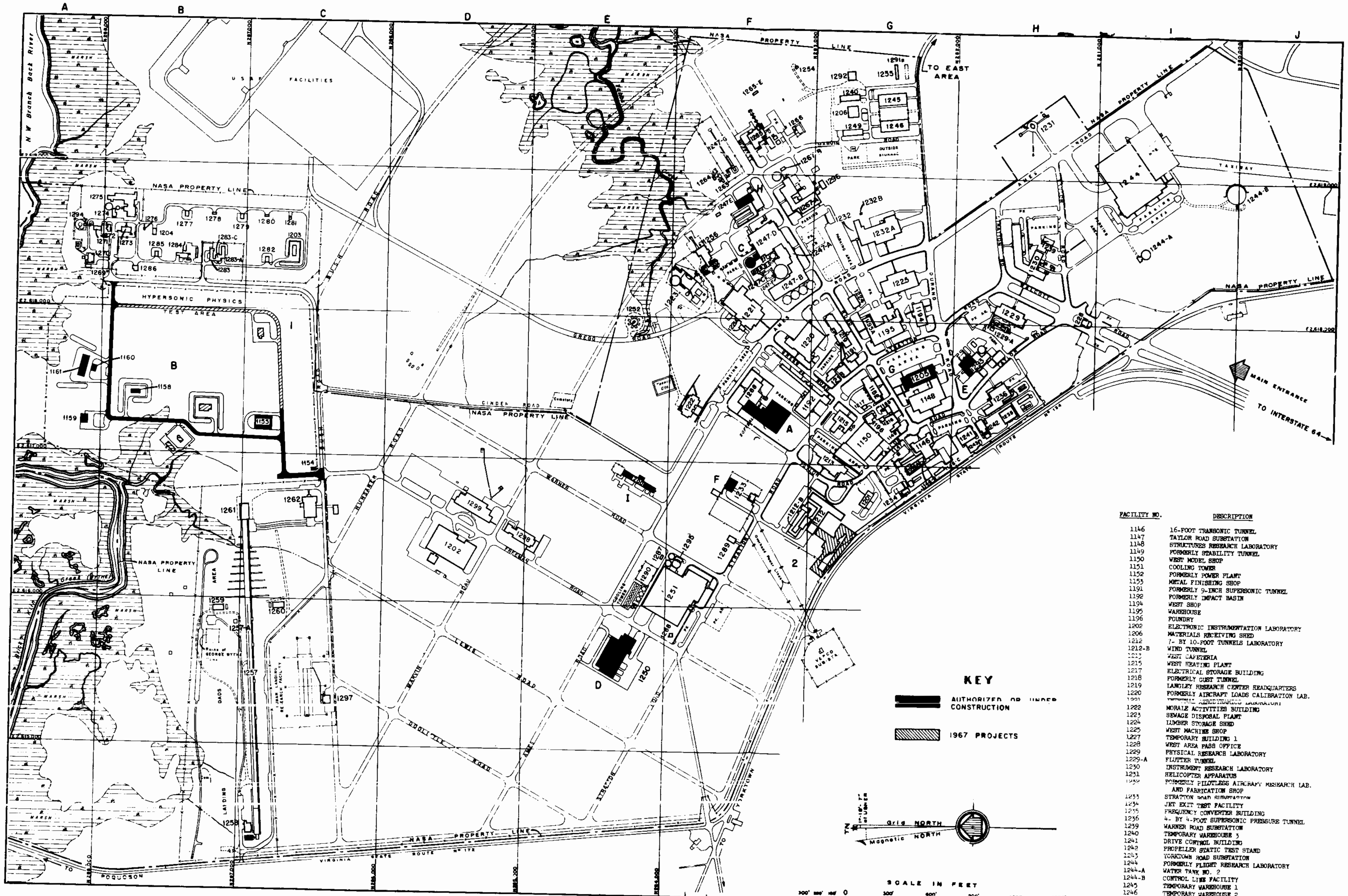
CONSTRUCTION OF FACILITIES

FISCAL YEAR 1967 ESTIMATES

LANGLEY RESEARCH CENTER

LANGLEY RESEARCH CENTER
FISCAL YEAR 1967 ESTIMATES

LOCATION PLAN



PROPOSED FISCAL YEAR 1967 PROJECTS

1. REACTIVE CHEMICAL DISTRIBUTION AREA
2. V/STOL TRANSITION WIND TUNNEL

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
1202	ELECTRONIC INSTRUMENTATION LABORATORY
1206	MATERIALS RECEIVING SHED
1212	7- BY 10-FOOT TUNNELS LABORATORY
1212-B	WIND TUNNEL
1213	WEST CAFETERIA
1215	WEST HEATING PLANT
1217	ELECTRICAL STORAGE BUILDING
1218	FORMERLY GUST TUNNEL
1219	LANGLEY RESEARCH CENTER HEADQUARTERS
1220	FORMERLY AIRCRAFT LOADS CALIBRATION LAB.
1221	[illegible] 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	STRATTON 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
1254	AMMUNITION STORAGE 1

FACILITY NO.	DESCRIPTION
1255	TEMPORARY WAREHOUSE 6
1256	9- BY 6-FOOT THERMAL STRUCTURES TUNNEL
1257	LANDING LOADS TRACK
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	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
1298	STABILIZATION AND CONTROL EQUIPMENT LABORATORY
1299	VEHICLE ANTENNA TEST FACILITY AND ADDITION

FACILITIES AUTHORIZED AND UNDER CONSTRUCTION

- A FLIGHT CONTROL RESEARCH FACILITY
- B MAGAZINE AND TEST AREA FOR HIGHLY REACTIVE CHEMICAL MATERIALS
- C INCD. CAP. FOR MACH 6 AND 8.5 TUNNELS
- D LIFE SUPPORT TECHNOLOGY LABORATORY
- E THERMAL CONTROL HOUSING AND BUILDING ADDITION FOR DYNAMICS RESEARCH LAB.
- F UTILITY IMPROVEMENTS
- G FATIGUE RESEARCH LABORATORY
- H ADDITION TO CENTRAL HIGH-PRESSURE AIR SUPPLY
- I HOT GAS RADIATION RESEARCH FACILITY

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

INSTALLATION SUMMARY
CONSTRUCTION OF FACILITIES
FISCAL YEAR 1967 BUDGET ESTIMATES

(Dollars in thousands)

NASA INSTALLATION	COGNIZANT PROGRAM OFFICE FOR INSTALLATION	LOCATION OF INSTALLATION	COUNTY	NEAREST CITY
Langley Research Center	Advanced Research & Technology	Langley AFB	--	Hampton, Virginia

INSTALLATION MISSION The LRC undertakes 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. The Center plans, develops and operates necessary facilities; generates new and advanced concepts; provides research advice and assistance to other branches of the Government; disseminates scientific and technical information; searches for and identifies potential industrial applications involved in the course of research.

PERSONNEL STRENGTH	FY 19	FY 19	FY 19
NASA PERSONNEL *(End of Year)*	4374	4304	4249
CONTRACTOR AND OTHER PERSONNEL	477	544	587
TOTAL ALL PERSONNEL	4851	4848	4836

LAND	NO. ACRES
NASA-OWNED	540
OTHER GOVERNMENT AGENCY-OWNED	3619
NON-FEDERAL *(Leases, easements)*	17
TOTAL LAND	4176
TOTAL CAPITAL INVESTMENT* *(Including NASA-Owned Land) (as of June 30, 1965)*	$ 276,178

PROJECT LINE ITEM	COGNIZANT OFFICE	FY 1959 THRU CURRENT YEAR	FY 1967 *(Estimated)*	FUTURE YEARS *(Estimated)*	TOTAL ALL YEARS *(Estimated)*
Reactive Chemical Distribution Area	ART	74	1,089	-	1,163
V/STOL Transition Research Wind Tunnel	ART	548	5,011	-	5,559
ALL OTHER PROJECTS		65,264			
TOTALS		65,886	6,100		

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* *Includes work in process.*

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1967 ESTIMATES

REACTIVE CHEMICAL DISTRIBUTION AREA

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 1966 and Prior Years	$74,000
FY 1967 Estimate	1,089,000
Total Funding Through FY 1967	$1,163,000

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$892,800
Liquid propellant magazine - hydrazine	LS	---	$205,200	205,200
Liquid propellant magazine - nitrogen tetroxide	LS	---	160,500	160,500
Liquid propellant magazine - hydrogen peroxide	LS	---	245,400	245,400
Site development	LS	---	281,700	281,700
Equipment				$196,200
Laboratory equipment	LS	---	196,200	196,200

	Unit of Measure	Quantity	Unit Cost	Total Cost
Design	---	---	---	---
Fallout Shelter (Not feasible)	---	---	---	None
		TOTAL		$1,089,000

PROJECT PURPOSE:

This project will provide an area with safe and proper conditions for receiving, interim storage, and distribution for operational use of reactive chemicals employed in various research programs.

PROJECT DESCRIPTION:

The project will consist of a reactive chemical distribution area at the Langley Research Center. It will include three magazines for storage of hydrogen peroxide, hydrazine, and nitrogen tetroxide, with necessary access roads and utilities. Storage capacity will be provided for 200,000 pounds of hydrogen peroxide, 50,000 pounds of hydrazine, and 50,000 pounds of nitrogen tetroxide. The location of this facility will be in an area reserved for hazardous operations. Adequate water pollution control systems have been incorporated into this project.

PROJECT JUSTIFICATION:

The Langley Research Center has an urgent need for a reactive chemical distribution area providing safe and proper conditions for receiving, interim storage, and distribution for operational use of reactive chemicals now employed in various research programs. The limited magazine facilities now available for these reactive liquid propellants are insufficient to meet present and anticipated needs. The use of reactive chemicals has greatly increased with resultant increases in the quantities of these chemicals which must be handled at any one time. These quantities greatly exceed accepted quantity-distance limits for reactive chemicals in those facilities used to handle and dispense such materials. To assure safe operations the Center has necessarily employed special procedures and precautionary measures involving these reactive chemicals which are costly and time-consuming. Increasing program requirements necessitate improved handling facilities to alleviate increasing schedule delays which result from these operating restrictions.

The reactive chemicals are utilized in a wide variety of research efforts, several of which are defined as follows:

Space Mechanics Research: A wide variety of research programs are being conducted on the Lunar Landing Research Facility involving the use of highly reactive liquid propellant fuels and oxidizers. The basic LEM landing research program utilizes large quantities of hydrogen peroxide and is well established with the principal purposes of determining the handling requirement for manned lunar (or other planetary) landing vehicles and establishing piloting techniques for the final letdown, contact and take-off (including aborts). In addition Astronaut Maneuvering Units are presently being developed for space use. These units will require thorough testing under the most realistic conditions possible. A research system is being installed that will permit six-degree-of-freedom operation and testing under zero and lunar "g" conditions. Although most testing will be accomplished with cold gas and peroxide, some operations must be performed with the actual system and the more reactive hydrazine and nitrogen tetroxide propellants. Other various advanced space mechanics research projects are anticipated requiring the cited reactive chemical materials.

Materials Research: Research data are urgently needed on materials for rocket motor components such as nozzles, insulators, etc., which must satisfactorily perform in highly erosive environments at temperatures and pressures of up to 7,800 degrees fahrenheit (F) and 1,000 pounds per square inch (psi) for up to two minutes duration. An existing test apparatus utilizing hydrazine-based fuels and nitrogen tetroxide oxidizer is currently employed in this research. In addition a hybrid gas generator also using nitrogen tetroxide as an oxidizer will be employed in this vital research effort in the near future. This research will permit utilization of higher performance propulsion systems for future launch and space applications.

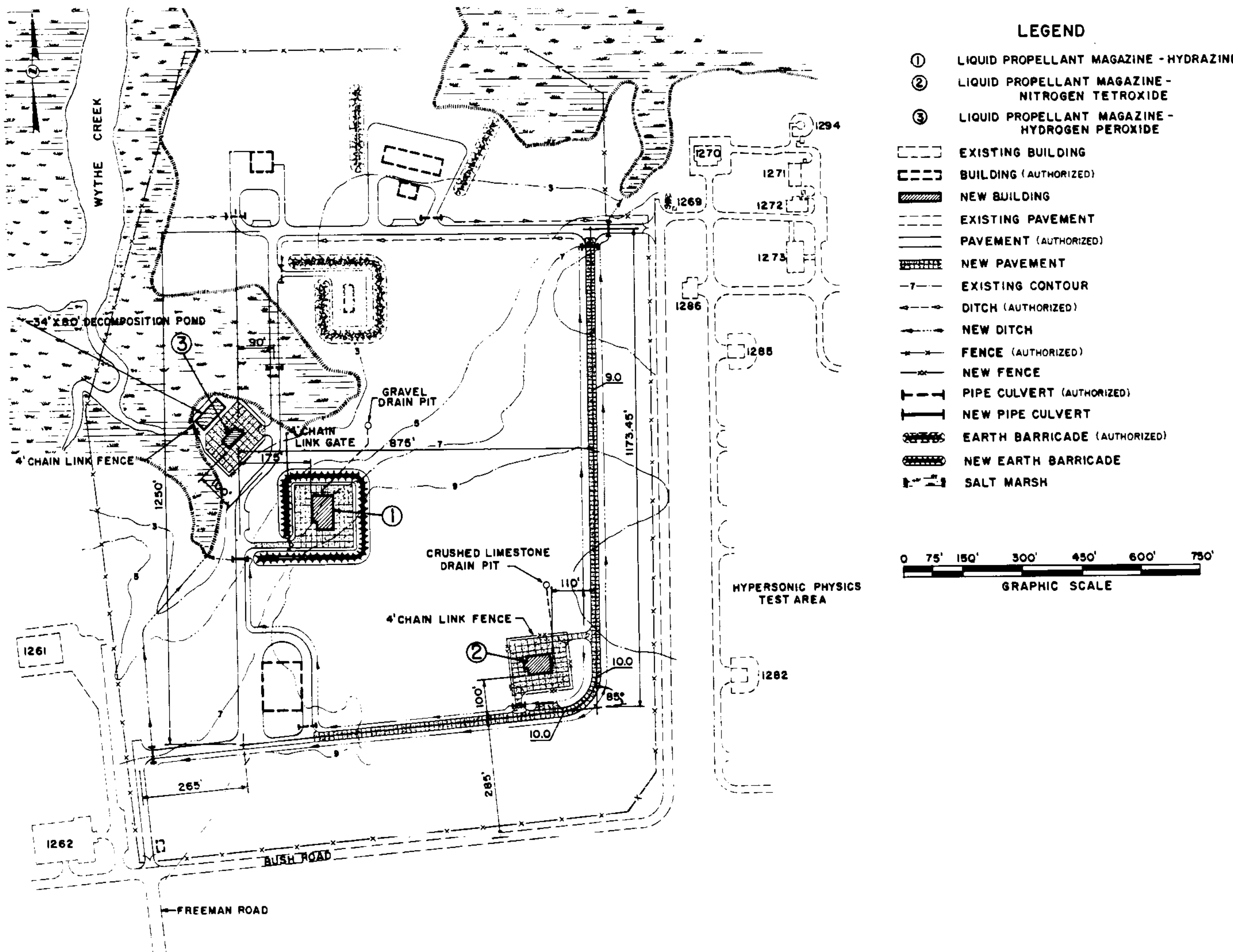
Launch Vehicle Research: A continuing research program into launch vehicle dynamics, guidance and control, thrust augmentation, etc., is being pursued through wind tunnel studies (Langley 16-foot Tunnel) which utilize hydrogen peroxide as an energy source and a flow medium. These studies are providing invaluable research data in the cited areas at a relatively low cost.

Construction of the requested magazine area for reactive liquid propellants will permit meeting of anticipated program needs in these areas of research.

ESTIMATED FUTURE YEAR FUNDING FOR THIS PROJECT: None

LANGLEY RESEARCH CENTER
FISCAL YEAR 1967 ESTIMATES

REACTIVE CHEMICAL DISTRIBUTION AREA



CONSTRUCTION OF FACILITIES

FISCAL YEAR 1967 ESTIMATES

V/STOL TRANSITION RESEARCH WIND TUNNEL

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 1966 and Prior Years	$548,000
FY 1967 Estimate	5,011,000
Total Funding Through FY 1967	$5,559,000

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$3,459,100
Tunnel structure	LS	---	$3,041,600	3,041,600
Site preparation	LS	---	417,500	417,500
Equipment				$1,551,900
Test section	LS	---	733,900	733,900
Instrumentation	LS	---	40,000	40,000
Tunnel drive and system control	LS	---	778,000	778,000
Design	---	---	---	---
Fallout Shelter (Not feasible)	---	---	---	None
		TOTAL		$5,011,000

PROJECT PURPOSE:

This project provides a facility to obtain quantitative research on the factors affecting the stability, control, and performance of V/STOL aircraft in transition and in STOL (short take-off and landing).

PROJECT DESCRIPTION:

The project consists of a closed wind tunnel with a 15 x 21.5 foot test section housed within a 100 x 80 x 60 foot high two-story test chamber. A 15 x 50 foot control room will be located adjacent to the test section on the second floor level of the test chamber. A 50 x 100 x 35 foot high single story model preparation area will be constructed adjacent to the test chamber and will be connected to the shop area of the existing 7 x 10 foot tunnel. The test section will be equipped with a model support system which permits fixing the model in the air stream at varying angles of attack and sideslip, and allows for varying the height of the model over a removable endless belt (moving-ground board installation) capable of simulating landing conditions up to 200 knots. The wind tunnel will be powered by an 8000 horsepower electric motor coupled to a 40 foot diameter propeller.

The existing 300 mph 7 x 10 foot Wind Tunnel at Langley will be demolished and the existing boundary layer piping relocated.

PROJECT JUSTIFICATION:

The development of V/STOL aircraft has progressed to the point where major improvements in the wind tunnel facilities used to obtain quantitative research information on the factors affecting the stability, control, and performance of V/STOL aircraft in transition and in short take-off and landing (STOL) operation are urgently needed. A reliable capability to investigate these characteristics is of vital importance to both military and civilian users.

The test-section-to-model-size-ratio for V/STOL wind tunnel testing must be greater than for conventional aircraft configurations, because the adverse effect of the walls on data accuracy is increased by the higher lift-to-air-velocity conditions of V/STOL flight.

To keep data corrections for wall effects within tolerable limits, i.e. where their uncertainties are not large enough to be significant, and at the same time to use models of sufficient size to represent appropriate details, requires a test section more than 15 x 20 feet in cross section. This provides the same capability for V/STOL research as the 7 x 10 foot wind tunnels have provided for many years in conventional aircraft research.

For several years NASA has crudely approximated this capability by installation of a short test section in the throat of one of the 7 x 10 foot tunnels. Although severely limited in speed, and suffering from very poor flow conditions due to its location and necessarily short test section, studies in this makeshift arrangement have demonstrated beyond doubt the value of the proposed facility which would eliminate these limitations.

Of the wind tunnels available to NASA only two are large enough to meet the size requirements, the 40 x 80 foot tunnel at Ames Research Center and 30 x 60 foot tunnel at Langley Research Center. The 40 x 80 foot tunnel is fully scheduled for two-shift operation, through the end of calendar year 1967, in support of Federal Aviation Agency Programs (large scale models of the Supersonic Transport, "Tee-tail", etc.), Department of Defense Programs (AF-F-111, AF-VTOL fighter, Army helicopter, AF-C5A, AF-CX6, etc.), and NASA programs (lifting reentry bodies, spacecraft recovery parachutes, spacecraft recovery rotors, space capsule aerodynamics, etc.), as well as continuing with NASA basic aerodynamic research. Realistically, it is not possible to consider cancellation or diversion of these full scale programs to accommodate small scale V/STOL research. It is expected that this high utilization rate for the 40 x 80 foot tunnel will be maintained in the foreseeable future.

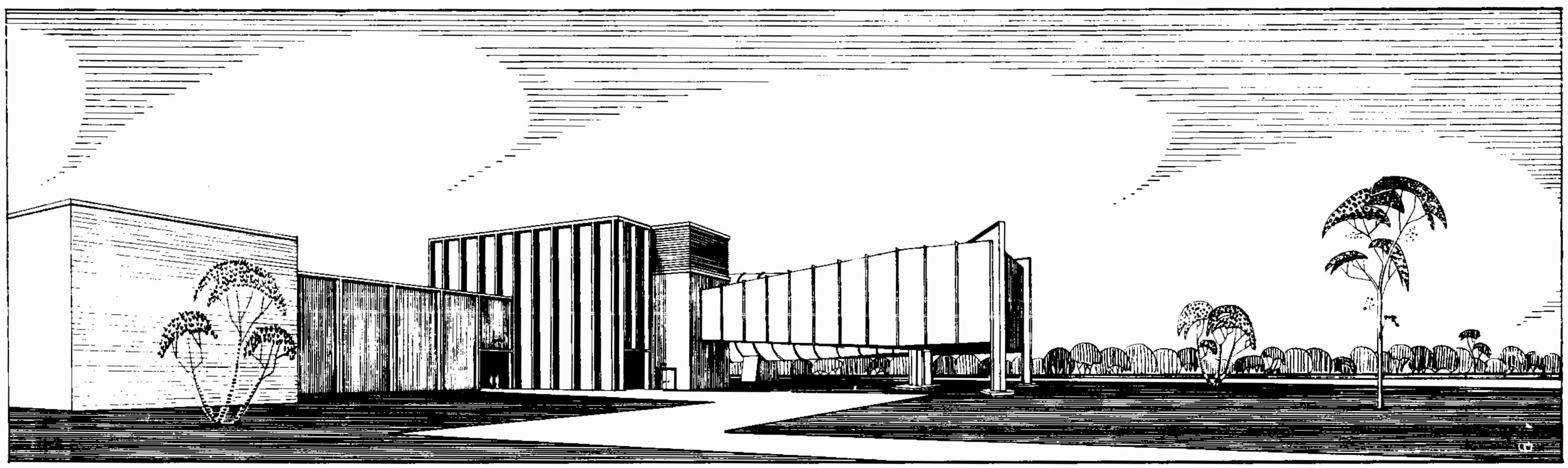
The 30 x 60 foot tunnel is an open throat facility providing a unique capability of making free-flight dynamic stability and control studies of models of new aircraft. It is expected that a high utilization rate for the 30 x 60 foot tunnel will also be maintained in the foreseeable future. Modification of the 30 x 60 foot facility to provide the characteristics desired in the proposed V/STOL facility would be extensive and would require closing of the throat with the resulting loss of the unique free-flight test capability. Extensive modifications to the tunnel-wall liners to provide the contraction ratios required to attain the high transition speeds desired, and a major change in the tunnel drive and power control systems to obtain the flow characteristics required would also be necessary. It has been estimated that the cost for modifying the 30 x 60 foot tunnel **would** be as much as the estimated cost for the new facility.

The proposed facility will provide a vital V/STOL research test capability not readily available in this country. The proposed facility would enable much needed general V/STOL research investigations to be conducted over the complete transition speed range at essentially full scale dynamics conditions. The test section size and configuration have been chosen to minimize the effects of the tunnel wall constraints and Reynolds number at the critical transition speed ranges under consideration in the V/STOL area. Test models of a size permitting the quick modifications desired during research investigations can be easily accommodated in this facility.

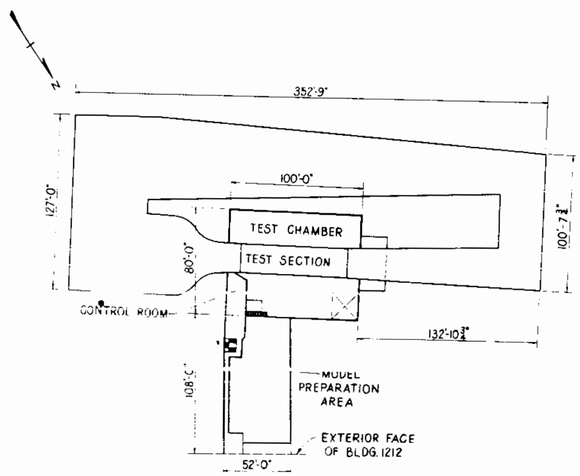
<u>ESTIMATED FUTURE YEAR FUNDING FOR THIS PROJECT:</u> None

LANGLEY RESEARCH CENTER
FISCAL YEAR 1967 ESTIMATES

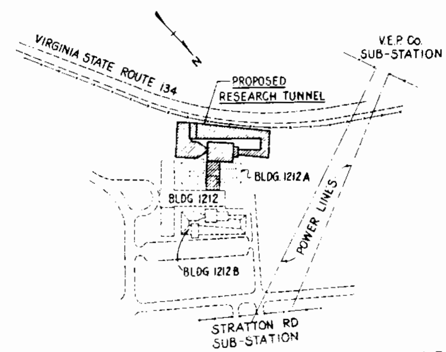
V/STOL TRANSITION RESEARCH WIND TUNNEL



PERSPECTIVE



FLOOR PLAN



PLOT PLAN

LEGEND
EXISTING
DEMOLISH
NEW

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1967 ESTIMATES

LEWIS RESEARCH CENTER

LEWIS RESEARCH CENTER
FISCAL YEAR 1967 ESTIMATES

LOCATION PLAN

LEGEND-EXISTING BUILDINGS

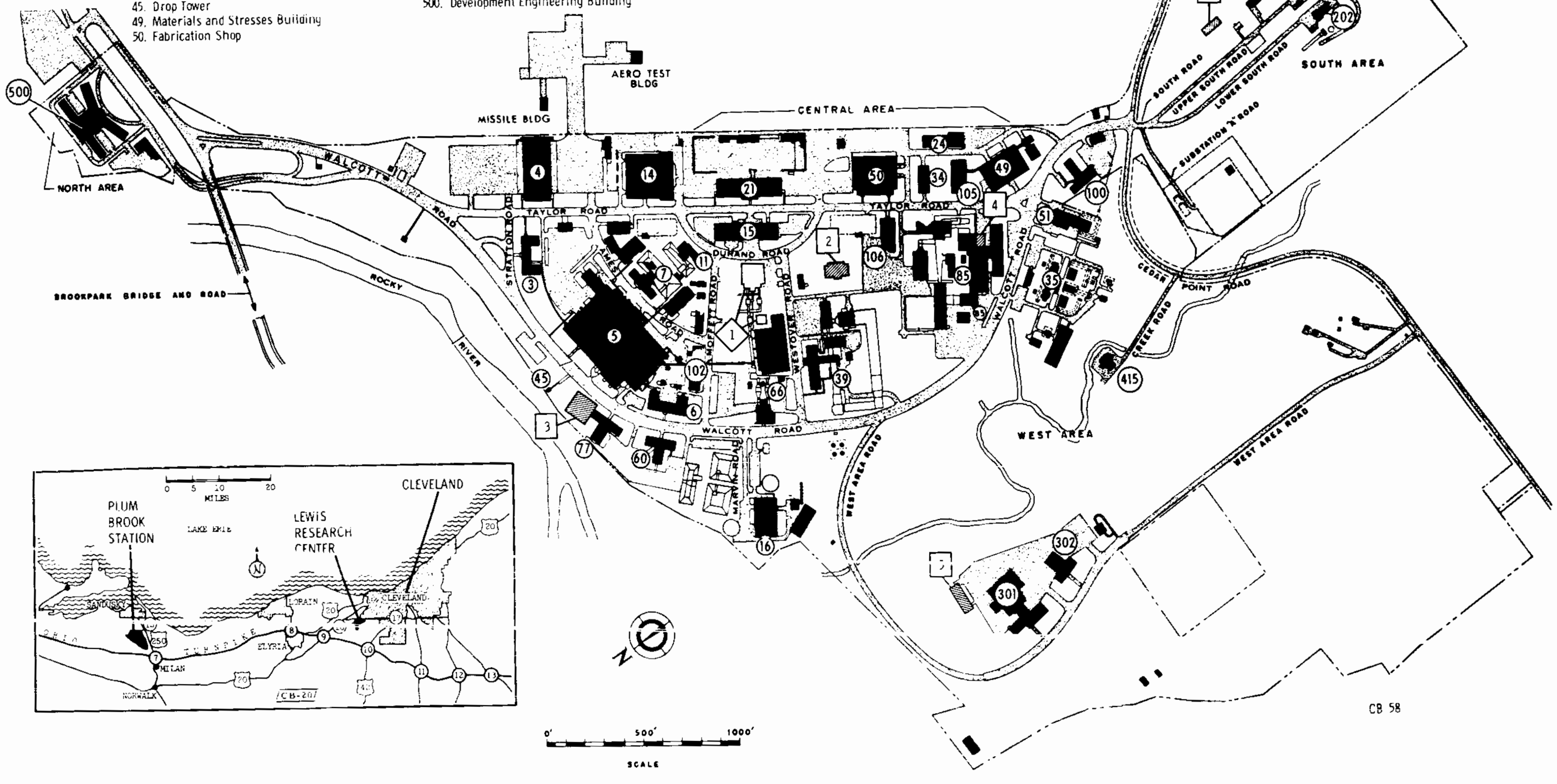
3. Administration Building
4. Flight Research Building
5. Engine Research Building
6. Chemistry Laboratory
7. Space Power Chambers
11. Icing Research Tunnel
14. Technical Services Building
15. Utilities Building
16. Electric Propulsion Research Building
21. Procurement and Supply Building
24. Special Projects Laboratory
34. Liquid Metals Corrosion Laboratory
35. Rocket Laboratory
39. 8x6-Foot Supersonic Wind Tunnel
45. Drop Tower
49. Materials and Stresses Building
50. Fabrication Shop
51. High Energy Fuels Laboratory
60. Propulsion Systems Laboratory Operations Building
66. Propulsion Systems Laboratory
77. Instrument Research Laboratory
85. 10x10-Foot Supersonic Wind Tunnel
100. Rocket Operations Building
102. Liquid Metals Power Laboratory
105. Materials Processing Laboratory
106. Basic Materials Laboratory
202. Rocket Engine Test Facility
203. Fracture Mechanics Laboratory
301. Electric Propulsion Laboratory
302. Energy Conversion Laboratory
415. Rocket Combustion Laboratory
500. Development Engineering Building

FACILITIES AUTHORIZED AND UNDER CONSTRUCTION

1. High-Load Capacity Tensile Testing Facility
2. Zero Gravity Facility
3. Addition to Instrument Research Laboratory
4. Building Addition to the 10x10-Foot Supersonic Wind Tunnel for Data Processing
5. Space Power Research Laboratory

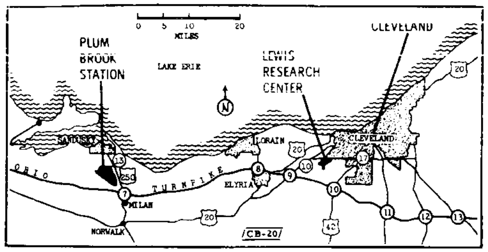
PROPOSED FISCAL YEAR 1967 PROJECTS

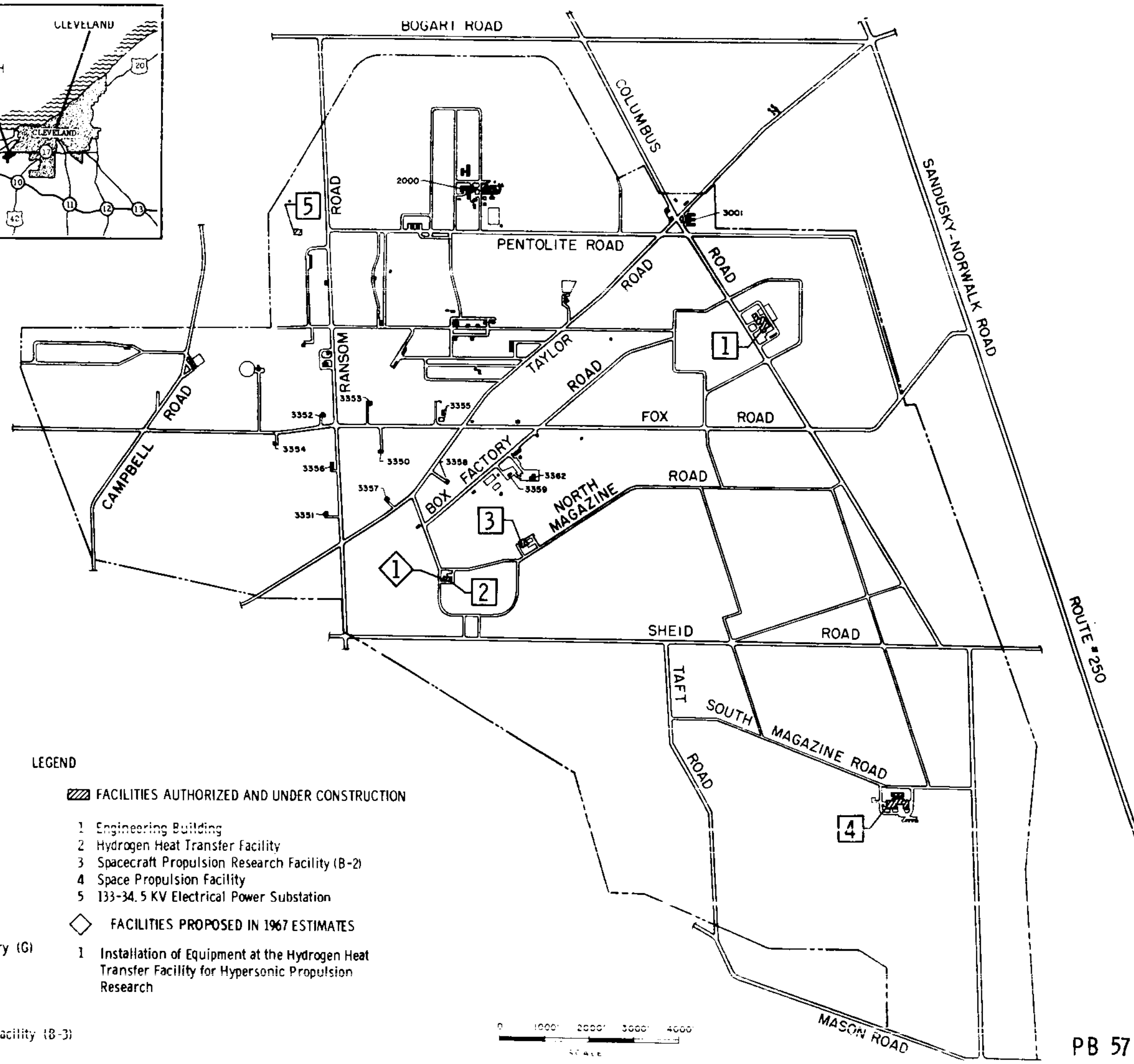
1. Expansion of the Propulsion Systems Laboratory for Supersonic Research



LEWIS RESEARCH CENTER
PLUM BROOK STATION
FISCAL YEAR 1967 ESTIMATES

LOCATION PLAN





LEGEND

▬ EXISTING FACILITIES

2000 Reactor Facility
3001 Administration Building
3350 Rocket Pump Laboratory (A)
3351 Rocket Turbo-pump Laboratory (C)
3352 Rocket Turbine Laboratory (D)
3353 Rocket Systems Dynamics Laboratory (E)
3354 Rocket Systems Hydraulic Laboratory (F)
3355 Rocket Turbine and Pump Pilot Laboratory (G)
3356 Central Control and Data Building (H)
3357 Fluorine Pump Laboratory (I)
3358 Rocket Systems Laboratory (J)
3359 Altitude Rocket Test Facility (B-1)
3362 Nuclear Rocket Dynamics and Controls Facility (B-3)

▨ FACILITIES AUTHORIZED AND UNDER CONSTRUCTION

1 Engineering Building
2 Hydrogen Heat Transfer Facility
3 Spacecraft Propulsion Research Facility (B-2)
4 Space Propulsion Facility
5 133-34.5 KV Electrical Power Substation

◇ FACILITIES PROPOSED IN 1967 ESTIMATES

1 Installation of Equipment at the Hydrogen Heat Transfer Facility for Hypersonic Propulsion Research

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

INSTALLATION SUMMARY
CONSTRUCTION OF FACILITIES
FISCAL YEAR 1967 BUDGET ESTIMATES

(Dollars in thousands)

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

INSTALLATION MISSION The Center provides research and development in the areas of advanced propulsion and space power generation. Basic and applied research is conducted in-house 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. The Center maintains technical management of NASA contracts on chemical and electric propulsion and on nuclear and solar space power systems, including the Centaur and Agena engine programs.

PERSONNEL STRENGTH	FY 1965	FY 1966	FY 1967
NASA PERSONNEL *(End of Year)*	4917	4842	4779
CONTRACTOR AND OTHER PERSONNEL	441	453	510
TOTAL ALL PERSONNEL	5358	5295	5289

LAND	NO. ACRES
NASA-OWNED	6330
OTHER GOVERNMENT AGENCY-OWNED	-
NON-FEDERAL *(Leases, easements)*	65
TOTAL LAND	6395
TOTAL CAPITAL INVESTMENT* *(Including NASA-Owned Land) (as of June 30, 19 65)*	$ 265,754

PROJECT LINE ITEM	COGNIZANT OFFICE	FY 1959 THRU CURRENT YEAR	FY 19 67 *(Estimated)*	FUTURE YEARS *(Estimated)*	TOTAL ALL YEARS *(Estimated)*
Expansion of Propulsion Systems Laboratory for Supersonic Research (Cleveland)	ART	700	14,000	-	14,700
Installation of Equipment at Hydrogen Heat Transfer Facility for Hypersonic Propulsion Research (Plum Brook)	ART	197	2,000	-	2,197
ALL OTHER PROJECTS		91,228			
TOTALS		92,125	16,000		

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* *Includes work in process.*

1/ Includes Plum Brook Station at Sandusky, Ohio.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1967 ESTIMATES

EXPANSION OF THE PROPULSION SYSTEMS LABORATORY FOR SUPERSONIC RESEARCH

AUTHORIZATION LINE ITEM: Lewis Research Center

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

LOCATION OF PROJECT: Lewis Research Center, Cleveland, Cuyahoga County, Ohio

COGNIZANT NASA INSTALLATION: Lewis Research Center

TYPE OF CONSTRUCTION PROJECT: New

FUNDING:

FY 1966 and Prior Years	$700,000
FY 1967 Estimate	14,000,000
Total Funding Through FY 1967	$14,700,000

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$1,350,000
Site improvements	LS	---	$20,000	20,000
Utilities and miscellaneous items	LS	---	140,000	140,000
Special construction, foundations, pads	LS	---	400,000	400,000
Hot turbine and engine test building	Sq. Ft.	31,000	21.61	670,000
Cold turbine cell	Sq. Ft.	5,200	17.30	90,000
Expansion of cooling tower water pump house	Sq. Ft.	2,070	14.49	30,000
Equipment				$12,650,000
Combustion air systems and heaters	LS	---	3,300,000	3,300,000

	Unit of Measure	Quantity	Unit Cost	Total Cost
Altitude exhaust system and coolers	LS	---	$5,200,000	$5,200,000
Test chambers	LS	---	845,000	845,000
Dynamometers, gear boxes, hydraulic system	LS	---	1,020,000	1,020,000
Cranes and safety systems, fuel systems	LS	---	575,000	575,000
Cooling towers and piping	LS	---	585,000	585,000
Electrical controls systems	LS	---	500,000	500,000
Data acquisition systems	LS	---	600,000	600,000
Process electric power and communication systems	LS	---	25,000	25,000
Design	---	---	---	---
Fallout Shelter (Not feasible)	---	---	---	None
		TOTAL		$14,000,000

PROJECT PURPOSE:

The purpose of this project is to provide a facility for full scale research on advanced engine components and engines to power supersonic airplanes at speeds up to Mach 3.

PROJECT DESCRIPTION:

The project consists of three test chambers for conducting full scale research of engine components and engines under cold flow and operating conditions. The test chambers will be connected to combustion air and exhaust systems of the existing Propulsion Systems Laboratory. Additional air heaters and exhaust gas coolers will provide the test conditions of 535 pounds of air per second at 165 pounds per square inch (psi), up to 1,200 degrees Fahrenheit (F.), and to reduce 3,500° F. exhaust gas to 170° F. Research runs of one hour at 100 percent power or seven hours at 40 percent power will be possible. Fuels will be delivered at ranges up to 320 gallons per minute, 500 psi, and at temperatures up to 500° F.; existing storage capacity is up to 100,000 gallons. Remote control operation of the system will be provided with monitoring of engine function and data acquisition. Data will be taken with 200 channels each of high and low speed digital recording wired directly to the existing central data system. The system will provide instant readback to operations personnel, plus permanent records. Safety systems will provide detection of various hazards, and fire control. Television monitoring will be provided for surveillance of the test chambers and other parts of the facility. Air intakes and exhausts will be treated to provide acceptable noise level.

Industrial type structures will house the chambers and service areas. Brick masonry portions contain control and data acquisition rooms. The facility will occupy approximately two acres at the Lewis Research Center and the site selection has been carefully determined by functional connections as well as economic considerations in association with the existing equipment of the Propulsion Systems Laboratory. Modifications are involved in increases of capacity of the cooling tower, basins and water pump house. Generally, structures will be of concrete foundations, steel frame, masonry and metal siding, acoustically treated, all compatible in design with adjacent Center structures.

PROJECT JUSTIFICATION:

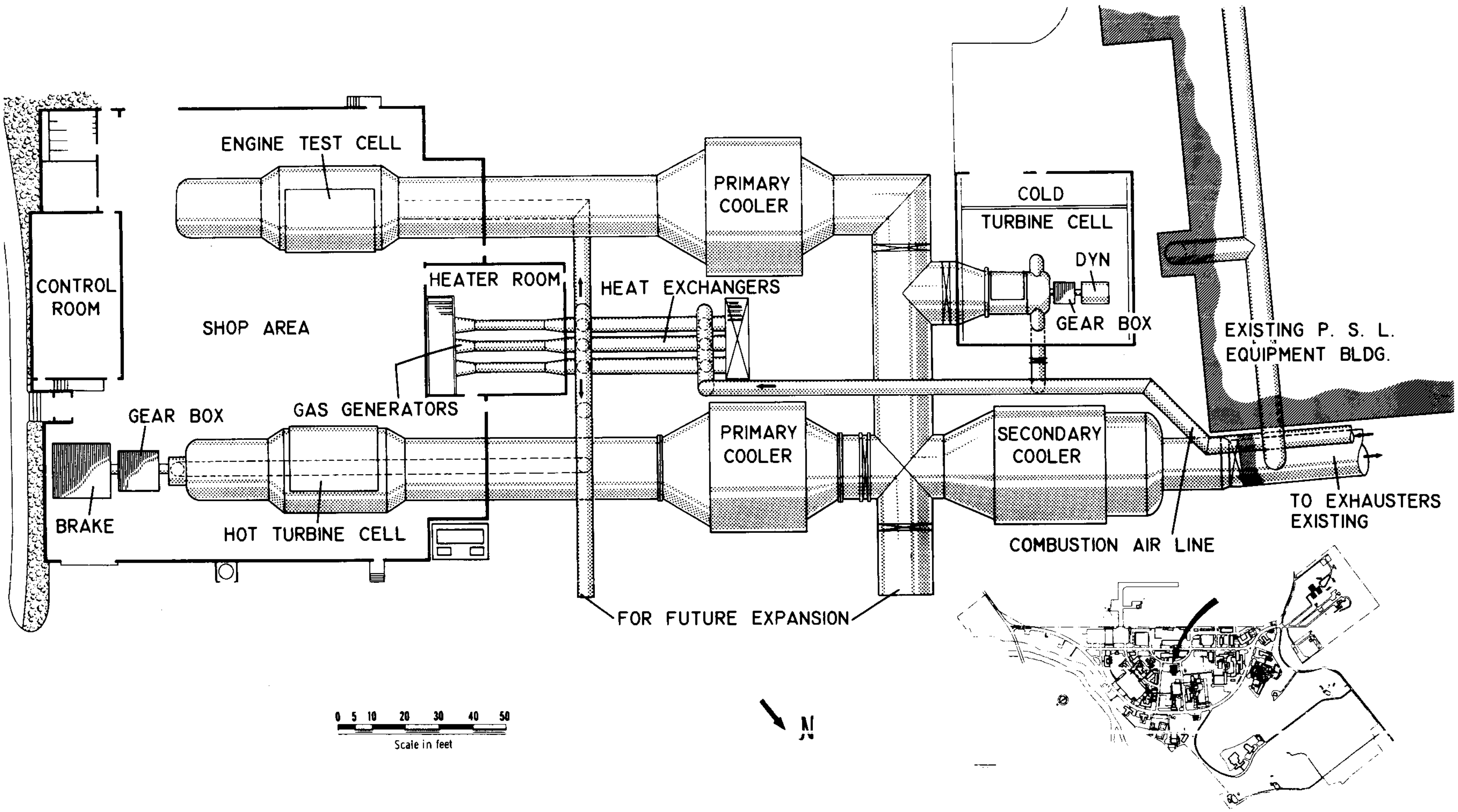
Intensive research and extensive testing of engine components and engines must be done in order to provide economically feasible and thoroughly reliable supersonic aircraft engines. The testing and research required must be performed under simulated flight conditions, and facilities for such demands do not now exist. The Propulsion Systems Laboratory at Lewis Research Center is now able to provide exhauster and compressor capacity for the simulation required and is singularly equipped with other equipment such as central data systems, basic heating capacity and basic cooling capacity so as to provide a strong support for developing the ultimate needs of test facilities for supersonic engine research.

This research is urgently required and the proposal herein offers the most expeditious and economical method of providing suitable facilities for the task.

ESTIMATED FUTURE YEAR FUNDING FOR THIS PROJECT: None

LEWIS RESEARCH CENTER
FISCAL YEAR 1967 ESTIMATES

EXPANSION OF THE PROPULSION SYSTEMS LABORATORY FOR SUPERSONIC RESEARCH



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CONSTRUCTION OF FACILITIES

FISCAL YEAR 1967 ESTIMATES

INSTALLATION OF EQUIPMENT AT THE HYDROGEN HEAT TRANSFER FACILITY
FOR
HYPERSONIC PROPULSION RESEARCH

AUTHORIZATION LINE ITEM: Lewis Research Center

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

LOCATION OF PROJECT: Plum Brook Station, Sandusky, Erie County, Ohio

COGNIZANT NASA INSTALLATION: Lewis Research Center

TYPE OF CONSTRUCTION PROJECT: Modifications and Additions

FUNDING:

FY 1966 and Prior Years	$197,000
FY 1967 Estimate	2,000,000
Total Funding Through FY 1967	$2,197,000

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$170,600
Site improvements	LS	---	$120,100	120,100
Building modifications	LS	---	7,300	7,300
Building addition	Sq. Ft.	2,400	18.00	43,200
Equipment				$1,829,400
Gas storage and fuel systems	LS	---	347,800	347,800
Fuel heater	LS	---	59,600	59,600
Transition elbow for pebble bed heater	LS	---	28,000	28,000
N2-02 mixing chamber	LS	---	31,700	31,700
Nozzles	LS	---	398,500	398,500

	Unit of Measure	Quantity	Unit Cost	Total Cost
Test Chamber	LS	---	82,000	82,000
Diffuser	LS	---	28,900	28,900
Cooling water systems	LS	---	41,600	41,600
Spray cooler	LS	---	50,800	50,800
Steam supply systems	LS	---	337,500	337,500
Ejector	LS	---	47,500	47,500
Safety systems	LS	---	64,600	64,600
Instrumentation	LS	---	225,600	225,600
Electrical controls	LS	---	85,300	85,300
Design	---	---	---	---
Fallout Shelter (Not feasible)	---	---	---	None
		TOTAL		$2,000,000

PROJECT PURPOSE:

The purpose of this project is to add equipment to the Hydrogen Heat Transfer Facility to provide a free jet in which to conduct hypersonic propulsion research at Mach 5-7 with a primary objective of testing and developing supersonic burning ram jet engines and components of reasonable scale.

PROJECT DESCRIPTION:

The equipment addition to the Hydrogen Heat Transfer Facility will provide a Mach 5-7 free jet having true air composition and altitude simulation to simulate representative flight trajectories. Nitrogen gas will be heated to 4500 degrees Rankine (R) in the existing graphite pebble bed heat exchanger and will be mixed with oxygen or a nitrogen-oxygen mixture to achieve a true air composition at a temperature of 2900 degrees Rankine (R). Stagnation pressure will be 1200 pounds per square inch.

It is proposed to provide a graphite lined transition section and elbow to the existing pebble bed heater. Also provided will be a nitrogen-oxygen mixing chamber downstream of the heater. The equipment will include three interchangeable hypersonic nozzles (each approximately 15 feet long) which will produce Mach 5, 6, and 7 free jets about 42 inches diameter. The test chamber will be about 12 feet in diameter by 18 feet long and will include an engine mount for force measurement devices. Connected to the test chamber will be a 40 foot long diffuser section discharging to atmosphere through a spray cooler and steam driven ejector exhaust system. Cooling water will be provided for the nozzles, test chamber, diffuser and spray cooler.

Existing hydrogen storage will be utilized as a fuel source for the research engine. Additional nitrogen-oxygen gas storage will be provided and existing gas storage will be relocated to accommodate this project. An extension to the existing facility building will be provided to house the test chamber and nozzle.

PROJECT JUSTIFICATION:

Development and testing of air-breathing engines in the hypersonic speed range requires the availability of large heated air facilities with capability of close simulation of flight static temperature, pressure, and Reynolds number. At Lewis Research Center and elsewhere, a major deterrent to research and development in the hypersonic range of air-breathing engines is the lack of any facility which can test complete engines above Mach 5 with complete simulation. There are a number of research problems which have not been resolved at Mach 5-7 including inlet-burner matching, ignition, fuel-air mixing, thermal choking, cooling and structures.

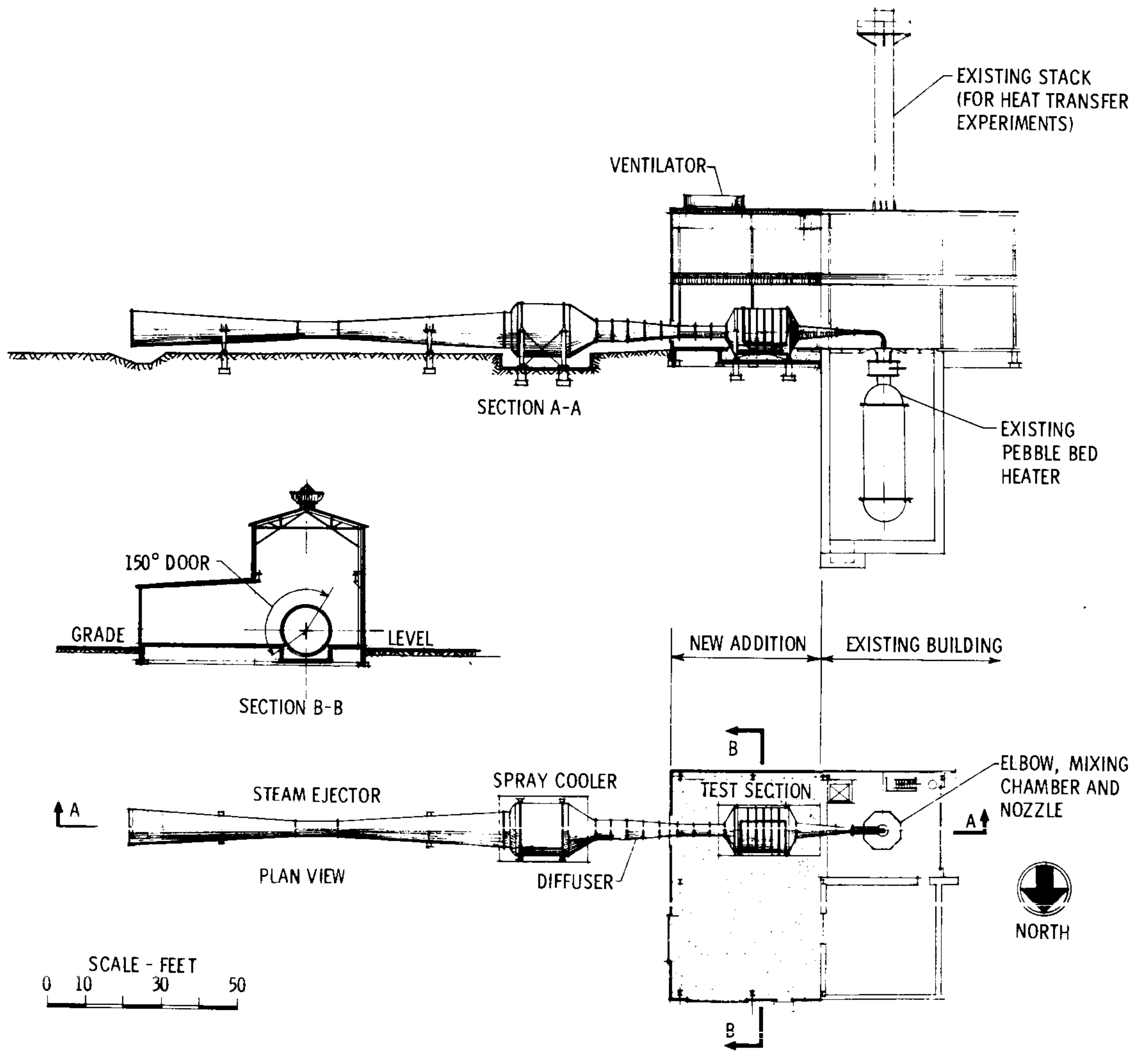
This request is concerned with a facility using a concept that has not been previously used. The heater materials problem is obviated to some extent by using graphite to heat nitrogen, and mixing the oxidant downstream of the graphite heater. With this scheme, Mach 5-7 conditions can be simulated by mixing hot nitrogen with oxygen or oxygen- nitrogen mixtures.

Installation of this equipment will not reduce the facility capability for heat transfer experiments.

ESTIMATED FUTURE YEAR FUNDING FOR THIS PROJECT: None

LEWIS RESEARCH CENTER
PLUM BROOK STATION
FISCAL YEAR 1967 ESTIMATES

INSTALLATION OF EQUIPMENT AT HYDROGEN HEAT TRANSFER FACILITY FOR HYPERSONIC PROPULSION RESEARCH



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1967 ESTIMATES

VARIOUS LOCATIONS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

INSTALLATION SUMMARY
CONSTRUCTION OF FACILITIES
FISCAL YEAR 19 67 BUDGET ESTIMATES

(Dollars in thousands)

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

INSTALLATION MISSION

PERSONNEL STRENGTH	FY 1965	FY 1966	FY 1967
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)*	Not
TOTAL LAND	Applicable
TOTAL CAPITAL INVESTMENT* *(Including NASA-Owned Land) (as of June 30, 1965)*	$ Not Applicable

PROJECT LINE ITEM	COGNIZANT OFFICE	FY 1962 THRU CURRENT YEAR	FY 1967 *(Estimated)*	FUTURE YEARS *(Estimated)*	TOTAL ALL YEARS *(Estimated)*
Facilities for S-IVB Stage Program	MSF	11,496.2	1,100.0	-	12,596.2
Launch Vehicle Service Tower	SSA	145.0	2,443.0	-	2,588.0
Aerobee 350 Launch Facility	SSA	60.0	1,200.0	-	1,260.0
Spin Test Facility	SSA	38.0	745.0	-	783.0
Water Distribution and Sewage Disposal Systems	TDA	146.0	990.0	-	1,136.0
ALL OTHER PROJECTS		608,010.5			
TOTALS		619,895.7	6,478.0		

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* *Includes work in process.*

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1967 ESTIMATES

WATER DISTRIBUTION AND SEWAGE DISPOSAL SYSTEMS

AUTHORIZATION LINE ITEM: Various Locations

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

LOCATION OF PROJECT: Goldstone Complex, Fort Irwin, California

COGNIZANT NASA INSTALLATION: Jet Propulsion Laboratory

TYPE OF CONSTRUCTION PROJECT: New

FUNDING:

FY 1966 and Prior Years	$146,000
FY 1967 Estimate	990,000
Total Funding Through FY 1967	$1,136,000

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$915,000
Sanitary sewer	LF	5,640	$4.61	26,000
Septic tanks	LS	---	27,000	27,000
Oxidation ponds	LS	---	31,000	31,000
Water distribution system	LF	148,000	4.65	689,000
Storage tanks	GAL	400,000	0.35	142,000
Equipment				$75,000
Substation	KVA	112.5	44.40	5,000
Effluent pumping station	LS	---	21,000	21,000
Booster pumping station	LS	---	49,000	49,000
Design	---	---	---	---

	Unit of Measure	Quantity	Unit Cost	Total Cost
Fallout Shelter (Not feasible)	---	---	---	None
		TOTAL		$990,000

PROJECT PURPOSE:

The proposed water and sewage utilities will provide the Goldstone complex with an adequate water supply and sewage disposal system to accommodate the present demands and future requirements.

PROJECT DESCRIPTION:

Water Supply - The water distribution system will begin with the installation of a pumphouse at the new one million gallon water storage tank presently being constructed by the Corps of Engineers approximately one mile west of Fort Irwin along the road to Goldstone. Under this project the water will be pumped from this tank to a primary storage tank at the Venus site. From the primary tank, water will flow by gravity to storage tanks at each site. The tanks at each site will feed water to the site distribution system by gravity. Each site will be protected with check valves and the tanks will have sufficient capacity to maintain operations at the site during periods of repair or shutdown of the primary storage tank.

Sewage Disposal - Due to existing conditions, each site in the Goldstone complex will have slightly different methods of sewage disposal. The methods are listed below:

Echo - Three (3) septic tanks will be added at this site. The effluent from these and the existing tanks will discharge into a central collecting system and flow by gravity to an oxidation pond.

Venus - The requirement at this site is to install two (2) additional septic tanks and to enlarge the existing tile fields.

Pioneer - An additional septic tank will be added and the liquid will be pumped to an oxidation pond east of the dry lake.

Mars - Three (3) additional septic tanks will be added. These tanks will be connected to the existing tile fields. Excess flow to these tile fields will be conveyed to oxidation ponds.

Antenna Range - The existing tile field will be enlarged.

PROJECT JUSTIFICATION:

The individual sites that comprise the Goldstone complex are presently supplied with water by a tank truck hauling water from Fort Irwin to storage tanks at each site. Continued expansion of the Goldstone facilities has created a continually growing demand for water. It is not possible nor economically feasible to attempt to continue supplying water in the present manner. The proposed system will supply an adequate amount of water to provide operational capability on a twenty-four hour, three-hundred sixty-five day cycle. As the state of the art increases, the demand for water to maintain operational temperatures for the electronic equipment constantly increases resulting in more hauling time under present conditions. The functional capability of the present sewage disposal systems in the Goldstone complex has been exceeded due to the increase in personnel, thus providing more effluent, and the inability of the soil due to its cementaceous nature to accommodate the increased flow. The proposed systems will eliminate the presently incurred expenses due to continual septic tank pumping and the blocking of the sanitary facilities at the sites. The present proposal is designed to provide adequate capacity and treatment for the existing facilities and any reasonable future expansion.

ESTIMATED FUTURE YEAR FUNDING FOR THIS PROJECT: None

GOLDSTONE COMPLEX, FORT IRWIN, CALIFORNIA
CONSTRUCTION OF FACILITIES
FISCAL YEAR 1967 ESTIMATES

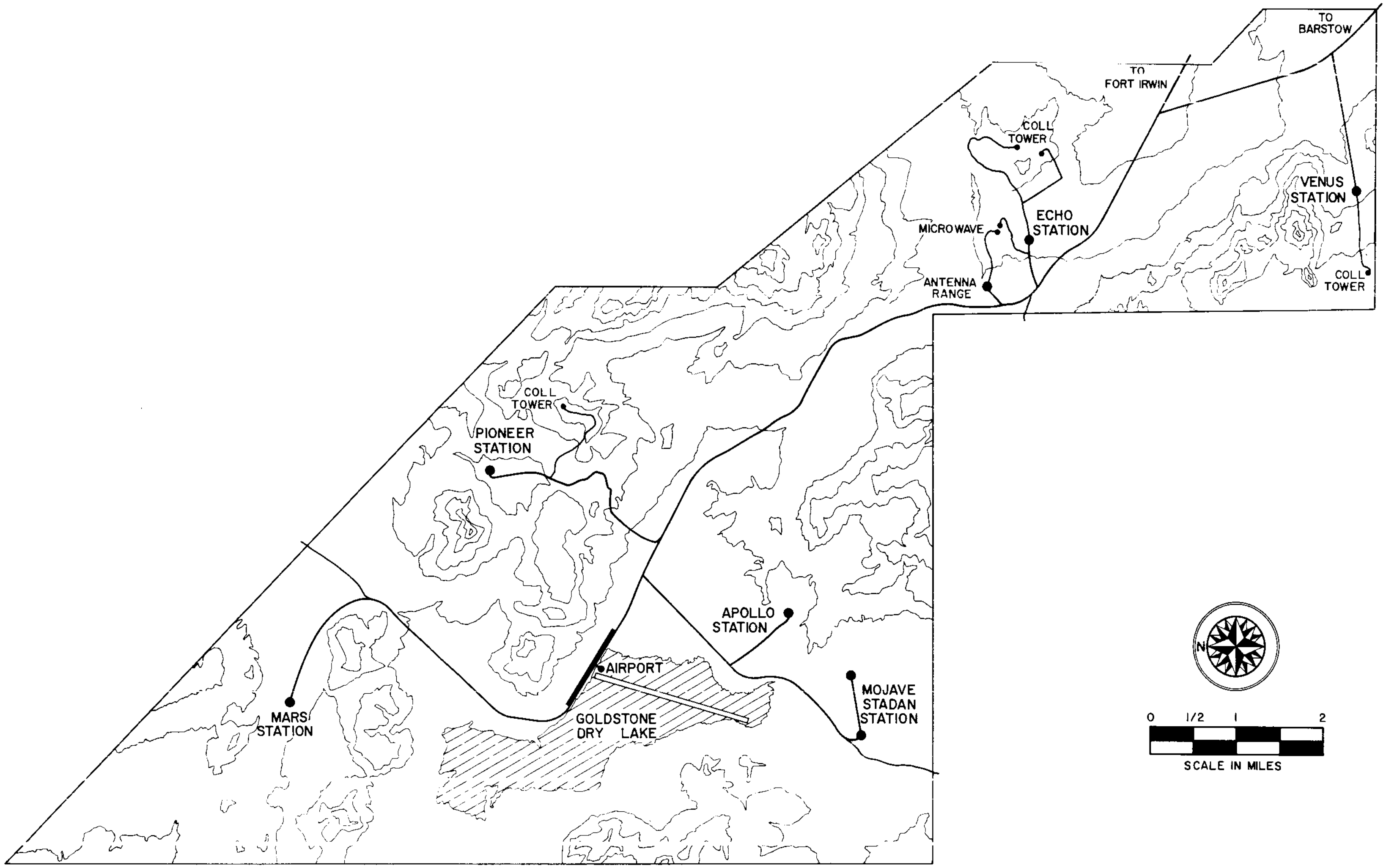
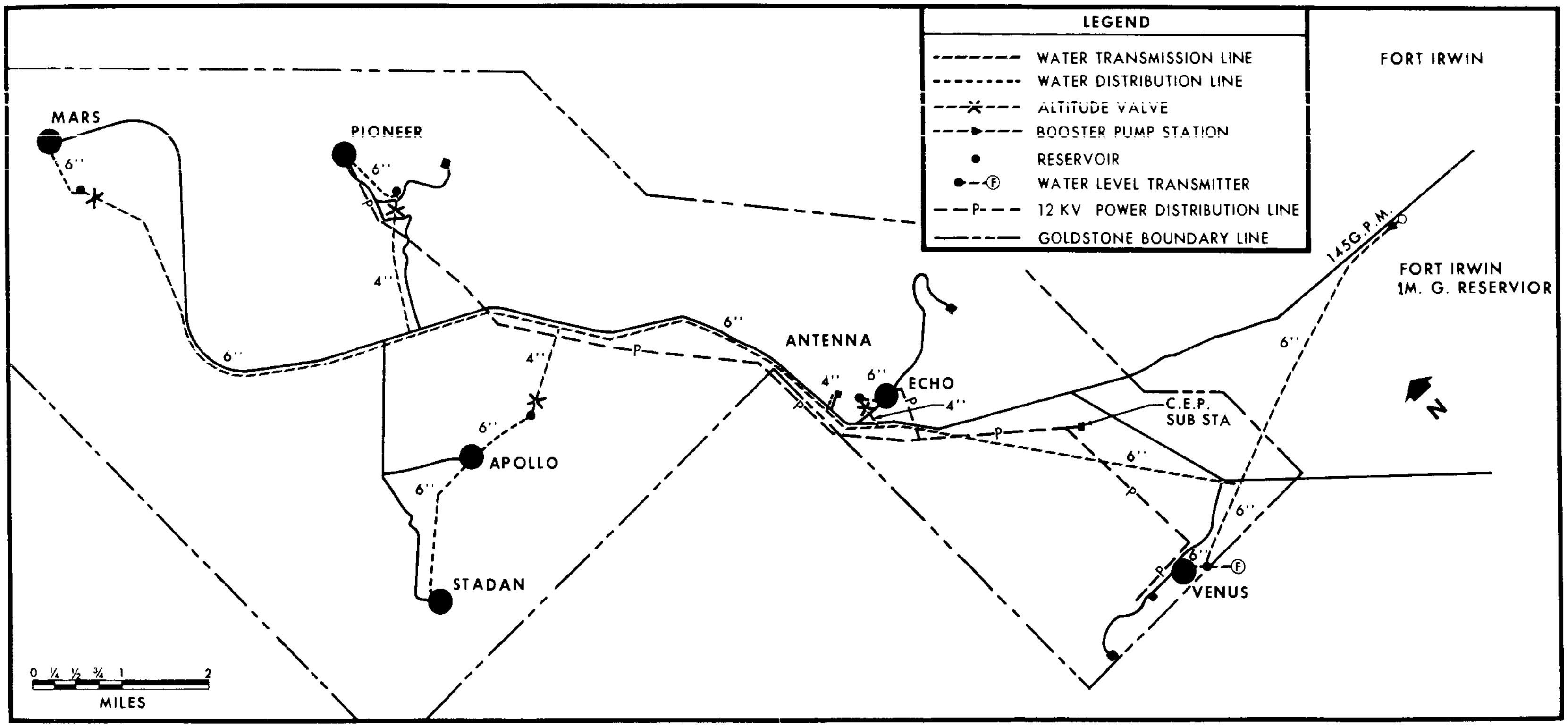
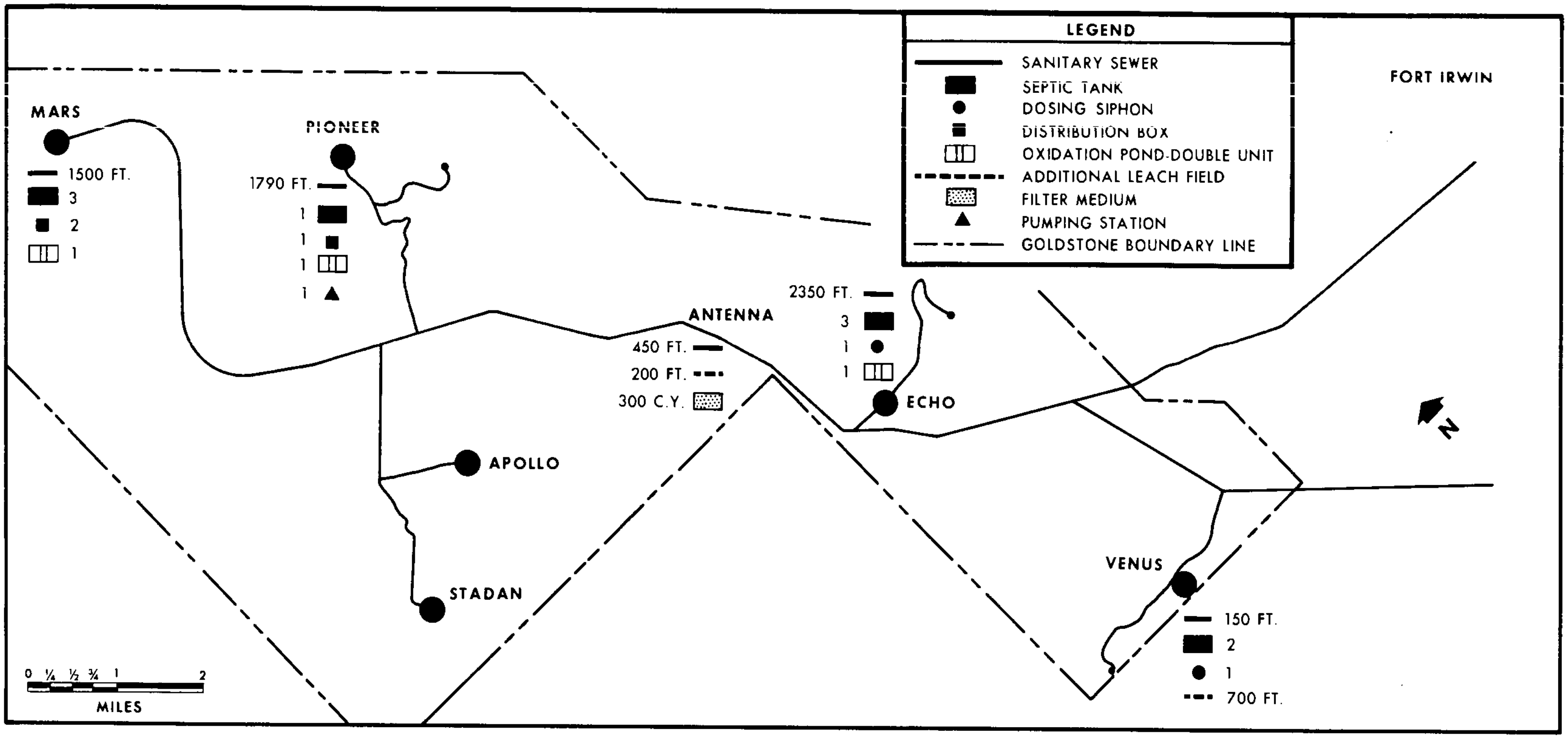


FIGURE STATION VICINITY MAP



GOLDSTONE COMPLEX, FORT IRWIN, CALIFORNIA
CONSTRUCTION OF FACILITIES
FISCAL YEAR 1967 ESTIMATES

WATER DISTRIBUTION SYSTEM



GOLDSTONE COMPLEX, FORT IRWIN, CALIFORNIA
CONSTRUCTION OF FACILITIES
FISCAL YEAR 1967 ESTIMATES

SEWER DISPOSAL SYSTEMS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1967 ESTIMATES

FACILITY PLANNING AND DESIGN

Page No.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

INSTALLATION SUMMARY

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1967 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 1965	FY 1966	FY 1967
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)*	Not
TOTAL LAND	Applicable
TOTAL CAPITAL INVESTMENT* *(Including NASA-Owned Land) (as of June 30, 1965)*	$ Not Applicable

PROJECT LINE ITEM	COGNIZANT OFFICE	FY 1962 THRU CURRENT YEAR	FY 1967 *(Estimated)*	FUTURE YEARS *(Estimated)*	TOTAL ALL YEARS *(Estimated)*
Facility Planning and Design	AA	46,330	7,000	Not Applicable	Not Applicable
ALL OTHER PROJECTS					
TOTALS		46,330	7,000		

NASA FORM 1029 (REV. JUN 65) PREVIOUS EDITIONS ARE OBSOLETE.

* *Includes work in process.*

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1967 ESTIMATES

FACILITY PLANNING AND DESIGN

The funds requested are used to conduct advance planning and design activities on projects for which construction funds will be requested in subsequent budgets.

The $7.0 million request covers work in the following three areas: (a) $1.5 million for preliminary designs and other special studies, (b) $3.5 million for the preparation of complete plans and specifications of those projects to be included in the FY 1968 fiscal year construction program, and (c) $2.0 million to complete the detailed design plans and specifications for the highly complex two position engine and stage test stand associated with the NERVA program.

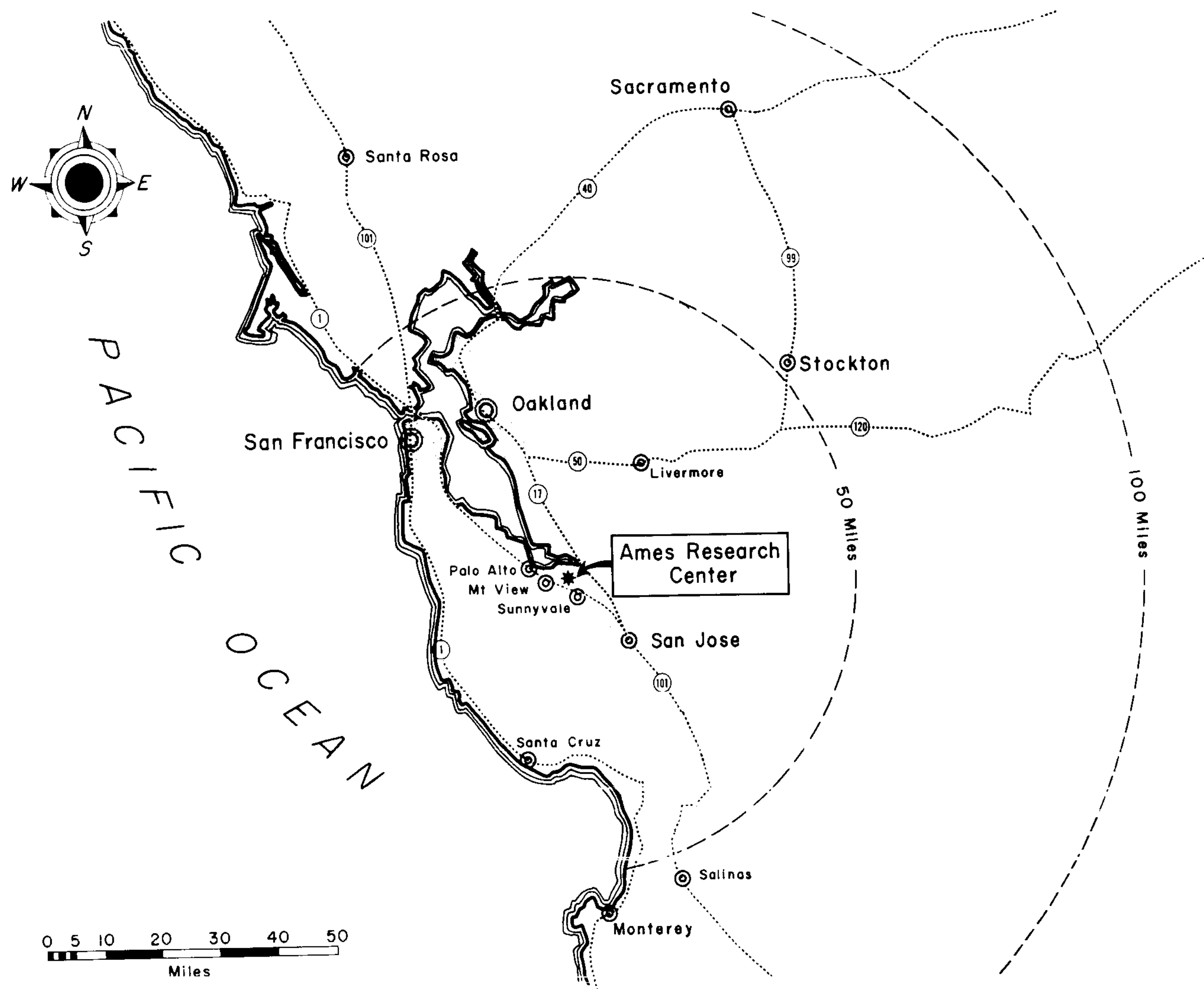
The $1.5 million for the first area covers the preparation and upgrading of master plans for the various NASA centers and other NASA installations, unforeseen construction studies, and the preparation of cost estimates and engineering studies which make up the preliminary designs for an estimated $80 to $100 million fiscal year 1969 construction program.

The $3.5 million for the second area covers the preparation of final and complete designs, plans, and specifications for an estimated FY 1968 facility construction activity amounting to a total of $80 to $100 million (excluding the Engine/Stage Test Stand 2-3 facility).

The $2.0 million for the third area covers the engineering and design of the Engine/Stage Test Stand 2-3 test complex which consists of two static test stands, a control center, and ancillary equipment. Each test stand will be capable of testing a nuclear rocket propulsion module in a vertical position during 5000 MW (power) operations. Studies, criteria development and site investigations are in progress and engineering and design will begin shortly. This work has been funded from prior years Facilities Planning and Design funds. $2.0 million are required in fiscal year 1967 to continue the engineering and design of this complex. The $50 million construction costs currently estimated for this test complex are not included in the $80 to $100 million figures shown for the second area requirements.

AMES RESEARCH CENTER
FISCAL YEAR 1967 ESTIMATES

VICINITY MAP



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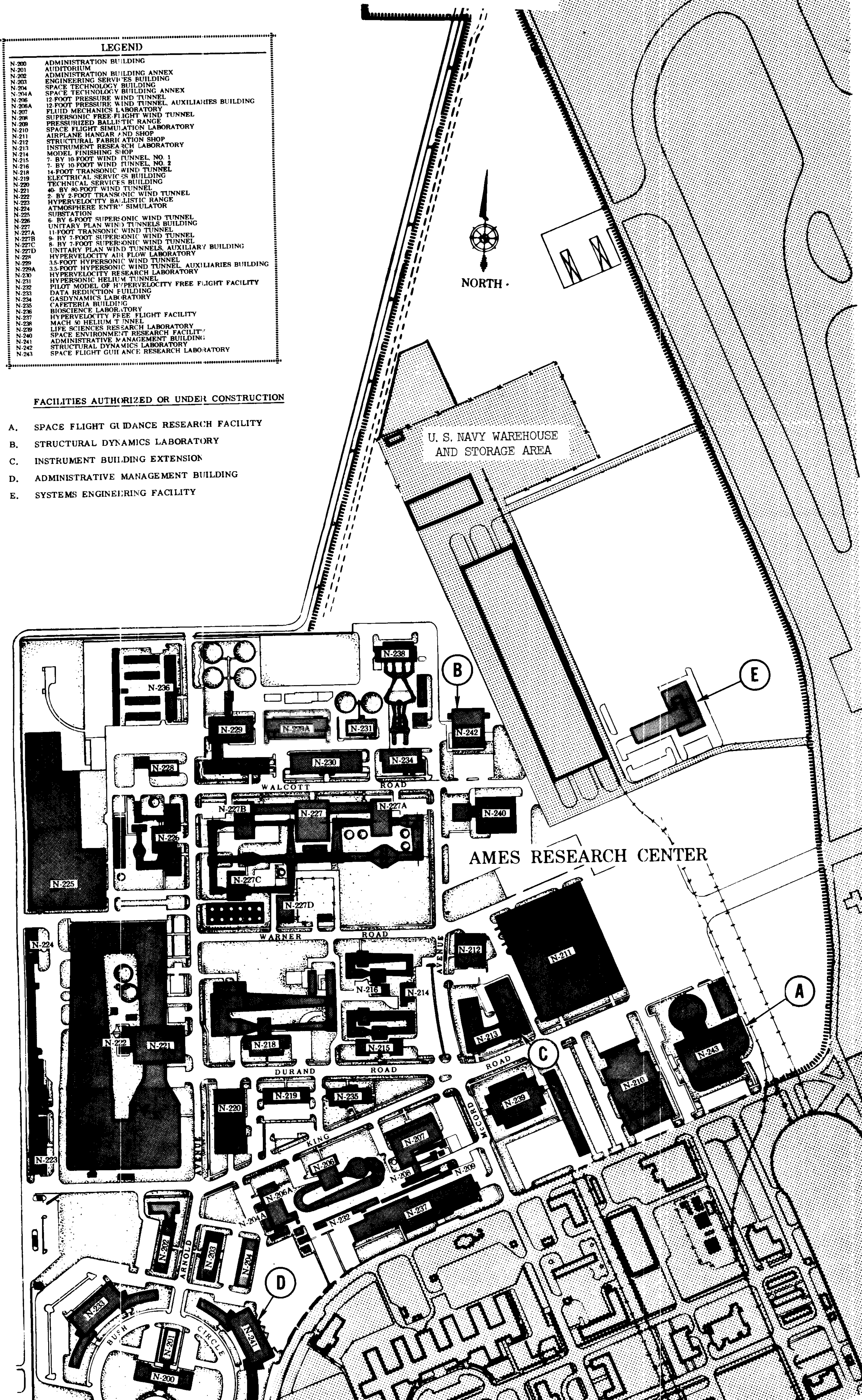
AMES RESEARCH CENTER
FISCAL YEAR 1967 ESTIMATES

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-204A	SPACE TECHNOLOGY BUILDING ANNEX
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-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, AUXILIARY 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
N-241	ADMINISTRATIVE MANAGEMENT BUILDING
N-242	STRUCTURAL DYNAMICS LABORATORY
N-243	SPACE FLIGHT GUIDANCE RESEARCH LABORATORY

FACILITIES AUTHORIZED OR UNDER CONSTRUCTION

A. SPACE FLIGHT GUIDANCE RESEARCH FACILITY

B. STRUCTURAL DYNAMICS LABORATORY

C. INSTRUMENT BUILDING EXTENSION

D. ADMINISTRATIVE MANAGEMENT BUILDING

E. SYSTEMS ENGINEERING FACILITY

LEGEND

N-200	ADMINISTRATION BUILDING
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N-243	SPACE FLIGHT GUIDANCE RESEARCH LABORATORY

FACILITIES AUTHORIZED OR UNDER CONSTRUCTION

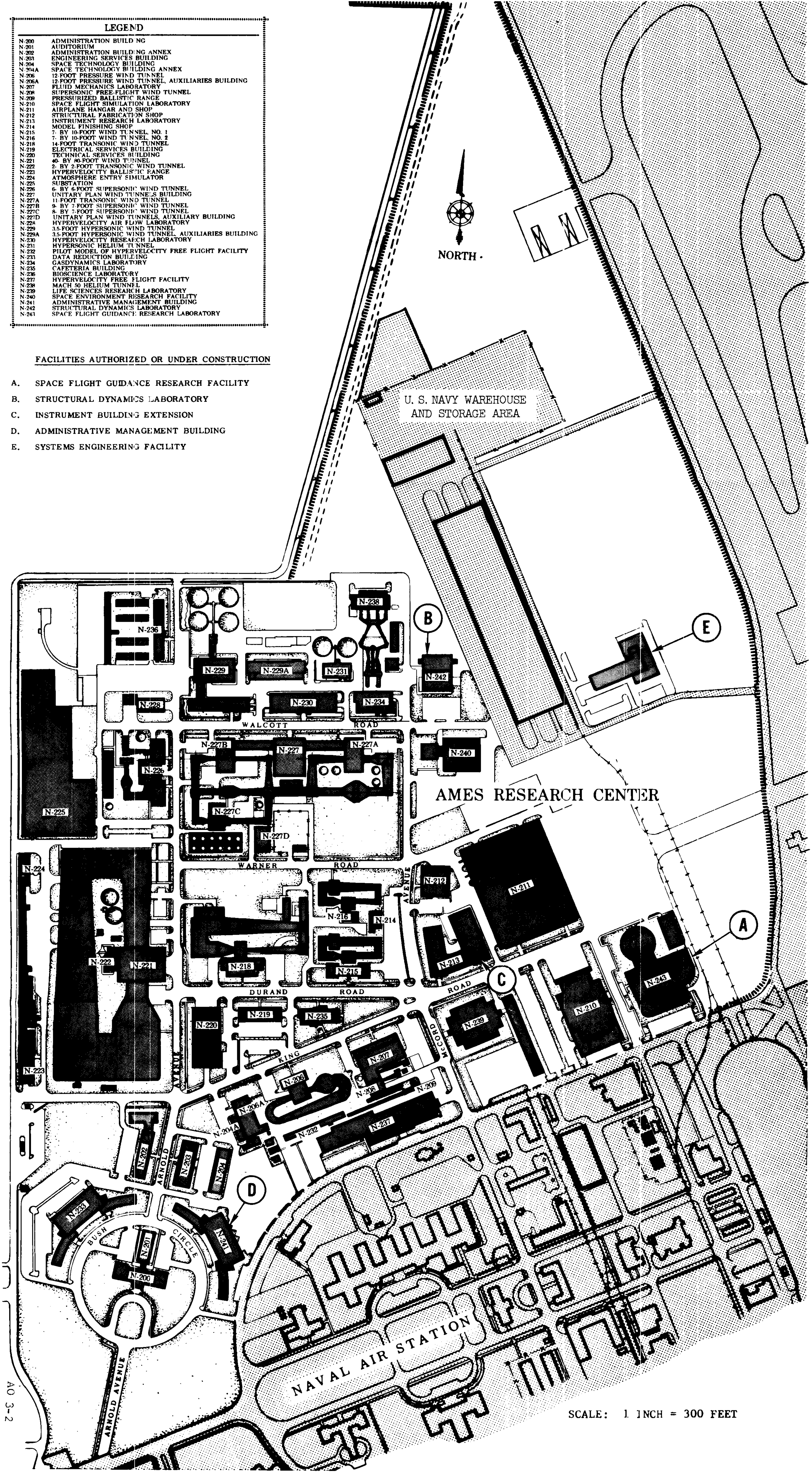
A. SPACE FLIGHT GUIDANCE RESEARCH FACILITY

B. STRUCTURAL DYNAMICS LABORATORY

C. INSTRUMENT BUILDING EXTENSION

D. ADMINISTRATIVE MANAGEMENT BUILDING

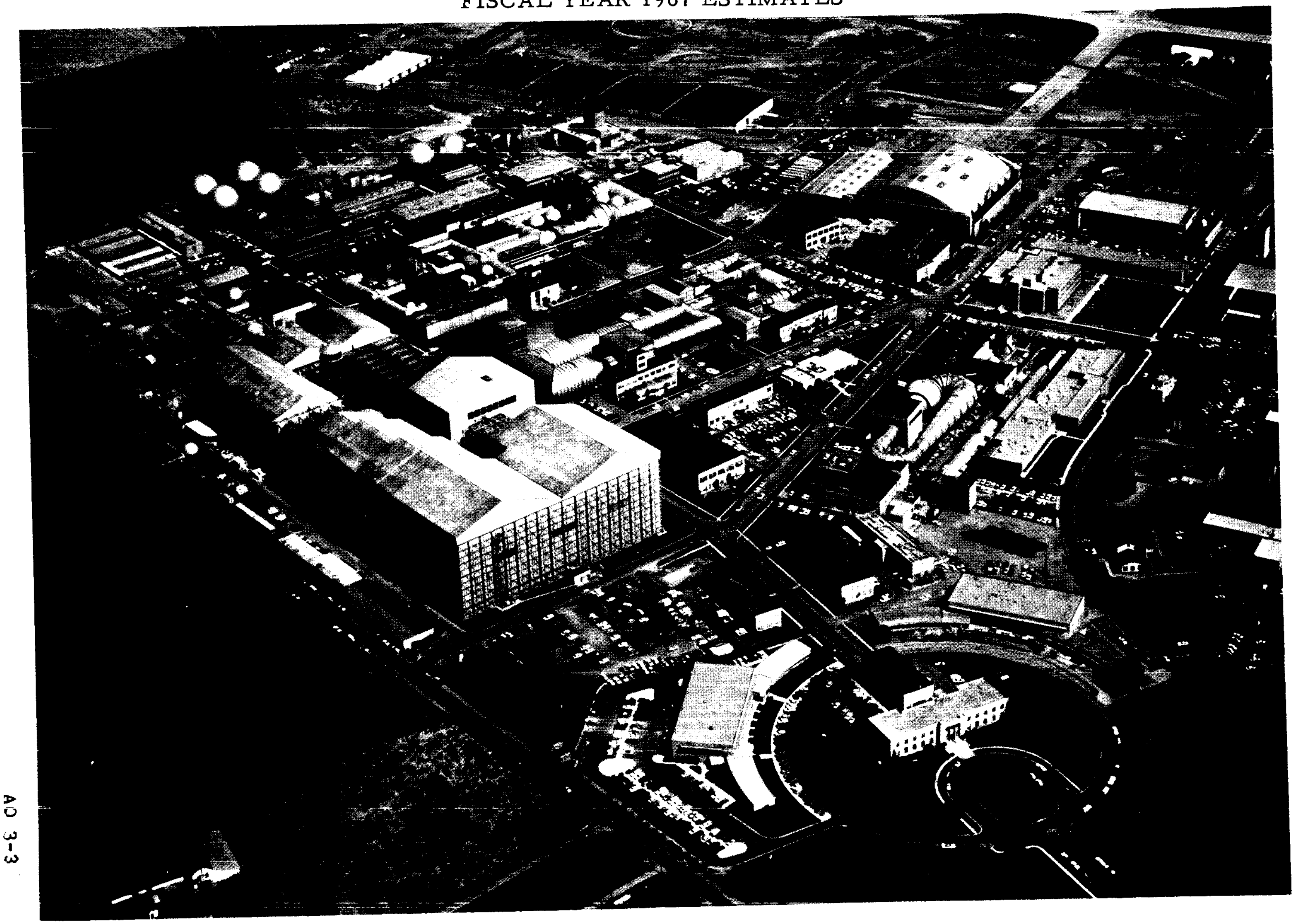
E. SYSTEMS ENGINEERING FACILITY



SCALE: 1 INCH = 300 FEET

AO 3-2

AMES RESEARCH CENTER
FISCAL YEAR 1967 ESTIMATES



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
ORGANIZATION AND STAFFING CHART
AMES RESEARCH CENTER

STAFFING SUMMARY

	66	67
Excepted	26	26
GS-16	20	20
GS-15	120	130
GS-14	139	190
All other GS	1,162	1,108
Wage Board	753	717
Total Permanent	2,220	2,191
Temporary	20	20
Total Positions	2,240	2,211

DIRECTOR

	66	67
Excepted	2	2
GS-15	3	3
All other GS	5	5
Total Permanent	10	10

PROGRAMS AND RESOURCES OFFICE

	66	67
GS-16	1	1
GS-15	1	1
GS-14	1	2
All other GS	8	7
Total Permanent	11	11

TECHNOLOGY UTILIZATION OFFICE

	66	67
GS-15	1	1
GS-14	1	1
All other GS	2	2
Total Permanent	4	4

PUBLIC INFORMATION OFFICE

	66	67
GS-14	1	1
All other GS	4	4
Total Permanent	5	5

OART MISSION ANALYSIS DIVISION

	66	67
Excepted	2	2
GS-16	2	2
GS-15	8	8
GS-14	11	17
All other GS	23	17
Total Permanent	46	46

ASSISTANT DIRECTOR AERONAUTICS AND FLIGHT MECHANICS

	66	67
Excepted	1	1
GS-15	-	1
GS-14	1	-
All other GS	1	1
Total Permanent	3	3

AERONAUTICS DIVISION

	66	67
Excepted	1	1
GS-16	1	1
GS-15	7	8
GS-14	10	13
All other GS	72	71
Wage Board	56	51
Total Permanent	147	145

FULL SCALE AND SYSTEMS RESEARCH DIVISION

	66	67
Excepted	2	2
GS-16	2	2
GS-15	15	16
GS-14	15	23
All other GS	82	70
Wage Board	10	10
Total Permanent	126	123

INSTRUMENTATION DIVISION

	66	67
Excepted	2	2
GS-16	1	1
GS-15	7	8
GS-14	10	10
All other GS	[illegible]	[illegible]
Wage Board	119	107
Total Permanent	253	240

SIMULATION SCIENCES DIVISION

	66	67
GS-16	1	1
GS-15	3	4
GS-14	3	3
All other GS	12	10
Wage Board	19	30
Total Permanent	38	48

ASSISTANT DIRECTOR ASTRONAUTICS

	66	67
Excepted	1	1
GS-15	1	1
All other GS	1	1
Total Permanent	3	3

THERMO AND GAS DYNAMICS DIVISION

	66	67
Excepted	2	2
GS-16	3	3
GS-15	16	19
GS-14	15	19
All other GS	91	85
Wage Board	45	45
Total Permanent	172	173

VEHICLE ENVIRONMENT DIVISION

	66	67
Excepted	1	1
GS-16	4	3
GS-15	11	13
GS-14	10	15
All other GS	96	90
Wage Board	36	34
Total Permanent	158	156

SPACE SCIENCES DIVISION

	66	67
Excepted	2	2
GS-15	8	8
GS-14	10	22
All other GS	35	22
Wage Board	16	16
Total Permanent	71	70

ASSISTANT DIRECTOR LIFE SCIENCES

	66	67
Excepted	2	2
GS-14	-	1
All other GS	3	2
Total Permanent	5	5

EXOBIOLOGY DIVISION

	66	67
Excepted	1	1
GS-16	1	1
GS-15	5	5
GS-14	3	8
All other GS	38	36
Total Permanent	48	51

ENVIRONMENTAL BIOLOGY DIVISION

	66	67
Excepted	2	2
GS-16	1	1
GS-15	6	5
GS-14	5	7
All other GS	45	45
Wage Board	2	4
Total Permanent	61	64

BIOTECHNOLOGY DIVISION

	66	67
Excepted	1	1
GS-16	-	1
GS-15	5	5
GS-14	4	9
All other GS	39	41
Total Permanent	49	57

ASSISTANT DIRECTOR DEVELOPMENT

	66	67
Excepted	1	1
All other GS	1	1
Total Permanent	2	2

SYSTEMS ENGINEERING DIVISION

	66	67
GS-16	1	1
GS-15	4	5
GS-14	7	7
All other GS	14	13
Total Permanent	26	26

PROJECT PIONEER

	66	67
Excepted	1	1
GS-15	4	4
GS-14	9	9
All other GS	32	33
Total Permanent	46	47

PROJECT BIOSATELLITE

	66	67
Excepted	1	1
GS-16	1	1
GS-15	5	5
GS-14	[illegible]	[illegible]
All other GS	[illegible]	[illegible]
Wage Board	7	7
Total Permanent	73	73

ASSISTANT DIRECTOR ADMINISTRATION

	66	67
Excepted	1	1
GS-14	1	1
All other GS	1	1
Total Permanent	3	3

LEGAL OFFICE

	66	67
GS-15	1	1
GS-14	1	1
All other GS	1	1
Total Permanent	3	3

MEDICAL OFFICE

	66	67
GS-15	1	1
Total Permanent	1	1

ADMINISTRATIVE SERVICES DIVISION

	66	67
All other GS	30	30
Wage Board	6	6
Total Permanent	36	36

FISCAL DIVISION

	66	67
GS-14	1	1
All other GS	76	76
Total Permanent	77	77

PERSONNEL DIVISION

	66	67
GS-15	1	1
GS-14	-	-
All other GS	55	46
Total Permanent	56	47

PROCUREMENT AND SUPPLY DIVISION

	66	67
GS-15	1	1
GS-14	2	2
All other GS	[illegible]	[illegible]
Wage Board	[illegible]	[illegible]
Total Permanent	97	102

TECHNICAL INFORMATION DIVISION

	66	67
All other GS	38	38
Wage Board	15	15
Total Permanent	53	53

RESEARCH FACILITIES AND EQUIPMENT DIVISION

	66	67
GS-16	1	1
GS-15	5	5
GS-14	8	8
All other GS	113	113
Wage Board	59	59
Total Permanent	186	186

TECHNICAL SERVICES DIVISION

	66	67
GS-15	1	1
GS-14	1	1
All other GS	5	5
Wage Board	344	314
Total Permanent	351	321

205-835 O - 66 - (Face p. AO 3-3)

ADMINISTRATIVE OPERATIONS

FISCAL YEAR 1967 ESTIMATES

AMES RESEARCH CENTER

MISSION AND CAPABILITIES:

The mission of the Ames Research Center has been broadened significantly since the establishment of NASA and now includes a major research responsibility in the life sciences, flight project management responsibility, and responsibility for spacecraft experimentation in the space sciences, in addition to the traditional research mission in the physical sciences. In the current and budget years, Ames has flight project management responsibility for Pioneer and Biosatellite projects. Pioneer is now providing 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.

Research in the physical sciences includes studies in atmosphere entry and environmental physics, guidance and control systems, and aeronautics. The work in entry and environmental physics includes basic studies of the physics 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 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 studies involving lunar approach, lunar landing, and rendezvous. The research in control systems is directed at examining various techniques applicable to satellite attitude stabilization and techniques applicable to verticle and short take-off (V/STOL) aircraft, the supersonic transport, and the Apollo spacecraft. The research program in aeronautics is directed at studies of the problems associated with high speed 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.

Research in the space sciences includes studies in the field 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, and micrometeoroids in space, and studies to determine the composition and structure of planets and of planetary and stellar atmospheres.

Research in the life sciences is conducted in three major areas: research in physiological, biochemical, and behavioral sciences concerned with obtaining a better understanding of the effects of terrestrial and extraterrestrial environments and the effects of atmospheric and space flight stresses upon living organisms; studies oriented toward the prediction, detection, and understanding of extraterrestrial life forms; and research in the human factors aspects of the relationship between man and the machines which transport him in the atmosphere and into space, and which will support him during lunar and planetary exploration.

SUMMARY OF RESOURCES REQUIREMENTS:

	1965	1966	1967
Authorized Positions, end of year..	2,270	2,240	2,211
Average Number of All Employees....	2,224	2,244	2,222
Administrative Operations..........	$31,807,000	$32,923,000	$33,475,000

INSTALLATION DESCRIPTION:

The Ames Research Center was established in 1940 and is located at the southern end of San Francisco Bay on about 226 acres of 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. 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, 1965, was $175,016,000.

ANALYSIS OF RESOURCES REQUIREMENTS BY OBJECT CLASSIFICATION:

	1965	1966	1967
11. Personnel Compensation.....	$21,027,000	$21,935,000	$22,572,000
12. Personnel Benefits.........	1,549,000	1,584,000	1,629,000
Total, personnel costs...	$22,576,000	$23,519,000	$24,201,000

	1965	1966	1967
21. Travel and Transportation of Persons................	$643,000	$676,000	$670,000
22. Transportation of Things....	23,000	25,000	25,000
23. Rent, Communications, and Utilities.................	4,575,000	4,733,000	5,133,000
24. Printing and Reproduction...	27,000	27,000	27,000
25. Other Services..............	1,611,000	1,537,000	1,706,000
Services of other agencies	137,000	140,000	150,000
26. Supplies and Materials......	1,296,000	1,148,000	1,100,000
31. Equipment...................	608,000	730,000	280,000
32. Lands and Structures........	311,000	388,000	133,000
42. Insurance Claims and Indemnities...............	---	---	---
Total....................	$31,807,000	$32,923,000	$33,475,000

JUSTIFICATION BY OBJECT CLASSIFICATION:

Personnel Distribution

	1965	1966	1967
Direct Personnel by Program			
Manned Space Flight			
Apollo........................	5	5	5
Space Science and Applications			
Physics and astronomy..........	53	66	66
Lunar and planetary exploration	124	110	109
Bioscience.....................	218	219	217
Meteorological satellites......	---	---	1
Advanced Research and Technology			
Basic research.................	320	320	316
Space vehicle systems..........	245	248	241
Electronics systems............	140	140	139
Human factor systems...........	134	137	137
Aeronautics....................	351	355	346
Sub-total, direct positions..	1,590	1,600	1,577

	1965	1966	1967
Support personnel			
Director and Staff...............	48	53	49
Administration...................	319	319	323
Research and development support.	253	248	242
Sub-total, support positions...	620	620	614
Total, permanent positions.....	2,210	2,220	2,191
Other positions:			
Positions under cooperative training agreements..........	---	---	---
Other temporary positions......	60	20	20
Total, all positions...............	2,270	2,240	2,211

Personnel requirements

The personnel complement is unquestionably the most critical resource at Ames because of the Center's obligation to conduct research on a broad base in both ground-based laboratories and flight projects and the severe restrictions on complement authorizations which results from similar agency commitments at all centers. Because of these limitations, the management of the manpower resource is the subject of careful and continual review and adjustment at all management levels within the Center. A constant trade-off between programs is carried on at the research division level to achieve the best possible balance between personnel requirements and resources available.

Personnel Costs

	1965	1966	1967
Total Positions.....................	2,270	2,240	2,211
Permanent..........................	2,210	2,220	2,191
Other..............................	60	20	20
Personnel Compensation:			
Annual cost of permanent positions........................	$21,093,000	$22,299,000	$22,435,000
Pay above the stated annual rate..	80,000	84,000	86,000
Lapses (deduct)..................	-638,000	-997,000	-519,000
Net cost of permanent positions...	20,535,000	21,386,000	22,002,000
Other personnel compensation......	492,000	549,000	570,000
Total compensation..............	21,027,000	21,935,000	22,572,000
NASA funded..................	21,027,000	21,935,000	22,572,000
Reimbursable.................	---	---	---

	1965	1966	1967
Personnel benefits...............	$1,549,000	$1,584,000	$1,629,000
NASA funded....................	1,549,000	1,584,000	1,629,000
Reimbursable...................	---	---	---
Total personnel costs............	22,576,000	23,519,000	24,201,000
NASA funded....................	22,576,000	23,519,000	24,201,000
Reimbursable...................	---	---	---
Average Number of All Employees (Man Years)...................	2,224	2,244	2,222

Personnel Costs - $24,201,000

The personnel cost for FY 1967 is estimated to be $24,201,000 covering 2,222 manyears of employment. Of this amount $22,572,000 is for personnel compensation and $1,629,000 for personnel benefits. The FY 1967 estimate includes an increase of $682,000 over the amount for the current fiscal year. This increase is required to cover the cost of the Federal Employees Salary Act of 1965 on a full year basis, for within-grade step increases and career development, for retirement contributions and other benefits.

The following table shows the major items which are included in the estimate for personnel costs:

	FY 1967 Estimate	Increase or Decrease from FY 1966
Personnel Compensation		
Net cost of permanent positions	$22,002,000	$+616,000
Other personnel compensation...	570,000	+21,000
Sub-total....................	$22,572,000	$+637,000
Personnel Benefits		
Retirement contributions.......	1,395,000	+40,000
Other benefits.................	234,000	+5,000
Sub-total....................	$1,629,000	$+45,000
Total, personnel costs...........	$24,201,000	$+682,000

Travel and Transportation of Persons - $670,000

There is a slight reduction of $6,000 in this category paralleling the reduction in the total number of permanent positions at the Ames Research Center.

Transportation of Things - $25,000

There is no change in this category from the FY 1966 level.

Rent, Communications, and Utilities - $5,133,000

The total increase of $400,000 in this category is almost entirely for the lease cost of ADP equipment. This includes the addition of four remote high-speed computing stations for more effective communications between the scientist and the computer. It also includes minor modifications to the existing basic computational system and increased use of extra shift time.

Printing and Reproduction - $27,000

Commercial printing costs have been significantly reduced in past years through the acquisition of modern printing equipment which has enhanced the in-house printing capability. Thus, the FY 1967 cost is expected to remain at the same level as in FY 1966.

Other Services - $1,856,000

Total increase for this category is $179,000. Support services, performed under contract, include janitorial services, refuse handling and art work. It is also planned to continue the use of business management consulting firms for reviewing and recommending potential modifications to current policies and practices. A minor increase of $10,000 in cost of fire protection services provided by the U.S. Navy is anticipated due to the increased number of new facilities becoming available in FY 1967.

Supplies and Materials - $1,100,000

Requirements for funds in this category are $48,000 lower in FY 1967 than for FY 1966, primarily because of the reduction in procurement of office supplies.

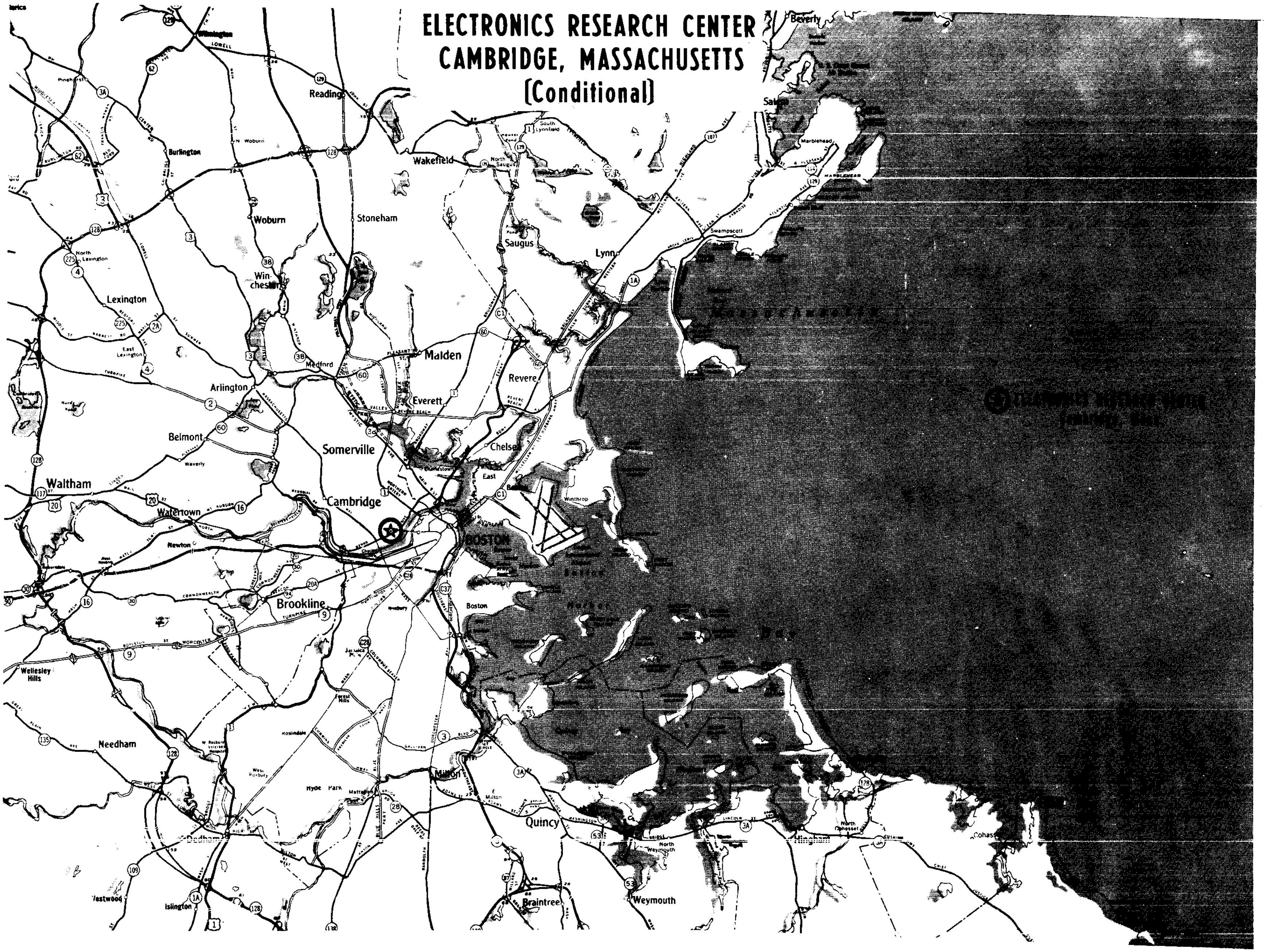
Equipment - $230,000

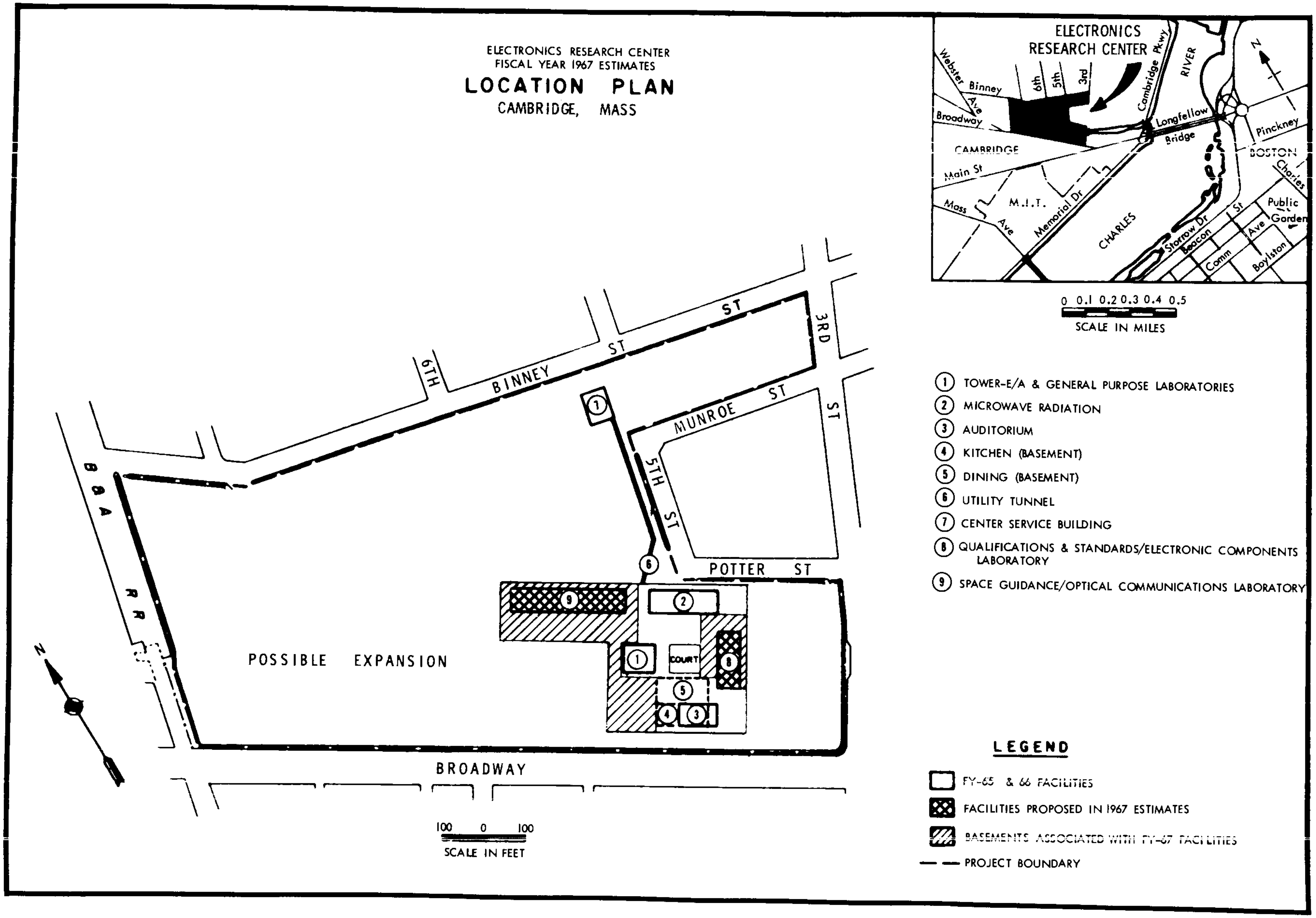
The requirement for equipment has been reduced $450,000 in FY 1967 from the FY 1966 level. The purchase in FY 1966 of the IBM 7094 computer ($344,000) associated with minor reductions in laboratory and photographic equipment makes up this sizeable reduction.

Lands and Structures - $183,000

This category has been reduced $205,000 in FY 1967. In FY 1966 a minor construction project for the addition to the old administration building to house the Mission Analysis Division was accomplished. With this one time item complete the subsequent reduction is realized.

ELECTRONICS RESEARCH CENTER
CAMBRIDGE, MASSACHUSETTS
(Conditional)




ELECTRONICS RESEARCH CENTER
FISCAL YEAR 1967 ESTIMATES
LOCATION PLAN
CAMBRIDGE, MASS
ELECTRONICS RESEARCH CENTER
Webster Ave
Binney
Broadway
6th
5th
3rd
Cambridge Pkwy
RIVER
Longfellow Bridge
Pinckney
CAMBRIDGE
BOSTON
Main St
Charles
M.I.T.
Mass Ave
Memorial Dr
CHARLES
Storrow Dr
Beacon St
Comm Ave
Public Garden
Boylston
0 0.1 0.2 0.3 0.4 0.5
SCALE IN MILES
BINNEY ST
6TH
3RD ST
MUNROE ST
5TH ST
POTTER ST
B & A RR
POSSIBLE EXPANSION
COURT
BROADWAY
N
100 0 100
SCALE IN FEET
1 TOWER-E/A & GENERAL PURPOSE LABORATORIES
2 MICROWAVE RADIATION
3 AUDITORIUM
4 KITCHEN (BASEMENT)
5 DINING (BASEMENT)
6 UTILITY TUNNEL
7 CENTER SERVICE BUILDING
8 QUALIFICATIONS & STANDARDS/ELECTRONIC COMPONENTS LABORATORY
9 SPACE GUIDANCE/OPTICAL COMMUNICATIONS LABORATORY
LEGEND
FY-65 & 66 FACILITIES
FACILITIES PROPOSED IN 1967 ESTIMATES
BASEMENTS ASSOCIATED WITH FY-67 FACILITIES
PROJECT BOUNDARY

ELECTRONICS RESEARCH CENTER
CAMBRIDGE, MASS.

AERIAL VIEW

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ORGANIZATION AND STAFFING CHART

ELECTRONICS RESEARCH CENTER

OFFICE OF THE DIRECTOR

	66	67
Excepted	2	2
GS-16	-	-
GS-15	4	7
GS-14	6	5
All other GS	16	19
Total Permanent	28	33

STAFFING SUMMARY

	66	67
Excepted	10	10
GS-16	10	10
GS-15	46	77
GS-14	83	126
All other GS	401	777
Total Permanent	550	1,000
Temporary	-	-
Total Positions	550	1,000

PROGRAMS AND RESOURCES OFFICE

	66	67
Excepted	1	1
GS-16	-	-
GS-15	3	4
GS-14	5	6
All other GS	41	48
Total Permanent	50	59

ADMINISTRATION OFFICE

	66	67
Excepted	1	1
GS-16	-	-
GS-15	1	3
GS-14	6	8
All other GS	102	159
Total Permanent	110	171

FACILITIES AND ENGINEERING OFFICE

	66	67
Excepted	1	1
GS-16	-	-
GS-15	4	4
GS-14	10	15
All other GS	69	134
Total Permanent	84	154

SYSTEMS DIVISION

	66	67
Excepted	1	1
GS-16	2	2
GS-15	7	9
GS-14	4	11
All other GS	22	66
Total Permanent	36	89

ELECTRONIC COMPONENTS DIVISION

	66	67
Excepted	1	1
GS-16	2	2
GS-15	8	16
GS-14	20	15
All other GS	54	119
Total Permanent	85	153

GUIDANCE AND CONTROL DIVISION

	66	67
Excepted	1	1
GS-16	2	2
GS-15	7	20
GS-14	14	33
All other GS	38	72
Total Permanent	62	128

INSTRUMENTATION AND DATA PROCESSING RESEARCH DIVISION

	66	67
Excepted	1	1
GS-16	2	2
GS-15	6	7
GS-14	9	17
All other GS	28	74
Total Permanent	46	101

ELECTROMAGNETIC DIVISION

	66	67
Excepted	1	1
GS-16	2	2
GS-15	6	7
GS-14	9	16
All other GS	31	86
Total Permanent	49	112

ADMINISTRATIVE OPERATIONS

FISCAL YEAR 1967 ESTIMATES

ELECTRONICS RESEARCH CENTER

MISSION AND CAPABILITIES:

The mission of the Electronics Research Center is to increase the agency's cabability by providing the knowledge and advanced technology needed to improve performance and reliability of space and aeronautical electronic systems and components. The Center meets this responsibility in two principal ways:

First, the Center organizes, manages, and conducts a comprehensive program of basic and applied space electronics research in order to: (a) investigate concepts and techniques that will provide the technological foundation for the development of electronic equipment of reduced weight, size, power drain, and complexity, able to operate for long periods of time in the temperatures, radiation, vacuum, and other harsh conditions found in space; (b) investigate concepts and techniques, establish performance characteristics, test procedures, and specifications for space electronic components and techniques that will make space electronics equipment inherently more reliable; and (c) devise new electronic concepts and techniques and prove their feasibility, both analytically and experimentally, leading to space and aeronautical electronic equipment with performance characteristics far beyond these of today.

Second, the Center provides a focal point for national space electronics research, coordinating nationwide research efforts and sponsoring electronics research conducted by industry, universities, and private institutions. In this capacity, the Center (a) responds to the needs of specific space and aeronautical programs and projects for new electronic techniques, concepts, and devices, and helps shape future electronics research to resolve anticipated problems in these programs; (b) distributes knowledge about basic and applied research on electronics within NASA and also to industry, universities, and other members of the scientific and engineering community; and (c) provides to NASA programs and projects electronic scientists and engineers who are fully knowledgeable in the electronics state-of-the-art.

Electronics research being managed and conducted by the Center during FY 1966 and FY 1967 is largely contracted with industry and universities and is focused in the following areas:

1. Space electronics materials and components.

2. Guidance and navigation of space vehicles, spacecraft, aircraft and supporting ground based equipment.

3. Space vehicle, spacecraft and aircraft control, stabilization and information systems.

4. Electronic system simulation, analysis, evaluation and integration in the fields of guidance, control, navigation, tracking, communication and instrumentation.

5. Electronic power conditioning and distribution.

6. Space and ground based instrumentation technology.

7. Space and ground based computers and computing systems.

8. Solid state physics, microwave propagation, microwave communications, and transmitting and receiving phenomena.

9. Optical communications.

An in-house research effort is being conducted by the Center staff on those tasks offering great promise for space electronics technology and on those problems requiring first-hand experience on the part of the Center personnel in order to contract related research with industry and universities.

SUMMARY OF RESOURCES REQUIREMENTS:

	1965	1966	1967
Authorized Positions, end of year.	250	550	1,000
Average Number of All Employees...	134	330	842
Administrative Operations.........	$3,201,000	$6,233,000	$15,143,000

INSTALLATION DESCRIPTION:

The Electronics Research Center is provisionally located in leased quarters in Cambridge, Massachusetts. The proposed permanent site is a tract in the Kendall Square area of Cambridge. The tract is one and a half miles west of the center of Boston and is immediately north of the Massachusetts Institute of Technology and one and a half miles from Harvard University. It consists of about 29 acres to be conveyed by the city of Cambridge to NASA and is bounded on the north by Binney Street, on the south by Broadway, on the east by Third Street, and on the west by the New York Central Railroad. An auxiliary urban site will be required in addition to the permanent urban site as noted in the January 1, 1964 report to Congress on NASA, Electronics Research Center.

ANALYSIS OF RESOURCES REQUIREMENTS BY OBJECT CLASSIFICATION:

	1965	1966	1967
11. Personnel Compensation....	$1,362,000	$3,389,000	$9,012,000
12. Personnel Benefits........	100,000	262,000	687,000
Total, personnel costs..	$1,462,000	$3,651,000	$9,699,000

	1965	1966	1967
21. Travel and Transportation of Persons................	$118,000	$302,000	$347,000
22. Transportation of Things....	28,000	70,000	136,000
23. Rent, Communications, and Utilities.............	340,000	688,000	1,836,000
24. Printing and Reproduction...	13,000	25,000	44,000
25. Other Services..............	316,000	610,000	1,990,000
Services of other agencies	464,000	258,000	359,000
26. Supplies and Materials......	64,000	229,000	412,000
31. Equipment...................	396,000	400,000	320,000
32. Lands and Structures........	---	---	---
42. Insurance Claims and Indemnities...............	---	---	---
Total.....................	$3,201,000	$6,233,000	$15,143,000

JUSTIFICATION BY OBJECT CLASSIFICATION:

Personnel Distribution

	1965	1966	1967
Direct Personnel by Program			
Advanced Research and Technology			
Electronics systems............	115	312	701
Sub-total, direct positions..	115	312	701
Support Personnel			
Director and Staff...............	22	27	35
Administration...................	94	158	189
Research and development support.	13	53	75
Sub-total, support positions...	129	238	299
Total, permanent positions.....	244	550	1,000
Other Positions:			
Positions under cooperative training agreements..........	---	---	---
Other temporary positions......	6	---	---
Total, all positions..............	250	550	1,000

Personnel requirements

The increase of $6,048,000 over FY 1966 provides for an increased staffing of 450 positions and the full year cost of personnel employed during FY 1966. The increase is in accordance with the phased growth originally planned in the long-range development of the Electronics Research Center and will provide for the staffing of those technical functions necessary to achieve program objectives. The personnel requirements of the Electronics Research Center are directly related to its primary mission to generate new scientific knowledge and stimulate advanced electronics technology for support of future missions.

Personnel Costs

	1965	1966	1967
Total Positions	250	550	1,000
Permanent	244	550	1,000
Other	6	---	---
Personnel Compensation:			
Annual costs of permanent positions	$2,593,000	$5,919,000	$10,604,000
Pay above the stated annual rate	10,000	23,000	40,000
Lapses (deduct)	-1,301,000	-2,678,000	-1,835,000
Net cost of permanent positions	1,302,000	3,264,000	8,809,000
Other personnel compensation	60,000	125,000	203,000
Total compensation	1,362,000	3,389,000	9,012,000
NASA funded	1,362,000	3,389,000	9,012,000
Reimbursable	---	---	---
Personnel benefits	100,000	262,000	687,000
NASA funded	100,000	262,000	687,000
Reimbursable	---	---	---
Total personnel costs	1,462,000	3,651,000	9,699,000
NASA funded	1,462,000	3,651,000	9,699,000
Reimbursable	---	---	---
Average Number of All Employees (Man Years)	134	330	842

Personnel Costs - $9,699,000

The estimate for personnel costs in FY 1967 increases by $6,048,000 over the FY 1966 requirement. This increase in funding is required to support the personnel growth from 550 personnel and 330 man years in FY 1966 to 1,000 personnel and 842 man years in FY 1967. The Federal Employees Salary Act of 1965, effective the first pay period in October, 1965, is estimated to increase personnel costs by $420,000 in FY 1967.

Travel and Transportation of Persons - $347,000

The estimate for travel and transportation of persons reflects an increase of $45,000 over FY 1966. Most of the increase ($25,000) is required for contract monitoring, and program planning and coordination to support the research and development effort. Of the balance, $13,000 is required for Electronics Research Center personnel to participate in scientific and technical committees and working panels, and $7,000 for administrative management relative to the organization and operations of the Center, which includes $1,000 for rental of passenger vehicles.

Transportation of Things - $136,000

These estimates are for transportation of household goods and personal effects and freight, drayage, express, and parcel post. The FY 1967 requirement is $66,000 above FY 1966. Costs for transportation of household goods and personal effects are $55,000 above FY 1966 due to the expected move of 153 employees as compared to the move of 95 employees in FY 1966. The balance of the requirement is for costs of shipment of supplies and equipment from commercial suppliers and other NASA installations.

Rent, Communications, and Utilities - $1,836,000

The estimate for rent, communications and utilities is $1,148,000 above the FY 1966 requirements. The increase results from the following:

$544,000 for rental of an additional 100,000 sq. ft. of office and laboratory space to accommodate an additional 450 personnel;

$516,000 for rental of electronic data processing equipment to support both management and the in-house research and development effort;

$39,000 for rental of other equipment; and

$49,000 for communications costs due to Center growth.

Printing and Reproduction - $44,000

Due to the extremely limited in-house capability, the printing and reproduction requirements will be provided by commercial firms and other Government agencies. The FY 1967 estimate is $19,000 above the FY 1966 requirement. Approximately one-half of the increase is for support of the construction program in the reproduction of plans, specifications, and blueprints. The balance is for technical reports and planning documents from the research laboratories.

Other Services - $2,349,000

An additional $1,481,000 will be required in FY 1967 to provide for contractor and other **government** agency services furnished on a continuing intermittent, or nonrecurring basis to supplement the in-house capabilities of the Center.

An increase of $960,000 is required for electronic data processing services. These services provide programmers, mathematicians, and other data processing specialists to support in-house research programs and tasks. In addition, these services provide for commercial processing for digitizing analog records, problem analysis, data reduction, and certain management functions such as payroll, cost accounting and inventory control and analysis.

An additional $169,000 is requested for maintenance and repair of buildings, maintenance of instruments and research equipment, and management studies.

An increase of $251,000 is requested for tuition, educational services and brochures, and service contracts to support the research laboratories. The funding is required primarily for service contracts, such as optical grinding, precision machine work, electronic fabrication and testing, and materials testing.

An increase of $101,000 is requested for services performed by other government agencies. Services provided are for security guards, telephone operators, janitors, and minor modifications to the additional space to be rented in FY 1967.

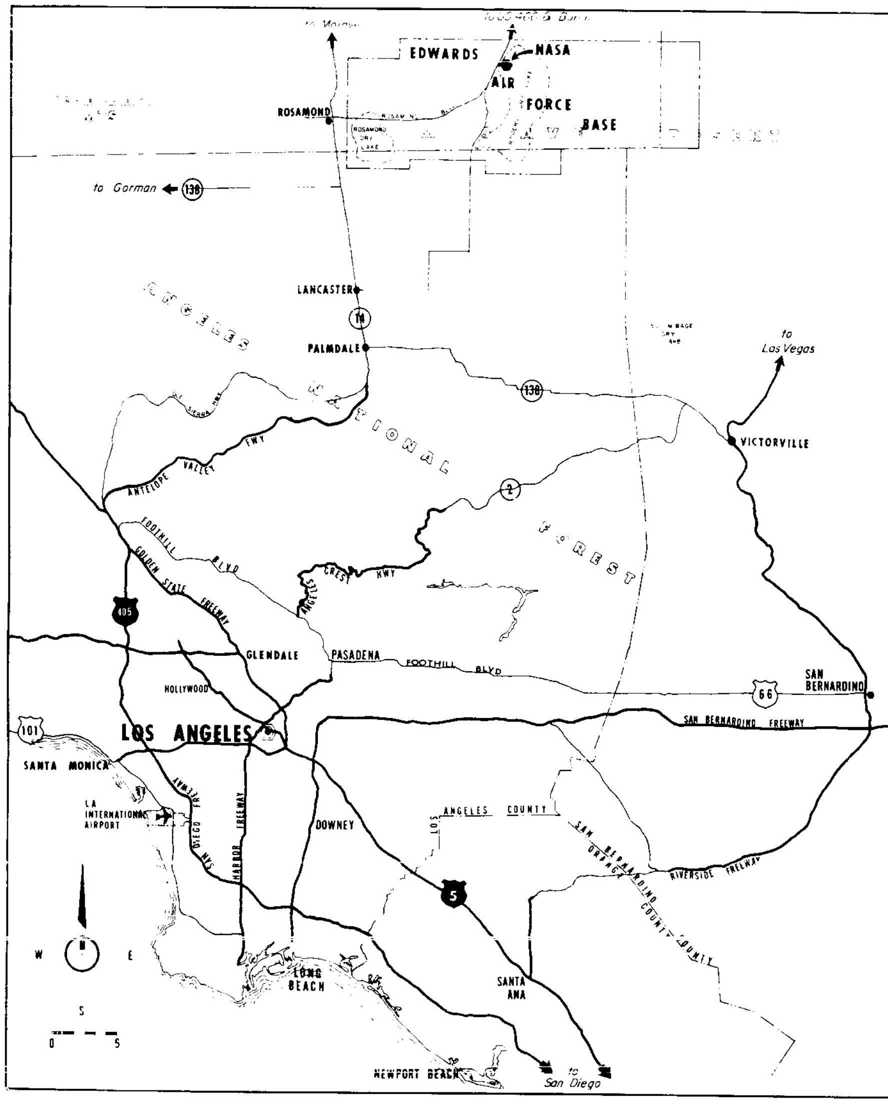
Supplies and Materials - $412,000

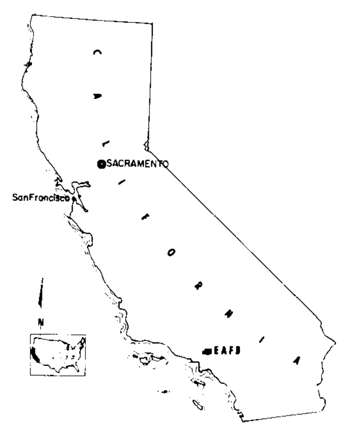
The level of funding requested for FY 1967 reflects an increase of $183,000 over the FY 1966 requirement. This additional funding is required to support the planned increase in personnel, and for technical support and in-house maintenance.

Equipment - $320,000

The amount requested is $80,000 less than the requirement for FY 1966 due to the reduction of purchases for shop machinery and electronic equipment.

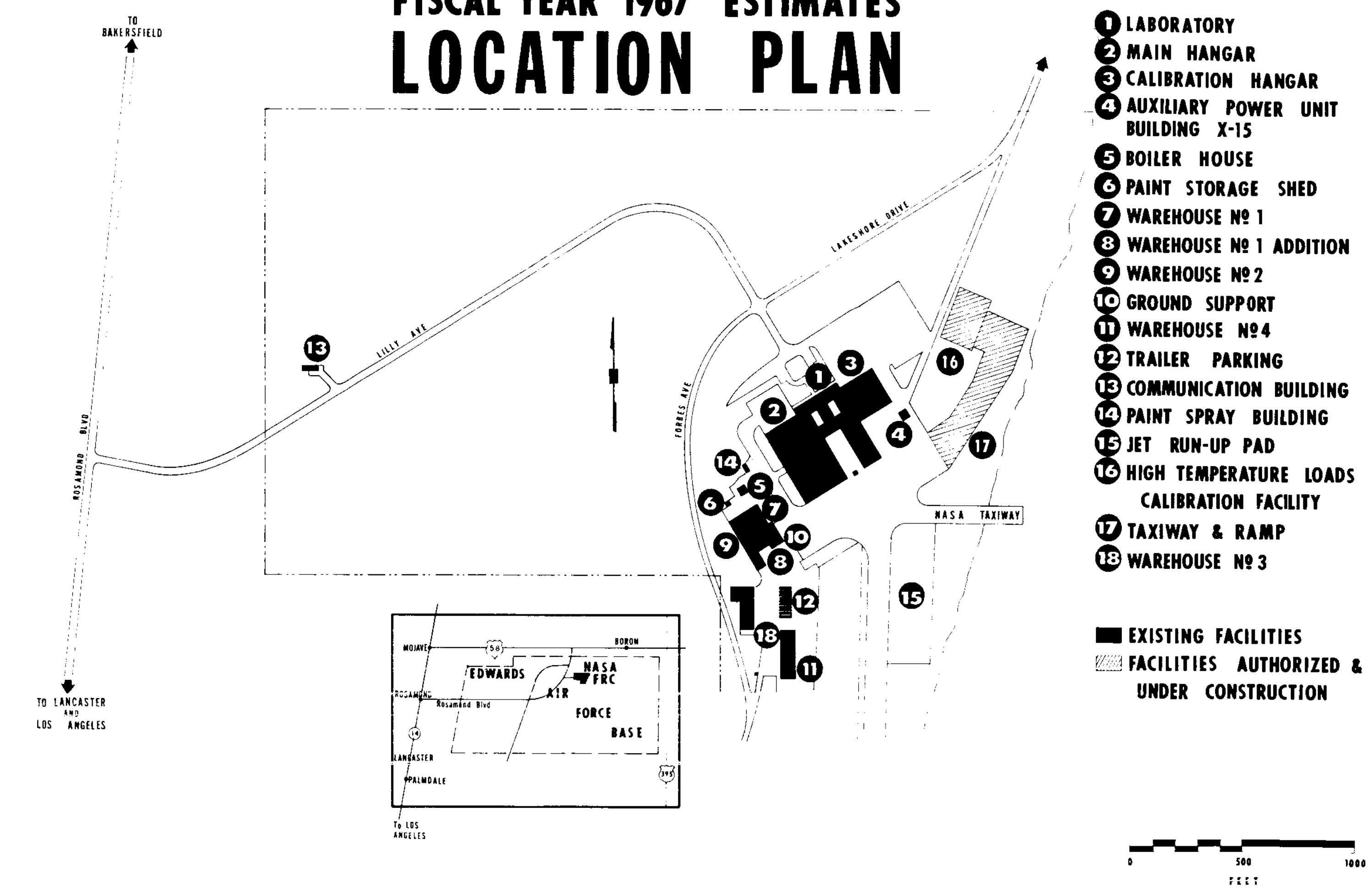
FLIGHT RESEARCH CENTER
FISCAL YEAR 1967 ESTIMATES
VICINITY MAP



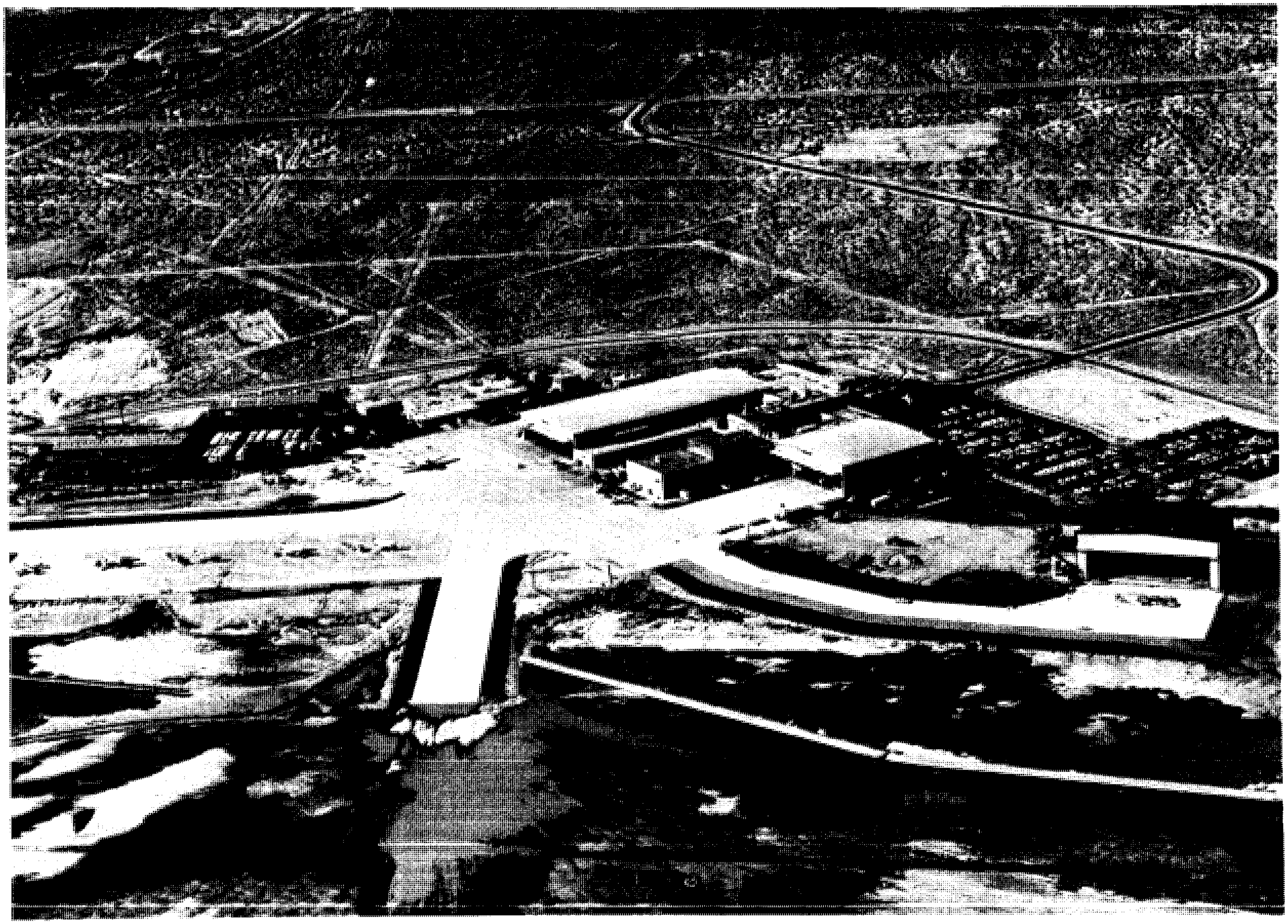


KEY PLAN

FLIGHT RESEARCH CENTER
FISCAL YEAR 1967 ESTIMATES
LOCATION PLAN



AO 3-23



Flight Research Center
Edwards, California

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ORGANIZATION AND STAFFING CHART

FLIGHT RESEARCH CENTER

STAFFING SUMMARY

	66	67
Excepted	6	6
GS-16	3	3
GS-15	20	21
GS-14	23	22
All other GS	307	300
Wage Board	245	244
Total Permanent	604	596
Temporary	14	14
Total Positions	618	610

OFFICE OF THE DIRECTOR

	66	67
Excepted	3	3
GS-16	1	1
GS-15	2	2
GS-14	1	1
All other GS	8	7
Wage Board	24	24
Total Permanent	39	38

RESEARCH DIVISION

	66	67
Excepted	1	1
GS-16	1	1
GS-15	9	8
GS-14	7	7
All other GS	102	102
Wage Board	1	1
Total Permanent	121	120

OPERATIONS DIVISION

	66	67
Excepted	2	2
GS-16	-	-
GS-15	6	8
GS-14	6	4
All other GS	22	21
Wage Board	123	122
Total Permanent	159	157

DATA SYSTEMS DIVISION

	66	67
Excepted	-	-
GS-16	1	1
GS-15	2	2
GS-14	7	8
All other GS	93	90
Wage Board	74	74
Total Permanent	177	175

ADMINISTRATIVE DIVISION

	66	67
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	2	2
All other GS	82	80
Wage Board	23	23
Total Permanent	108	106

ADMINISTRATIVE OPERATIONS

FISCAL YEAR 1967 ESTIMATES

FLIGHT RESEARCH CENTER

MISSION AND CAPABILITIES:

The Flight Research Center, established in 1947, conducts research in and evaluates problems of manned flight, both within and outside the atmosphere. The work 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.

The current and projected programs at this center include aeronautics projects, such as 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 psace flight program concerning project Apollo is provided through lunar landing research.

Most important of the facilities and special equipment for conducting these programs are the aircraft. They range from lightweight civil aircraft for handling qualities investigations to century series fighters used for pilot proficiency and general investigations and to X-15 rocket aircraft used for hypersonic research and reentry investigations. Special purpose vehicles such as 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:

	1965	1966	1967
Authorized Positions, end of year	669	618	610
Average Number of All Employees....	617	617	610
Administrative Operations..........	$10,523,000	$9,335,000	$9,641,000

INSTALLATION DESCRIPTION:

The Flight Research Center, Edwards, California, is 65 air miles north of Los Angeles. The Center is located at the north end of Edwards Air Force Base on 218 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 three-station radar range operated by the Center is located on the third floor of the office-laboratory building. A high temperature loads calibration facility is under construction. The total capital investment as of June 30, 1965 was $31,398,000.

ANALYSIS OF RESOURCES REQUIREMENTS BY OBJECT CLASSIFICATION:

		1965	1966	1967
11.	Personnel Compensation........	$6,105,000	$6,312,000	$6,510,000
12.	Personnel Benefits............	441,000	453,000	481,000
	Total, personnel costs......	$6,546,000	$6,765,000	$6,991,000
21.	Travel and Transportation of Persons......................	221,000	222,000	220,000
22.	Transportation of Things......	20,000	40,000	40,000
23.	Rent, Communications, and Utilities...................	393,000	317,000	270,000
24.	Printing and Reproduction.....	23,000	20,000	20,000
25.	Other Services................	1,467,000	911,000	989,000
	Services of other agencies..	37,000	4,000	4,000
26.	Supplies and Materials........	422,000	475,000	506,000
31.	Equipment.....................	1,293,000	480,000	500,000
32.	Lands and Structures..........	101,000	100,000	100,000
42.	Insurance Claims and Indemnities................	---	1,000	1,000
	Total......................	$10,523,000	$9,335,000	$9,641,000

JUSTIFICATION BY OBJECT CLASSIFICATION:

Personnel Distribution

	1965	1966	1967
Direct Personnel by Program			
Manned Space Flight			
Apollo..........................	51	37	6

	1965	1966	1967
Space Science and Applications			
Physics and astronomy............	2	2	2
Advanced Research and Technology			
Basic research...................	1	1	1
Space vehicle systems............	29	49	49
Electronics systems..............	34	28	28
Human factor systems.............	13	13	13
Aeronautics......................	317	319	345
Tracking and Data Acquisition......	39	37	37
Technology Utilization.............	1	1	1
Sub-total, direct positions......	487	487	482
Support personnel			
Director and Staff.................	11	11	10
Administration.....................	107	106	104
Sub-total, support positions.....	118	117	114
Total, permanent positions.......	605	604	596
Other positions:			
Positions under cooperative training agreements.............	14	14	14
Other temporary positions........	50	-	-
Total, all positions................	669	618	610

Personnel requirements

The research effort may change slightly due to the new B-70 and F-111 airplane programs which are contingent on delivery dates of the aircraft; the effort on the Apollo S/C (LLRV) will terminate during the 1st quarter.

Personnel Costs

	1965	1966	1967
Total Positions....................	669	618	610
Permanent........................	605	604	596
Other..............................	64	14	14
Personnel Compensation:			
Annual cost of permanent positions.....................	$5,689,000	$5,979,000	$6,009,000
Pay above the stated annual rate.	22,000	23,000	23,000
Lapses (deduct)..................	-71,000	-229,000	-24,000
Net cost of permanent positions..	5,640,000	5,773,000	6,008,000
Other personnel compensation.....	465,000	539,000	502,000
Total compensation.............	6,105,000	6,312,000	6,510,000
NASA funded.................	6,105,000	6,312,000	6,510,000
Reimbursable................	---	---	---
Personnel benefits................	441,000	453,000	481,000
NASA funded.....................	441,000	453,000	481,000
Reimbursable....................	---	---	---
Total personnel costs..............	6,546,000	6,765,000	6,991,000
NASA funded.....................	6,546,000	6,765,000	6,991,000
Reimbursable....................	---	---	---
Average Number of All Employees (Man Years).....................	617	617	610

Personnel Costs - $6,991,000

The personnel cost for FY 1967 is estimated at $6,991,000 covering 610 man years of employment. The amount of $6,510,000 is requested for personnel compensation and $481,000 for personnel benefits. The FY 1967 estimate includes an increase of $226,000 over the amount for the current fiscal year. This increase is required to cover the additional costs due to the Federal Employees Salary Act of 1965 for a full year; within-grade increases; the career development program; retirement contributions; and other benefits.

The following table shows the major items which are included in the estimated personnel costs:

	FY 1967 Estimate	Increase or Decrease from FY 1966
Personnel Compensation:		
Net cost of permanent positions..........	$6,008,000	+$235,000
Other personnel compensation............	502,000	-37,000
Sub-total..........................	6,510,000	+ 198,000

	FY 1967 Estimate	Increase or Decrease from FY 1966
Personnel Benefits:		
Retirement contributions..............	395,000	22,000
Other benefits........................	86,000	6,000
Sub-total..........................	481,000	28,000
Total, personnel costs..................	$6,991,000	$226,000

Travel and Transportation of Persons - $220,000

Increased travel required in connection with the XB-70 program and other flight projects is offset by reduced travel in other areas. This fact, coupled with a reduction in personnel assigned to the Center, results in a net reduction of $2,000.

Transportation of Things - $40,000

The FY 1967 level is the same as FY 1966. The funds are primarily for the transportation of spare parts and equipment from other government agencies and the shipment of household goods of new personnel hired to fill vacated positions.

Rent, Communications, and Utilities - $270,000

A net decrease of $47,000 in FY 1967 is estimated because of the purchase of a digital computer system which is scheduled for delivery in late FY 1966. The savings related to ADP equipment rental are offset by an increase in utilities of $31,000 which results from the completion of the High Temperature Loads Calibration Facility.

Printing and Reproduction - $20,000

The funding for this category remains at the same level as FY 1966.

Other Services - $993,000

The funding for other services provides for an increase of $78,000 over FY 1966. This increase is primarily related to the new High Temperature Loads Calibration Facility which will become operational, and custodial services in the form of security and janitorial services that must be provided.

Supplies and Materials - $506,000

The funding for this category shows an increase of $31,000. This increase is requested to cover cost that will be incurred in the expanded flight programs, primarily the XB-70. Areas of increases will be general operating and service materials, and hardware items.

Equipment - $500,000

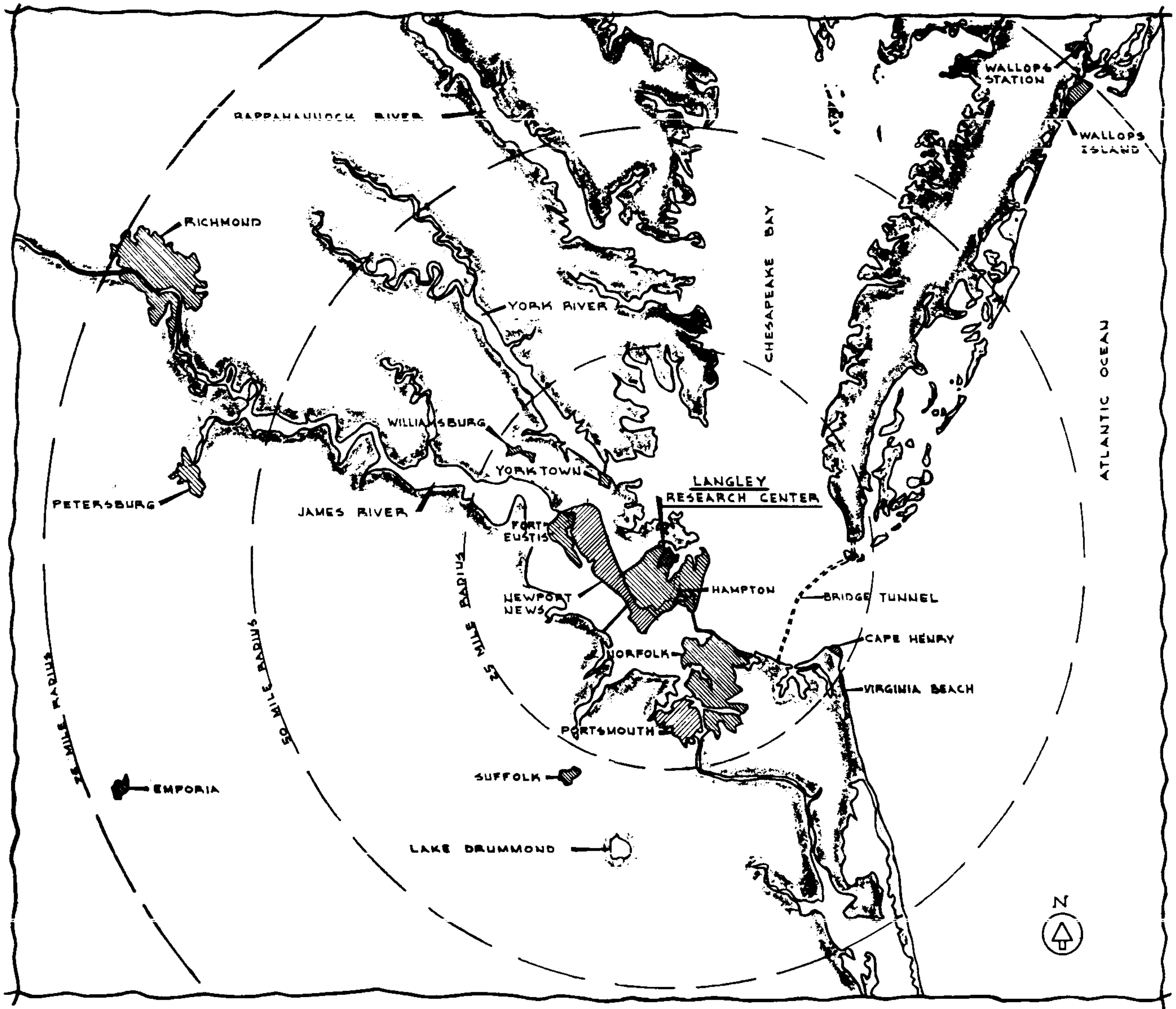
This category is estimated at approximately the FY 1966 level. The slight increase of $20,000 is almost entirely for replacement of motor vehicles and training and electronics equipment.

Lands and Structures - $100,000

The FY 1967 request remains at the FY 1966 level. These funds are required to modify a part of the main building into laboratory and shop space.

Insurance Claims and Indemnities - $1,000

The funding in this category remains the same as FY 1966.

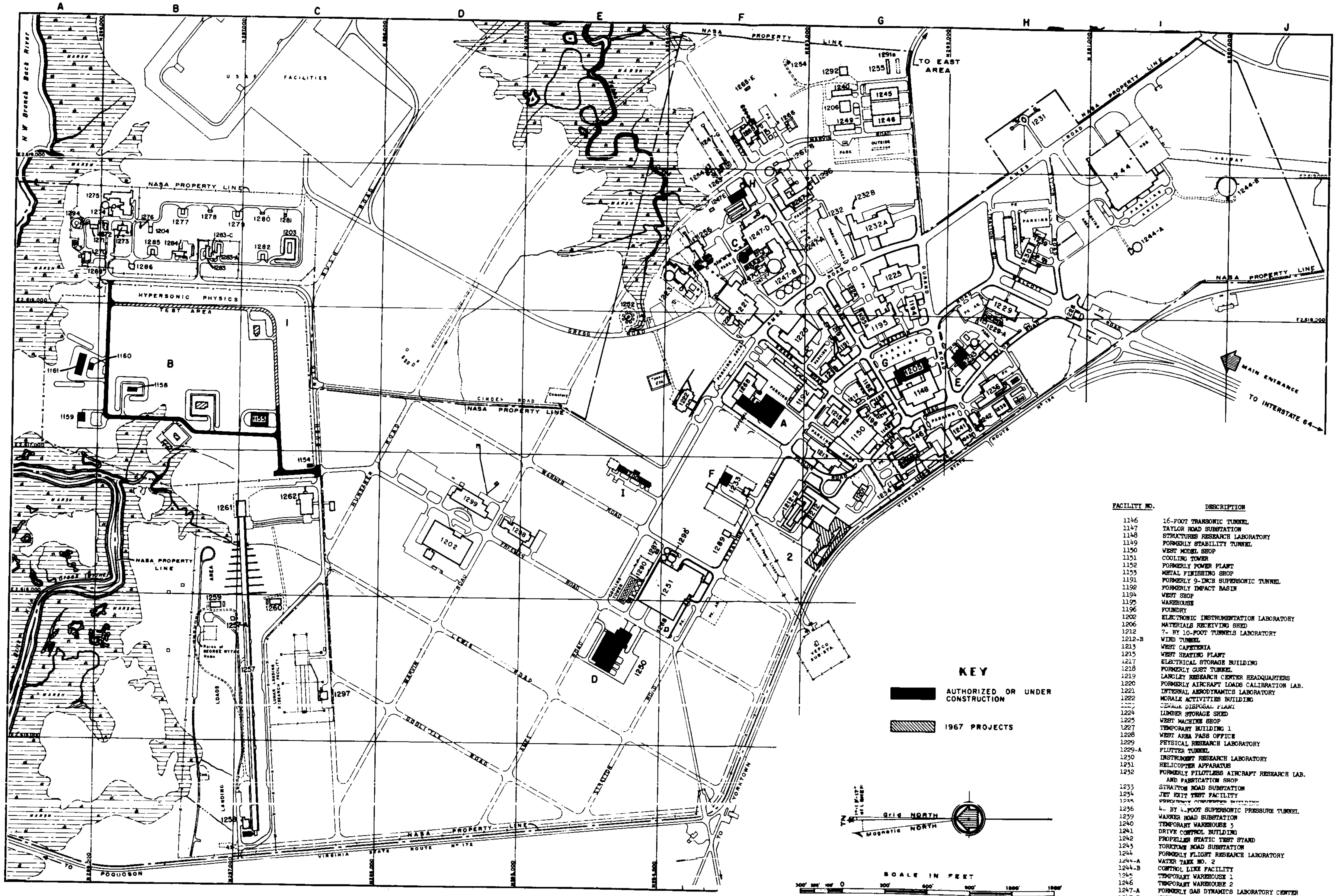


LANGLEY RESEARCH CENTER AND VICINITY

1" = 8 MILES

LANGLEY RESEARCH CENTER
FISCAL YEAR 1967 ESTIMATES

LOCATION PLAN



WEST AREA

PROPOSED FISCAL YEAR 1967 PROJECTS

1. REACTIVE CHEMICAL DISTRIBUTION AREA
2. V/STOL TRANSITION WIND TUNNEL

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
1202	ELECTRONIC INSTRUMENTATION LABORATORY
1206	MATERIALS RECEIVING SHED
1212	7- BY 10-FOOT TUNNELS LABORATORY
1212-B	WIND TUNNEL
1213	WEST CAFETERIA
1215	WEST HEATING PLANT
1217	ELECTRICAL STORAGE 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	STRATTON 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
1254	AMMUNITION STORAGE 1

FACILITY NO.	DESCRIPTION
1255	TEMPORARY WAREHOUSE 6
1256	9- BY 6-FOOT THERMAL STRUCTURES TUNNEL
1257	LANDING LOADS TRACK
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	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
1298	STABILIZATION AND CONTROL EQUIPMENT LABORATORY
1299	VEHICLE ANTENNA TEST FACILITY AND ADDITION

FACILITIES AUTHORIZED AND UNDER CONSTRUCTION

A	FLIGHT CONTROL RESEARCH FACILITY
B	MAGAZINE AND TEST AREA FOR HIGHLY REACTIVE CHEMICAL MATERIALS
C	INCD. CAP. FOR MACH 6 AND 8.5 TUNNELS
D	LIFE SUPPORT TECHNOLOGY LABORATORY
E	THERMAL CONTROL HOUSING AND BUILDING ADDITION FOR DYNAMICS RESEARCH LAB.
F	UTILITY IMPROVEMENTS
G	FATIGUE RESEARCH LABORATORY
H	ADDITION TO CENTRAL HIGH-PRESSURE AIR SUPPLY
I	HOT GAS RADIATION RESEARCH FACILITY

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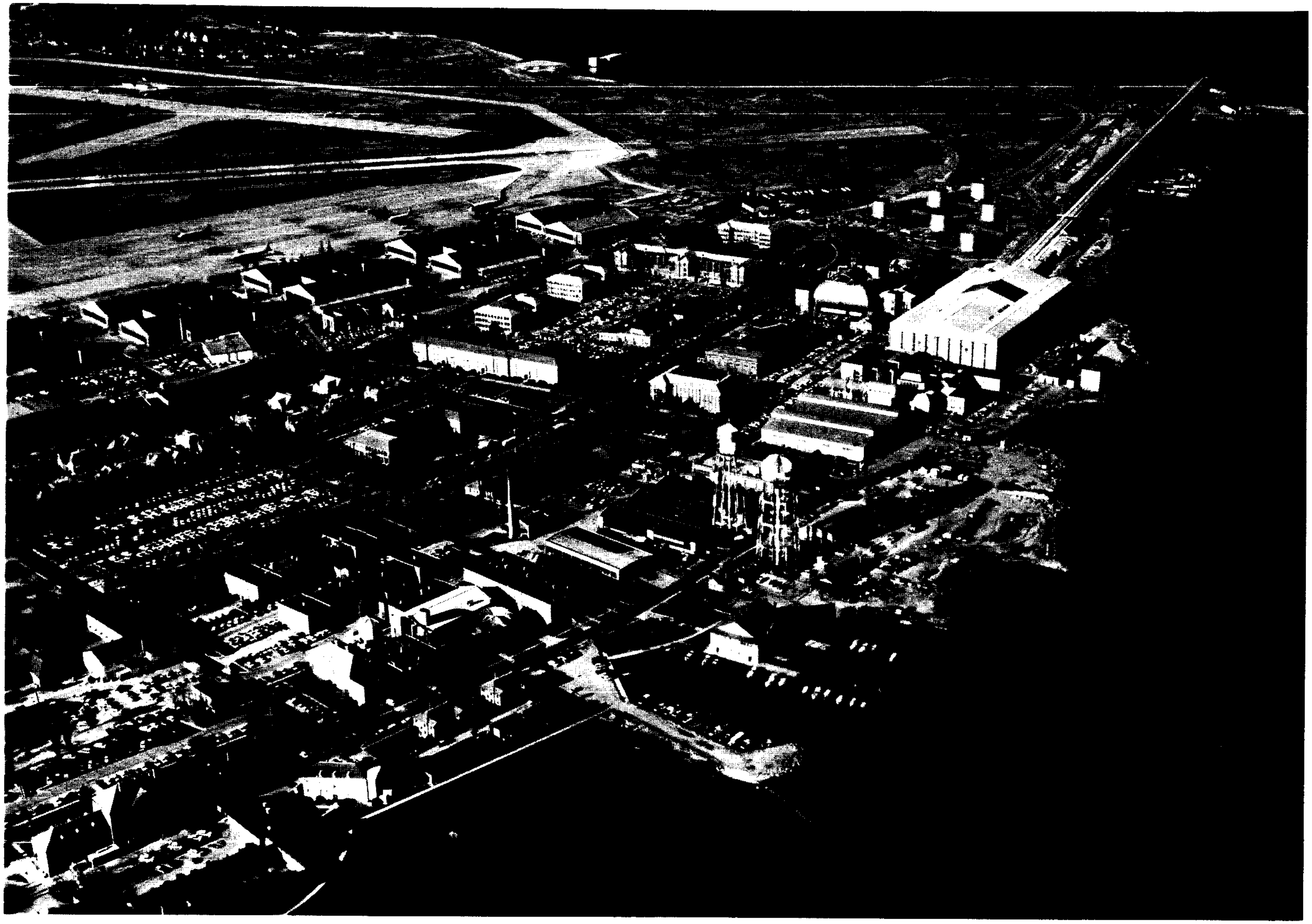
LANGLEY RESEARCH CENTER
Hampton, Virginia

AERIAL VIEW - West Area

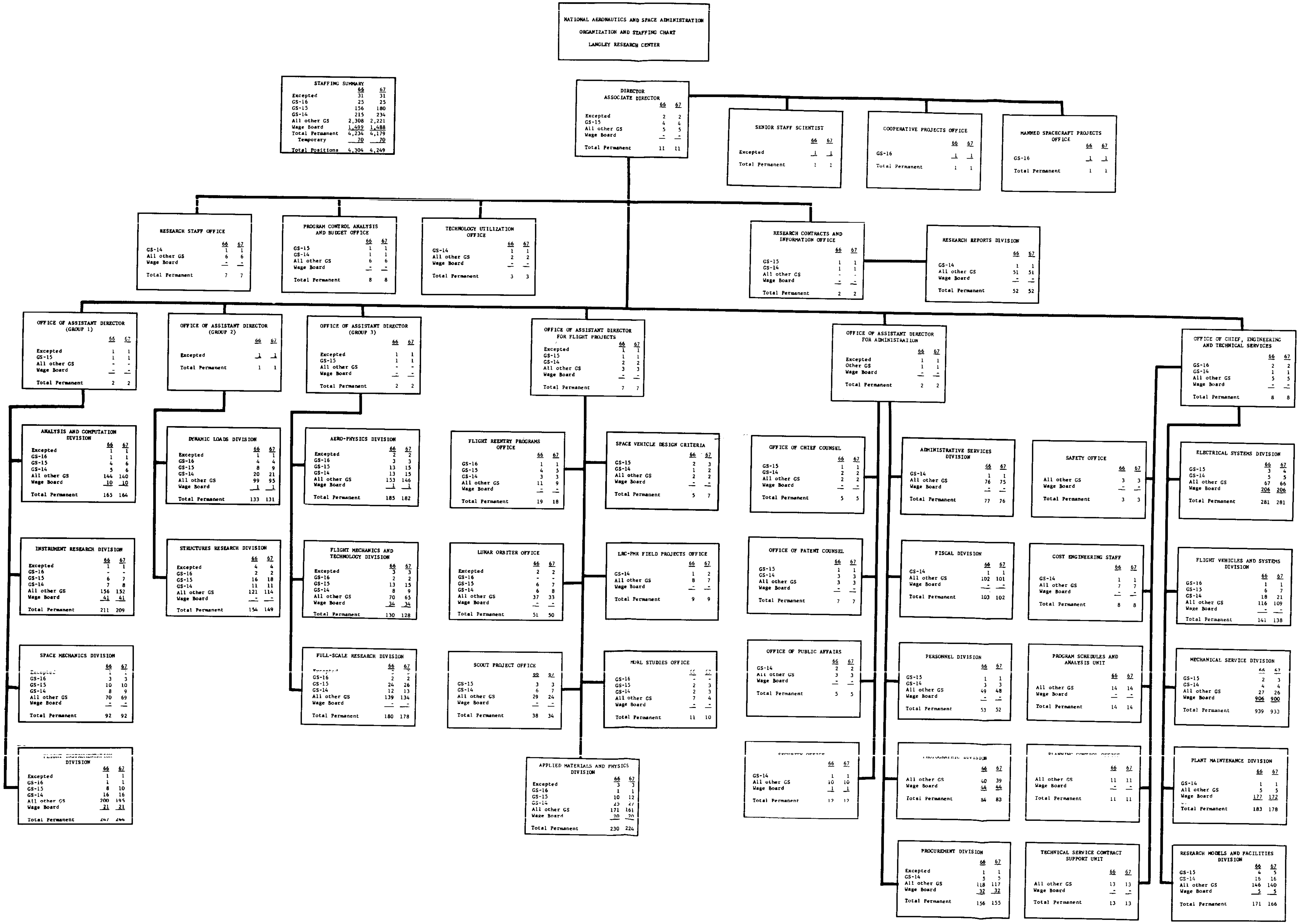
AO 3-33

LANGLEY RESEARCH CENTER
Hampton, Virginia



AERIAL VIEW - East Area

AO 3-34



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ADMINISTRATIVE OPERATIONS

FISCAL YEAR 1967 ESTIMATES

LANGLEY RESEARCH CENTER

MISSION AND CAPABILITIES:

The Langley Research Center conducts a broad range of programs to advance the aeronautical and space flight capabilities of the nation.

The aeronautical research program aims at the extension of aircraft performance, the assurance of adequate stability and control, the specification of critical operating loads and fatigue criteria, the optimization of vehicle structures and materials, the reduction of aircraft noise, the refinement of new propulsive systems, and the improvement of flight safety and operations techniques. Special emphasis is placed on the acquisition of sufficient basic technology to facilitate the successful development of efficient supersonic and high-subsonic-speed transports, high-performance military aircraft, practicable hypersonic ramjet vehicles, and advanced vertical-and-short-takeoff-and-landing (V/STOL) aircraft.

In the space flight field, the Langley Research Center executes a broad range of research programs to provide a rational basis for future space developments, and manages and supports a large number of current space flight projects. Especially noteworthy are the investigations of atmosphere entry aerothermodynamics, heat shielding, and communications "blackout" for earth-orbital, lunar, and planetary missions; the definition of structural dynamics characteristics of large launch vehicles and spacecraft landing systems; the evolution of advanced configurations for lifting entry and controlled landing spacecraft, recoverable first-stage boosters, earth-to-orbit vehicles, and expandable space structures; the determination of the effects of heat, vacuum, loads, noise, climate, micrometeoroids, and radiation of the operational environments on the performance of vehicle systems and materials; the generation of technology for improved navigation and control systems, instrumentation, data handling and communication equipment, vehicle propulsion and power devices, and aerospace materials; the development of space vehicles for refined measurements of the earth's geodetic elements and atmospheric density, and of the interplanetary micrometeoroid hazard; the management of the Lunar Orbiter project for detailed photographic and geophysical surveys of the moon; the perfection of navigation aids and surface strength assessment techniques for lunar and planetary landing missions; the operation of the Scout launch vehicle in its various national and international satellite and entry vehicle applications; and the provision of wide ranges of crucial technology for the Gemini and Apollo programs, as well as a number of other unmanned space projects. The Langley Research Center also investigates basic problems regarding the design and operation of advanced planetary exploration spacecraft, and has a prominent role in the definition of the Mars probe/lander vehicles of the Voyager program.

As a continuation of the Langley Research Center's pioneering efforts that produced the research airplane and Mercury spacecraft projects, special emphasis is placed on research for the extension of manned flight capabilities. Research on advanced flight concepts, therefore, includes closely coupled studies of man's functional performance and vehicular accommodations, to maximize the integrated potentials of crew, vehicle, and mission. Here, the unique laboratory capabilities for simulation of the piloting experience of rendezvous, extraterrestrial landings, all-weather navigation and landing, etc., facilitate the establishment of handling requirements, optimum displays and controls, and operational techniques for new generations of vehicles and missions. The Center also improves the technology of man-machine integration on the complete vehicle level, as in its studies of promising designs for manned orbital laboratories; on the systems level, as in its research on flight crew operations with advanced life support systems for long duration missions; and on the applications level, as in its evaluation of the merits and feasibility of manned support of a large orbiting telescope. Such work also provides a sound foundation for the Center's responsibilities in the identification of appropriate uses for Apollo applications vehicles.

The new knowledge and capabilities acquired through such research serve as vital stepping stones to the realization of national flight aspirations.

SUMMARY OF RESOURCES REQUIREMENTS:

	1965	1966	1967
Authorized Positions, end of year.	4,374	4,304	4,249
Average Number of All Employees...	4,316	4,335	4,227
Administrative Operations.........	$58,998,000	$63,006,000	$62,587,000

INSTALLATION DESCRIPTION:

The Langley Research Center, Hampton, Virginia, is located approximately 100 air miles south of Washington, D. C. The Center is divided into two separate areas adjacent to the runway facilities of the Langley Air Force Base, and occupies 772 acres of government owned land. The West Area consists of 750 acres of which 430 acres are owned by NASA and 320 acres are under permit from the Air Force. The East Area consists of 22 acres under permit from the Air Force. Runways, some utilities, and certain other facilities are used jointly by NASA and the Air Force. In addition, there are 110 acres of NASA owned land located in the city of Newport News, Virginia, 3,277 acres under permit from other government agencies, and 17 acres under lease. The total acreage owned, under permit, or leased, is 4,176. The total capital investment as of June 30, 1965, was $276,178,000.

ANALYSIS OF RESOURCES REQUIREMENTS BY OBJECT CLASSIFICATION:

	1965	1966	1967
11. Personnel Compensation......	$39,355,000	$41,036,000	$41,999,000
12. Personnel Benefits..........	2,880,000	2,993,000	3,043,000
Total, personnel costs....	$42,235,000	$44,029,000	$45,042,000
21. Travel and Transportation of Persons................	1,430,000	1,503,000	1,489,000
22. Transportation of Things....	373,000	370,000	370,000
23. Rent, Communications, and Utilities.................	4,984,000	5,607,000	6,035,000
24. Printing and Reproduction...	175,000	201,000	201,000
25. Other Services..............	2,699,000	2,807,000	3,319,000
Services of other agencies	63,000	63,000	63,000
26. Supplies and Materials......	2,681,000	2,700,000	2,720,000
31. Equipment...................	3,401,000	5,256,000	2,878,000
32. Lands and Structures........	957,000	470,000	470,000
42. Insurance Claims and Indemnities...............	---	---	---
Total....................	$58,998,000	$63,006,000	$62,587,000

JUSTIFICATION BY OBJECT CLASSIFICATION:

Personnel Distribution

	1965	1966	1967
Direct Personnel by Program			
Manned Space Flight			
Apollo....................................	10	9	9
Advanced mission studies....................	14	14	13
Space Science and Applications			
Physics and astronomy.......................	82	63	46
Lunar and planetary.........................	102	148	154
Sustaining university program...............	1	---	---
Launch vehicle development..................	2	3	2
Launch vehicle procurement..................	41	35	35
Bioscience..................................	---	1	1
Meteorological satellites...................	13	13	12
Communication and applications technology satellites................................	4	3	3

	1965	1966	1967
Advanced Research and Technology			
Basic research	350	354	348
Space vehicle systems	754	714	700
Electronics systems	512	515	500
Human factor systems	55	58	65
Space power and electric propulsion systems	22	21	20
Chemical propulsion	48	57	61
Aeronautics	718	713	706
Tracking and Data Acquisition	19	20	21
Sub-total, direct positions	2,747	2,741	2,696
Support personnel			
Director and Staff	32	32	32
Administration	515	515	510
Research and development support	950	946	941
Sub-total, support positions	1,497	1,493	1,483
Total, permanent positions	4,244	4,234	4,179
Other positions:			
Positions under cooperative training agreements	49	50	50
Other temporary positions	81	20	20
Total, all positions	4,374	4,304	4,249

Personnel requirements

The current and projected research effort is devoted to a broad range of programs to advance national aeronautical and space flight capabilities in accordance with NASA missions. In the field of aeronautics, the Langley Research Center program is directed to the extension of aircraft performance and other related problems with special emphasis on acquisition of sufficient basic technology to facilitate the development of efficient supersonic transports, hypersonic ramjet vehicles, and V/STOL aircraft. Activity in support of space flight includes research in many scientific disciplines to provide a rational basis for future space accomplishments. The Center also directs a number of space flight projects, varying in size and scope from sounding rockets to the lunar orbiter project for detailed photographic and geophysical surveys of the moon. Minor reassignments of personnel between programs will be effected in conformity with changing program priorities and assigned Center complement.

Personnel Costs

	1965	1966	1967
Total Positions....................	4,374	4,304	4,249
Permanent.........................	4,244	4,234	4,179
Other.............................	130	70	70
Personnel Compensation:			
Annual cost of permanent positions......................	$38,587,000	$40,491,000	$40,627,000
Pay above the stated annual rate.	148,000	156,000	156,000
Lapses (deduct)..................	-876,000	-1,148,000	-133,000
Net cost of permanent positions..	37,859,000	39,499,000	40,650,000
Other personnel compensation.....	1,496,000	1,537,000	1,349,000
Total compensation..............	39,355,000	41,036,000	41,999,000
NASA funded..................	39,355,000	41,036,000	41,999,000
Reimbursable.................	---	---	---
Personnel benefits.................	2,880,000	2,993,000	3,043,000
NASA funded......................	2,880,000	2,993,000	3,043,000
Reimbursable.....................	---	---	---
Total personnel costs..............	42,235,000	44,029,000	45,042,000
NASA funded......................	42,235,000	44,029,000	45,042,000
Reimbursable.....................	---	---	---
Average Number of All Employees (Man Years)......................	4,316	4,335	4,227

Personnel Costs - $45,042,000

The personnel costs for FY 1967 are estimated to be $45,042,000 covering 4,227 man years of employment. Of this amount, $41,999,000 is requested for personnel compensation and $3,043,000 for personnel benefits. The FY 1967 estimate includes an increase of $1,013,000 over the amount for the current fiscal year. This increase is requested to cover the cost of the Federal Employees Salary Act of 1965 on a full year basis, for within-grade step increases and career development, for retirement contributions and other benefits.

The following table shows the major items which are included in the estimate for personnel costs:

	FY 1967 Estimate	Increase or Decrease from FY 1966
Personnel compensation:		
Net cost of permanent positions........	$40,650,000	$+1,151,000
Other personnel compensation...........	1,349,000	-188,000
Sub-total...........................	41,999,000	+963,000
Personnel benefits:		
Retirement contributions...............	2,652,000	+76,000
Other personnel benefits...............	391,000	-26,000
Sub-total...........................	3,043,000	+50,000
Total, personnel costs...................	$45,042,000	$+1,013,000

Travel and Transportation of Persons - $1,489,000

This requirement for travel reflects a reduction of $14,000 in FY 1967. This reduction is based upon continuing improvement of contract administration procedures and a reduction in permanent personnel.

Transportation of Things - $370,000

The requirements for this service is estimated to remain at the FY 1966 level.

Rent, Communications, and Utilities - $6,035,000

This category increases by $428,000 in the FY 1967 estimates. The major portion of this increase, $321,000, is for lease of ADP equipment. In FY 1966, the Center began a three phase replacement program of its existing ADP system. Procurement for Phase I, with the exception of the part that will be purchased in FY 1967, is underway. In addition, in FY 1967 the Center will lease the Phase II increment until such time as funds are available for its purchase. No funds are requested at this time for Phase III requirements.

Costs of communications increase $10,000. This increase is to provide communication services to new buildings that will be completed in FY 1967.

Likewise, utilities increase by $100,000 in FY 1967 because of increased consumption of electrical power required for the new buildings.

The foregoing increases are partially offset by minor decreases in other sub-object classifications.

Printing and Reproduction - $201,000

The cost of printing and reproduction is estimated to remain at the same level in FY 1967 as the FY 1966 requirement. Contractual printing is utilized to supplement in-house capabilities during peak work loads and also for work beyond the scope of the in-house reproduction facilities.

Other Services - $3,382,000

The estimate for this category is $512,000 greater than for FY 1966. Maintenance cost on ADP equipment increases by $256,000 due to full year funding for maintenance on equipment purchased in FY 1966.

Custodial services increase by $217,000 in FY 1967 as a result of anticipated higher wage rates due to the minimum wage standards set in the Service Contract Act of October 1965.

Small increases are also estimated for maintenance on aircraft and buildings in FY 1967.

Supplies and Materials - $2,720,000

The estimate for supplies and materials in FY 1967 is $20,000 higher than the level in FY 1966. This increase is required for general maintenance and the additional supplies and materials that will be required to support the new facilities that will become available during late FY 1966 and FY 1967.

Equipment - $2,878,000

The FY 1967 estimate for equipment is $2,378,000 less than the level for FY 1966. This reduction is related to procurement in FY 1966 of the initial increment of equipment in Phase I of the program to replace the existing ADP system. In FY 1967, $1,982,000 is required to complete the purchase of equipment under Phase I.

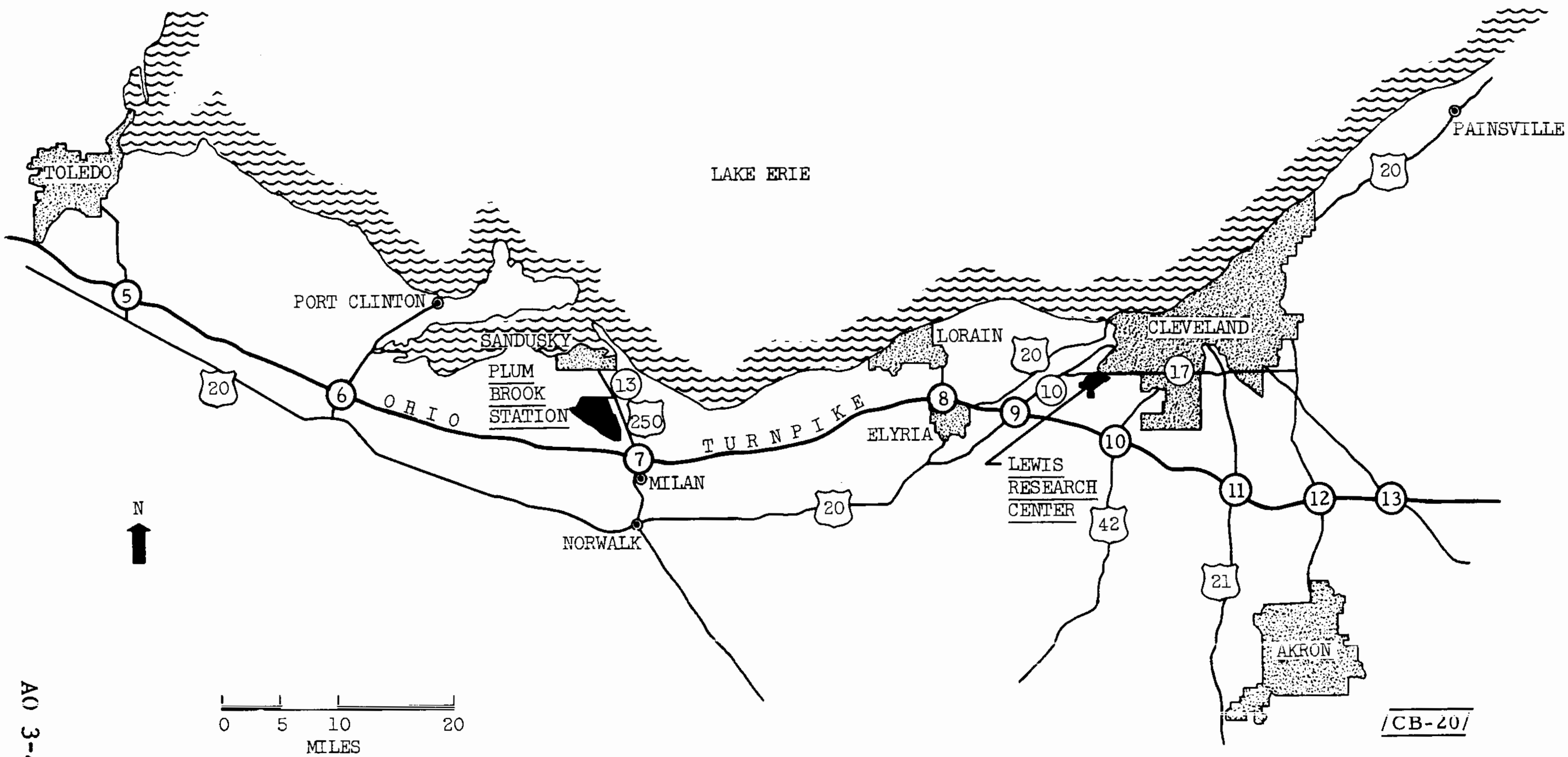
Requirements for other equipment items, such as mechanical and shop machinery, reflect a minor increase in FY 1967. These increased requirements, although offset by the reduction in procurement of ADP equipment, are required to replace out-dated and worn equipment.

Lands and Structures - $470,000

The estimate for FY 1967 is the same as the requirement for FY 1966. The Center will continue in FY 1967 to up-grade support facilities through needed alterations and repairs.

LEWIS RESEARCH CENTER
FISCAL YEAR 1967 ESTIMATES

LOCATION OF LEWIS RESEARCH CENTER INCLUDING PLUM BROOK STATION



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LEWIS RESEARCH CENTER
FISCAL YEAR 1967 ESTIMATES

LOCATION PLAN

LEGEND-EXISTING BUILDINGS

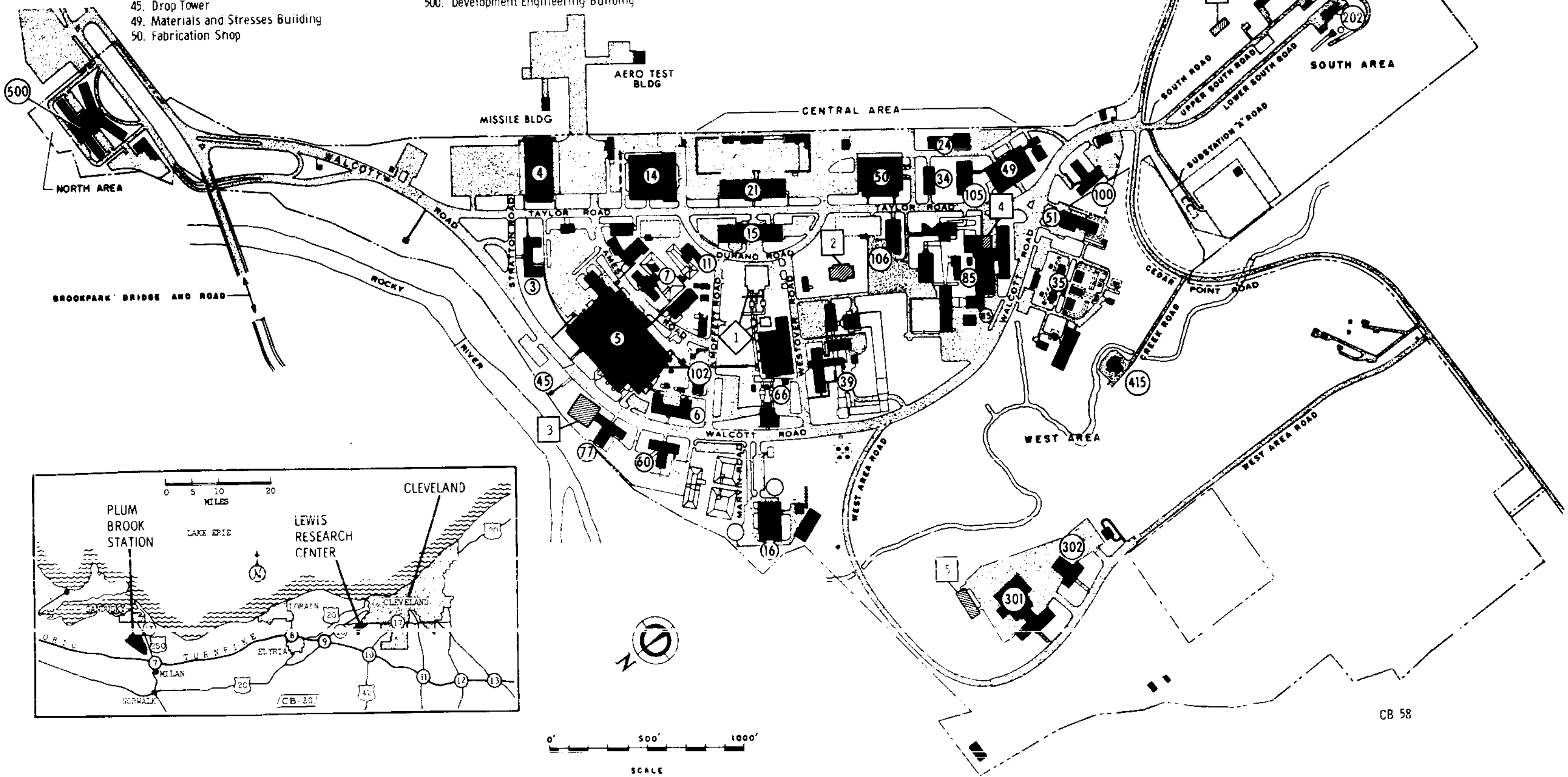
3. Administration Building
4. Flight Research Building
5. Engine Research Building
6. Chemistry Laboratory
7. Space Power Chambers
11. Icing Research Tunnel
14. Technical Services Building
15. Utilities Building
16. Electric Propulsion Research Building
21. Procurement and Supply Building
24. Special Projects Laboratory
34. Liquid Metals Corrosion Laboratory
35. Rocket Laboratory
39. 8x6-Foot Supersonic Wind Tunnel
45. Drop Tower
49. Materials and Stresses Building
50. Fabrication Shop
51. High Energy Fuels Laboratory
60. Propulsion Systems Laboratory Operations Building
66. Propulsion Systems Laboratory
77. Instrument Research Laboratory
85. 10x10-Foot Supersonic Wind Tunnel
100. Rocket Operations Building
102. Liquid Metals Power Laboratory
105. Materials Processing Laboratory
106. Basic Materials Laboratory
202. Rocket Engine Test Facility
203. Fracture Mechanics Laboratory
301. Electric Propulsion Laboratory
302. Energy Conversion Laboratory
415. Rocket Combustion Laboratory
500. Development Engineering Building

FACILITIES AUTHORIZED AND UNDER CONSTRUCTION

1. High-Load Capacity Tensile Testing Facility
2. Zero Gravity Facility
3. Addition to Instrument Research Laboratory
4. Building Addition to the 10x10-Foot Supersonic Wind Tunnel for Data Processing
5. Space Power Research Laboratory

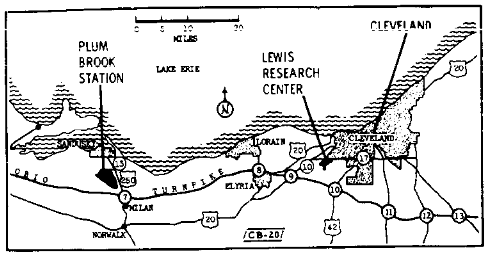
PROPOSED FISCAL YEAR 1967 PROJECTS

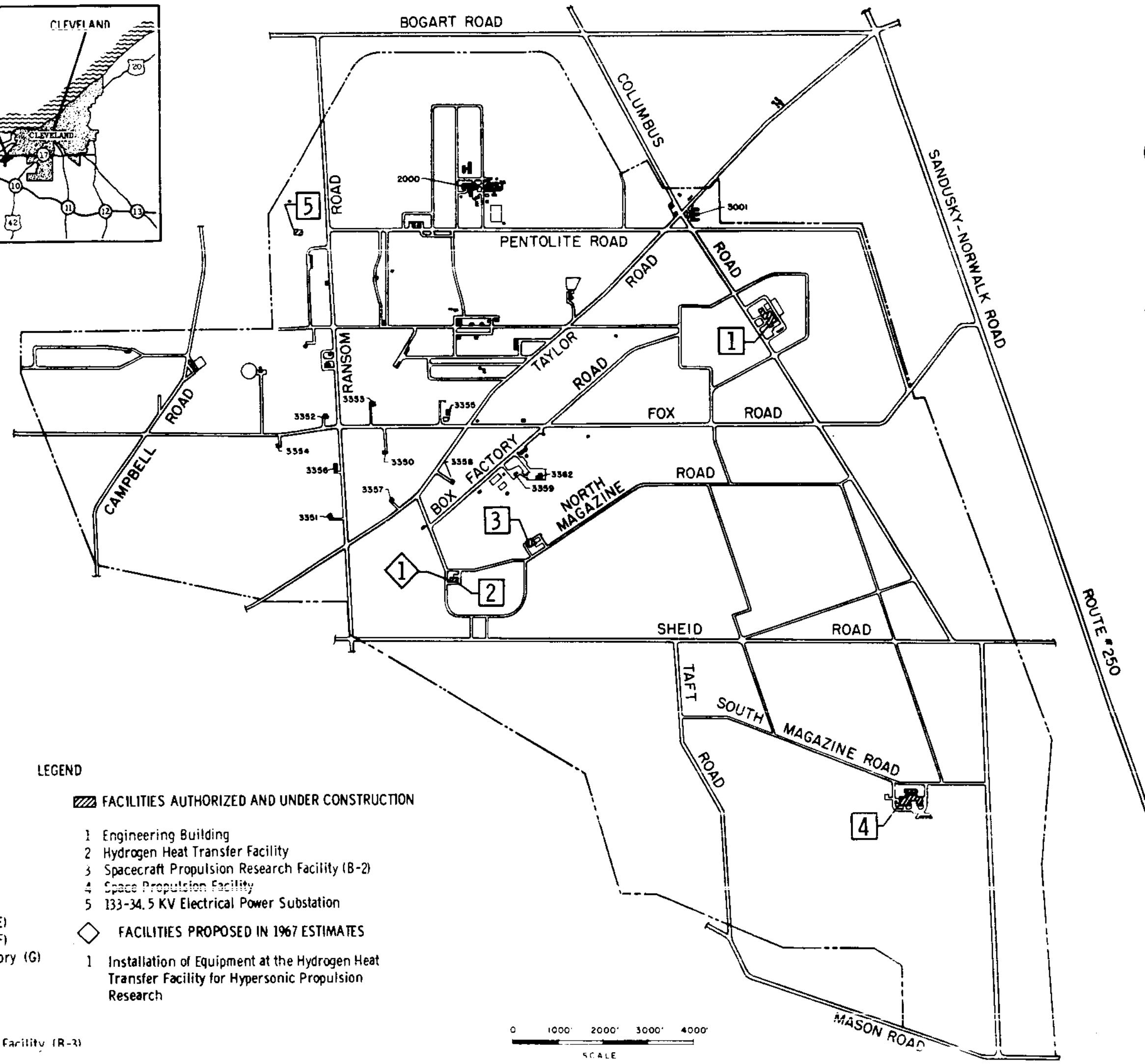
1. Expansion of the Propulsion Systems Laboratory for Supersonic Research



LEWIS RESEARCH CENTER
PLUM BROOK STATION
FISCAL YEAR 1967 ESTIMATES

LOCATION PLAN





LEGEND

EXISTING FACILITIES

2000 Reactor Facility
3001 Administration Building
3350 Rocket Pump Laboratory (A)
3351 Rocket Turbo-pump Laboratory (C)
3352 Rocket Turbine Laboratory (D)
3353 Rocket Systems Dynamics Laboratory (E)
3354 Rocket Systems Hydraulic Laboratory (F)
3355 Rocket Turbine and Pump Pilot Laboratory (G)
3356 Central Control and Data Building (H)
3357 Fluorine Pump Laboratory (I)
3358 Rocket Systems Laboratory (J)
3359 Altitude Rocket Test Facility (B-1)
3362 Nuclear Rocket Dynamics and Controls Facility (B-3)

FACILITIES AUTHORIZED AND UNDER CONSTRUCTION

1 Engineering Building
2 Hydrogen Heat Transfer Facility
3 Spacecraft Propulsion Research Facility (B-2)
4 Space Propulsion Facility
5 133-34.5 KV Electrical Power Substation

◇ FACILITIES PROPOSED IN 1967 ESTIMATES

1 Installation of Equipment at the Hydrogen Heat Transfer Facility for Hypersonic Propulsion Research

LEWIS RESEARCH CENTER
FISCAL YEAR 1967 ESTIMATES

CLEVELAND FACILITIES

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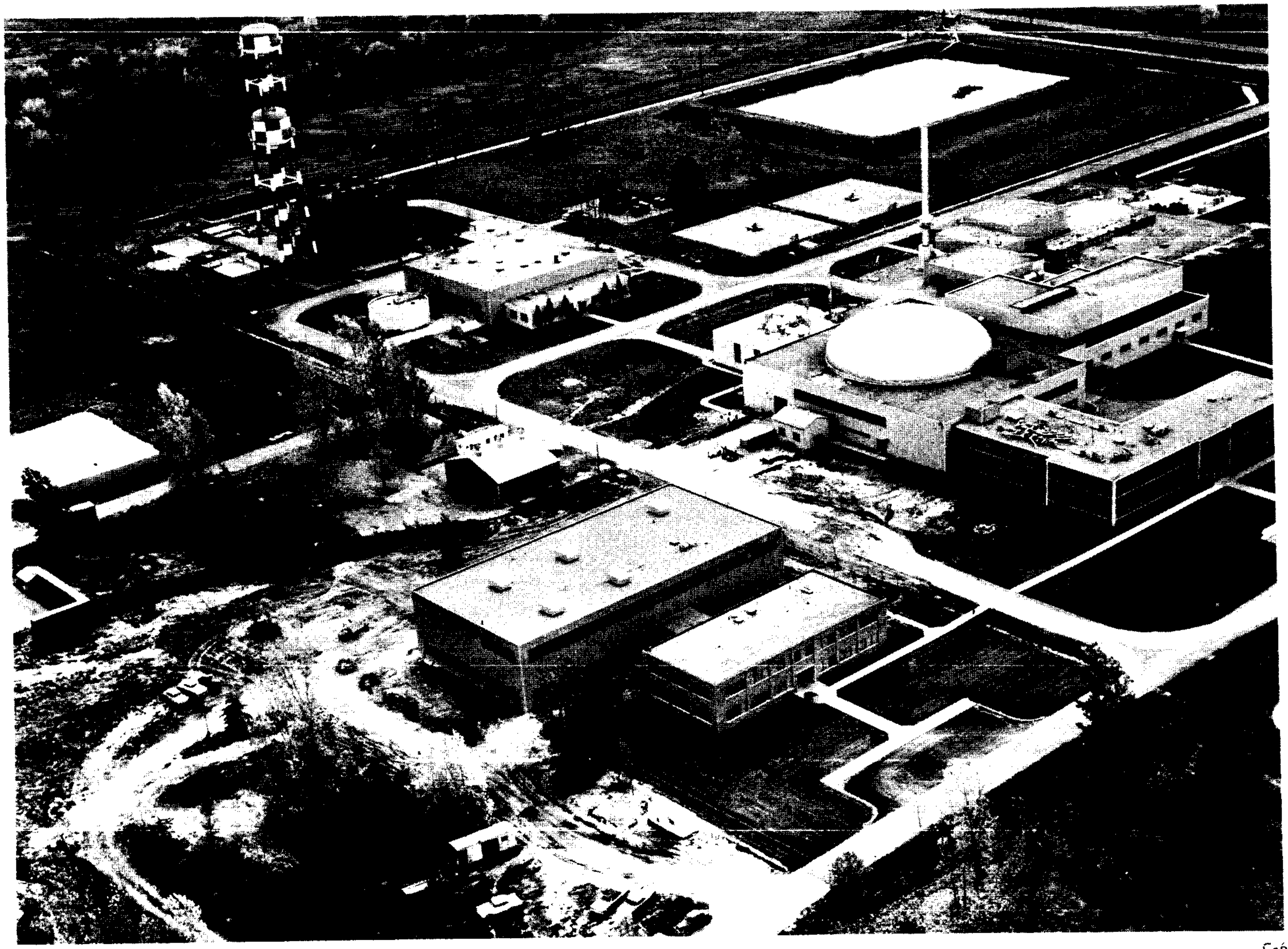
LEWIS RESEARCH CENTER
FISCAL YEAR 1967 ESTIMATES

PLUM BROOK STATION
(NORTH PORTION SHOWING REACTOR GROUP)



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LEWIS RESEARCH CENTER
FISCAL YEAR 1967 ESTIMATES

PLUM BROOK STATION
(ENGINEERING BUILDING)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ORGANIZATION AND STAFFING CHART

LEWIS RESEARCH CENTER

STAFFING SUMMARY

	66	67
Excepted	30	30
GS-16	26	26
GS-15	155	175
GS-14	301	320
All other GS	2,568	2,478
Wage Board	1,730	1,718
Total Permanent	4,810	4,747
Temporary	32	32
Total Positions	4,842	4,779

RESOURCES PLANNING OFFICE

	66	67
Excepted	1	1
GS-16	-	-
GS-15	-	-
GS-14	2	2
All other GS	9	9
Wage Board	-	-
Total Permanent	12	12

OFFICE OF THE DIRECTOR

	66	67
Excepted	2	2
GS-16	-	-
GS-15	1	1
GS-14	-	-
All other GS	2	2
Wage Board	-	-
Total Permanent	5	5

OFFICE OF ASSOCIATE DIRECTOR FOR RESEARCH

	66	67
Excepted	1	1
GS-16	-	-
GS-15	-	-
GS-14	-	-
All other GS	1	1
Wage Board	-	-
Total Permanent	2	2

OFFICE OF RESEARCH PLANS AND PROGRAMS

	66	67
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	1	1
All other GS	3	3
Wage Board	-	-
Total Permanent	5	5

MISSION ANALYSES BRANCH

	66	67
Excepted	-	-
GS-16	-	-
GS-15	4	4
GS-14	2	2
All other GS	16	16
Wage Board	-	-
Total Permanent	22	22

CHEMISTRY AND ENERGY CONVERSION DIVISION

	66	67
Excepted	2	2
GS-16	3	3
GS-15	16	17
GS-14	22	24
All other GS	88	85
Wage Board	-	-
Total Permanent	131	131

ELECTROMAGNETIC PROPULSION DIVISION

	66	67
Excepted	1	1
GS-16	1	1
GS-15	13	14
GS-14	14	15
All other GS	104	97
Wage Board	-	-
Total Permanent	133	128

MATERIAL AND STRUCTURES DIVISION

	66	67
Excepted	2	2
GS-16	2	2
GS-15	12	14
GS-14	14	15
All other GS	114	108
Wage Board	-	-
Total Permanent	144	141

INSTRUMENT AND COMPUTING DIVISION

	66	67
Excepted	1	1
GS-16	1	1
GS-15	10	12
GS-14	11	14
All other GS	186	181
Wage Board	52	52
Total Permanent	261	261

FLUID SYSTEMS COMPONENTS DIVISION

	66	67
Excepted	2	2
GS-16	4	4
GS-15	10	14
GS-14	21	21
All other GS	87	80
Wage Board	-	-
Total Permanent	124	121

NUCLEAR REACTOR DIVISION

	66	67
Excepted	2	2
GS-16	3	3
GS-15	10	10
GS-14	27	30
All other GS	96	91
Wage Board	-	-
Total Permanent	138	136

OFFICE OF ASSOCIATE DIRECTOR FOR DEVELOPMENT

	66	67
Excepted	1	1
GS-16	-	-
GS-15	1	1
GS-14	-	-
All other GS	1	1
Wage Board	-	-
Total Permanent	3	3

OFFICE OF DEVELOPMENT PLANS AND PROGRAMS

	66	67
Excepted	1	1
GS-16	-	-
GS-15	1	1
GS-14	2	2
All other GS	8	8
Wage Board	-	-
Total Permanent	12	12

OFFICE OF RELIABILITY AND QUALITY ASSURANCE

	66	67
Excepted	-	-
GS-16	1	1
GS-15	3	3
GS-14	17	18
All other GS	20	20
Wage Board	-	-
Total Permanent	41	42

SPACE POWER SYSTEM DIVISION

	66	67
Excepted	2	2
GS-16	-	-
GS-15	9	10
GS-14	26	28
All other GS	118	113
Wage Board	-	-
Total Permanent	155	153

CENTAUR PROJECT

	66	67
Excepted	1	1
GS-16	3	3
GS-15	14	15
GS-14	22	27
All other GS	128	115
Wage Board	1	1
Total Permanent	169	162

AGENA PROJECT

	66	67
Excepted	1	1
GS-16	3	3
GS-15	8	7
GS-14	16	17
All other GS	70	63
Wage Board	-	-
Total Permanent	98	91

CHEMICAL ROCKET SYSTEMS DIVISION

	66	67
Excepted	2	2
GS-16	3	3
GS-15	7	8
GS-14	15	14
All other GS	98	95
Wage Board	-	-
Total Permanent	125	122

ADVANCED DEVELOPMENT AND EVALUATION DIVISION

	66	67
Excepted	2	2
GS-16	1	1
GS-15	9	13
GS-14	18	18
All other GS	147	143
Wage Board	-	-
Total Permanent	177	177

SPACECRAFT TECHNOLOGY DIVISION

	66	67
Excepted	1	1
GS-16	-	-
GS-15	6	10
GS-14	10	11
All other GS	108	102
Wage Board	-	-
Total Permanent	125	124

PLUM BROOK STATION OFFICE OF DIRECTOR

	66	67
Excepted	1	1
GS-16	-	-
GS-15	1	1
GS-14	-	-
All other GS	6	6
Wage Board	-	-
Total Permanent	8	8

ROCKET SYSTEMS DIVISION

	66	67
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	6	6
All other GS	60	56
Wage Board	-	-
Total Permanent	67	63

REACTOR DIVISION

	66	67
Excepted	-	-
GS-16	1	1
GS-15	1	1
GS-14	10	10
All other GS	84	80
Wage Board	-	-
Total Permanent	96	92

ENGINEERING DIVISION

	66	67
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	7	7
All other GS	43	41
Wage Board	1	1
Total Permanent	52	50

ADMINISTRATION DIVISION

	66	67
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	-	-
All other GS	21	21
Wage Board	5	5
Total Permanent	26	26

FACILITIES SERVICE DIVISION

	66	67
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	1	1
All other GS	14	14
Wage Board	301	301
Total Permanent	316	316

STAFF ASSISTANTS

	66	67
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	3	3
All other GS	44	44
Wage Board	-	-
Total Permanent	47	47

OFFICE OF ASSISTANT DIRECTOR FOR ADMINISTRATION

	66	67
Excepted	1	1
GS-16	-	-
GS-15	-	-
GS-14	-	-
All other GS	6	6
Wage Board	-	-
Total Permanent	7	7

PERSONNEL DIVISION

	66	67
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	2	2
All other GS	62	62
Wage Board	-	-
Total Permanent	65	65

FINANCE DIVISION

	66	67
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	1	1
All other GS	71	71
Wage Board	-	-
Total Permanent	72	72

ADMINISTRATIVE SERVICES DIVISION

	66	67
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	1	1
All other GS	46	46
Wage Board	-	-
Total Permanent	47	47

PROCUREMENT AND SUPPLY DIVISION

	66	67
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	6	6
All other GS	180	172
Wage Board	26	26
Total Permanent	212	204

TECHNICAL INFORMATION DIVISION

	66	67
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	1	1
All other GS	95	95
Wage Board	19	19
Total Permanent	115	115

STAFF ASSISTANTS

	66	67
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	1	1
All other GS	30	30
Wage Board	-	-
Total Permanent	31	31

OFFICE OF CHIEF OF TECHNICAL SERVICES

	66	67
Excepted	1	1
GS-16	-	-
GS-15	1	1
GS-14	-	-
All other GS	3	3
Wage Board	-	-
Total Permanent	5	5

PLANT SERVICES DIVISION

	66	67
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	1	1
All other GS	40	40
Wage Board	125	122
Total Permanent	166	163

TEST INSTALLATIONS DIVISION

	66	67
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	1	1
All other GS	20	20
Wage Board	646	643
Total Permanent	667	664

FACILITIES OPERATIONS DIVISION

	66	67
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	1	1
All other GS	36	36
Wage Board	330	327
Total Permanent	368	365

FABRICATION DIVISION

	66	67
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	1	1
All other GS	32	32
Wage Board	218	215
Total Permanent	252	249

ENGINEERING DESIGN DIVISION

	66	67
Excepted	-	-
GS-16	-	-
GS-15	5	5
GS-14	8	8
All other GS	160	160
Wage Board	6	6
Total Permanent	179	179

FACILITIES ENGINEERING DIVISION

	66	67
Excepted	1	1
GS-16	-	-
GS-15	5	5
GS-14	9	9
All other GS	71	71
Wage Board	-	-
Total Permanent	86	86

CONSTRUCTION OFFICE

	66	67
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	-	-
All other GS	22	22
Wage Board	-	-
Total Permanent	23	23

OFFICE OF ASSISTANT DIRECTOR FOR PUBLIC AFFAIRS

	66	67
Excepted	1	1
GS-16	-	-
GS-15	1	1
GS-14	1	1
All other GS	18	17
Wage Board	-	-
Total Permanent	21	20

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ADMINISTRATIVE OPERATIONS

FISCAL YEAR 1967 ESTIMATES

LEWIS RESEARCH CENTER

MISSION AND CAPABILITIES:

The principle mission of the Center has always been propulsion. During World War II, many improvements were made in reciprocating aircraft engines, engine fuels, superchargers, and other engine accessories. After the war, all facilities were converted for research on turbojet engines, and a rocket laboratory was built. The maximum operating altitude of turbojet engines was greatly increased, pioneer work was done on afterburners, combustion efficiency and the efficiency of compressors and turbines was improved, and an air-cooled turbine blade was developed. Rocket work proceeded slowly at first, but the feasibility of using high-energy fluorine and hydrogen instead of kerosene as the fuel, was established. With the establishment of the NASA, work on ion propulsion and spacecraft power systems expanded from theoretical studies and bench-type experiments into hardware approaching practical sizes, and new facilities were added to develop systems which will power and propel our advanced future missions.

The primary mission of the Lewis Research Center is now research and development in the areas of advanced propulsion and space power generation. This includes work on the high-energy chemical, nuclear, and electric rocket engines and 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.

This in-house research provides technical input and direction to the related development, or contractual, efforts for which Lewis has managerial responsibility. For example, the Lewis Research Center maintains technical management of NASA contracts on electric propulsion, nuclear and solar turbo-electric space power systems, and liquid hydrogen rocket technology. In addition, Lewis has the development responsibility for the Atlas-Centaur and the Atlas-Agena launch vehicles.

Major research tools, or facilities, at the Lewis Research Center (including the Plum Brook Station) are designed to simulate various flight conditions and range from atmospheric wind tunnels to large space environment facilities (or vacuum tanks). 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 towers, 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:

	1965	1966	1967
Authorized Positions, end of year..	4,917	4,842	4,779
Average Number of All Employees....	4,861	4,748	4,642
Administrative Operations..........	$68,546,000	$67,207,000	$66,284,000

INSTALLATION DESCRIPTION:

The Lewis Research Center occupies two sites. The older one, established in 1941, is on the southwest edge of Cleveland, Ohio, and consists of 82 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 of which about 15 acres are leased from Cleveland. A newer site, established in 1956, is located south of Sandusky, Ohio, on land formerly occupied by the Plum Brook Ordnance Works. Known as the Plum Brook Station, it occupies 6,031 acres, of which 5,981 are owned and 50 are in easements. The research programs at Plum Brook are under the technical direction of personnel located at Cleveland. They are conducted at the larger site because of the need for large separation distances to minimize hazards. 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 turbopumps are developed for cryogenic propellants. The total capital investment of the Lewis Research Center, including the Plum Brook Station, as of June 30, 1965 was $265,754,000.

ANALYSIS OF RESOURCES REQUIREMENTS BY OBJECT CLASSIFICATION:

		1965	1966	1967
11.	Personnel Compensation.......	$46,439,000	$47,993,000	$49,064,000
12.	Personnel Benefits...........	3,373,000	3,499,000	3,581,000
	Total, personnel costs.....	$49,812,000	$51,492,000	$52,645,000
21.	Travel and Transportation of Persons................	1,469,000	1,470,000	1,455,000
22.	Transportation of Things.....	303,000	303,000	303,000
23.	Rent, Communications, and Utilities..............	3,839,000	3,389,000	3,449,000
24.	Printing and Reproduction....	50,000	50,000	50,000

		1965	1966	1967
25.	Other Services..............	$3,862,000	$3,654,000	$3,656,000
	Services of other agencies	139,000	139,000	139,000
26.	Supplies and Materials......	2,435,000	2,028,000	2,055,000
31.	Equipment..................	6,323,000	4,380,000	2,230,000
32.	Lands and Structures........	312,000	300,000	300,000
42.	Insurance Claims and Indemnities..............	2,000	2,000	2,000
	Total....................	$68,546,000	$67,207,000	$66,284,000

JUSTIFICATION BY OBJECT CLASSIFICATION:

Personnel Distribution

	1965	1966	1967
Direct Personnel by Program			
Manned Space Flight			
Apollo.........................	24	---	---
Space Science and Applications			
Lunar and planetary exploration	1	---	---
Launch vehicle development.....	247	230	170
Launch vehicle procurement.....	116	125	124
Advanced Research and Technology			
Basic research.................	465	485	490
Space vehicle systems..........	219	208	210
Electronics systems............	59	70	70
Human factor systems...........	1	---	---
Space power and electric propulsion systems.................	851	734	713
Nuclear rockets................	625	457	447
Chemical propulsion............	422	558	565
Aeronautics....................	85	250	305
Technology Utilization...........	6	6	6
Sub-total, direct positions..	3,121	3,123	3,100

	1965	1966	1967
Support personnel			
Director and Staff	17	17	17
Administration	575	561	556
Research and development support	1,102	1,109	1,074
Sub-total, support positions	1,694	1,687	1,647
Total, permanent positions	4,815	4,810	4,747
Other positions:			
Positions under cooperative training agreements	11	11	11
Other temporary positions	91	21	21
Total, all positions	4,917	4,842	4,779

Personnel Costs

	1965	1966	1967
Total Positions	4,917	4,842	4,779
Permanent	4,815	4,810	4,747
Other	102	32	32
Personnel Compensation:			
Annual cost of permanent positions	$45,017,000	$47,854,000	$48,371,000
Pay above the stated annual rate	173,000	184,000	186,000
Lapses (deduct)	-859,000	-1,900,000	-1,399,000
Net cost of permanent positions	44,331,000	46,138,000	47,158,000
Other personnel compensation	2,108,000	1,855,000	1,906,000
Total compensation	46,439,000	47,993,000	49,064,000
NASA funded	46,439,000	47,993,000	49,064,000
Reimbursable	---	---	---
Personnel benefits	3,373,000	3,499,000	3,581,000
NASA funded	3,373,000	3,499,000	3,581,000
Reimbursable	---	---	---
Total personnel costs	49,812,000	51,492,000	52,645,000
NASA funded	49,812,000	51,492,000	52,645,000
Reimbursable	---	---	---
Average Number of All Employees (Man Years)	4,861	4,748	4,642

Personnel Costs - $52,645,000

The personnel cost for FY 1967 is estimated to be $52,645,000 covering 4,642 manyears of employment. Of this amount $49,064,000 is requested for personnel compensation and $3,581,000 for personnel benefits. The FY 1967 estimates include an increase of $1,153,000 over FY 1966. This increase is required to cover the cost of the Federal Employees Salary Act of 1965 on a full year basis, for within-grade step increases, and career development, for retirement contributions and other benefits.

The following table shows the major items which are included in the estimate for personnel cost:

	FY 1967 Estimate	Increase or Decrease from FY 1966
Personnel Compensation		
Net cost of permanent positions..	$47,158,000	$+1,020,000
Other personnel compensation.....	1,906,000	+51,000
Sub-total......................	$49,064,000	$+1,071,000
Personnel Benefits		
Retirement contributions.........	$3,055,000	$+64,000
Other personnel benefits.........	526,000	+18,000
Sub-total......................	$3,581,000	$+82,000
Total personnel cost...............	$52,645,000	$+1,153,000

Travel and Transportation of Persons - $1,455,000

This estimate is $15,000 less than the FY 1966 level. This reduction is primarily due to a proportionate reduction in permanent positions.

Transportation of Things - $303,000

The FY 1967 level for this category is the same as FY 1966. The majority of the cost under this item is for transportation of equipment transfered to the Lewis Research Center from other federal agencies.

Rent, Communications, and Utilities - $3,449,000

This estimate is $60,000 higher than in the current year. Savings realized in FY 1967 for lease of ADP equipment are due to the purchase of a new system in FY 1966 and are less than the increased cost for utilities. Increased utility costs are directly related to new facilities becoming operational in FY 1967 and increased power requirements generated by increased tunnel usage for supersonic transport research.

Printing and Reproduction - $50,000

It is estimated that printing and reproduction requirements will remain at the FY 1966 level.

Other Services - $3,795,000

This estimate is a net increase of $2,000 over the FY 1966 level. Included in the estimate is an increase of $43,000 related to the maintenance requirements for ADP equipment procured in FY 1966 and for maintenance of EAM equipment, offset by decreases in the maintenance and repair of facilities.

Supplies and Materials - $2,055,000

There is an increase of $27,000 anticipated in FY 1967 requirements to cover the cost of plumbing supplies to support center facilities. The balance of the requested funds are at the same level as FY 1966 and are needed for normal support expenses at the Center.

Equipment - $2,230,000

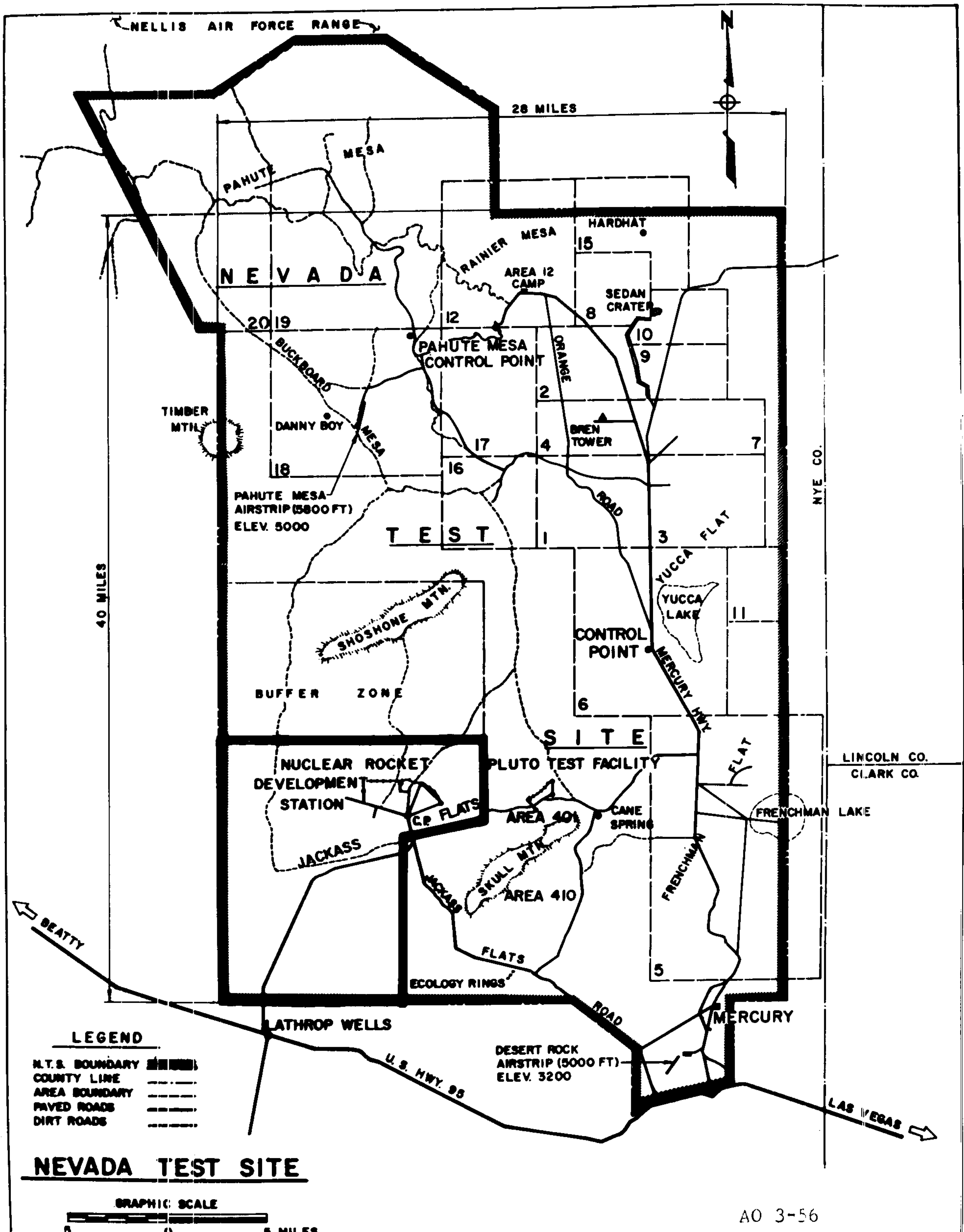
This estimate is $2,150,000 less than the current year level. This decrease is the result of the purchase of a new ADP system in FY 1966. Other equipment items will remain at the FY 1966 level of operations.

Lands and Structures - $300,000

No increase is requested in this estimate. Experience indicates that a stabilized level of effort is required in the alteration and repair of new and existing facilities.

Insurance Claims and Indemnities - $2,000

This estimate does not change from FY 1966. These funds are needed to settle miscellaneous and small claims.



NELLIS AIR FORCE RANGE
N
28 MILES
40 MILES
PAHUTE
MESA
RAINIER MESA
HARDHAT
15
AREA 12 CAMP
SEDAN CRATER
N E V A D A
20
19
12
8
10
9
PAHUTE MESA CONTROL POINT
ORANGE
BUCKBOARD
2
TIMBER MTN.
DANNY BOY
MESA
BREN TOWER
17
4
7
18
16
PAHUTE MESA AIRSTRIP (5800 FT) ELEV. 5000
ROAD
T E S T
1
3
FLAT
YUCCA
YUCCA LAKE
11
NYE CO.
SHOSHONE MTN.
CONTROL POINT
MERCURY HWY.
BUFFER ZONE
6
S I T E
NUCLEAR ROCKET DEVELOPMENT STATION
PLUTO TEST FACILITY
LINCOLN CO.
CLARK CO.
C.P. FLATS
AREA 401
CANE SPRING
FRENCHMAN LAKE
JACKASS
SKULL MTN.
AREA 410
FRENCHMAN
BEATTY
FLATS
5
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

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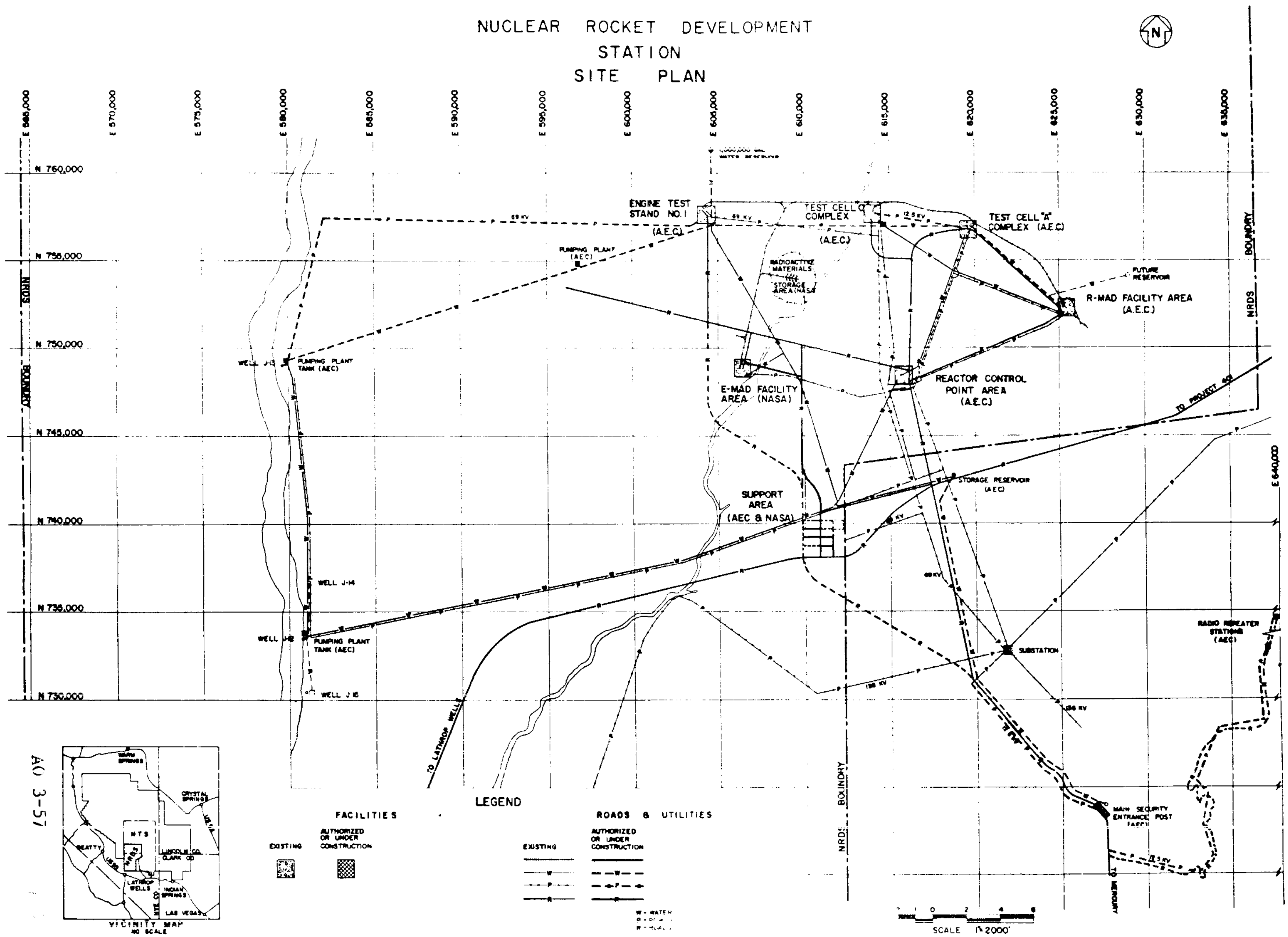
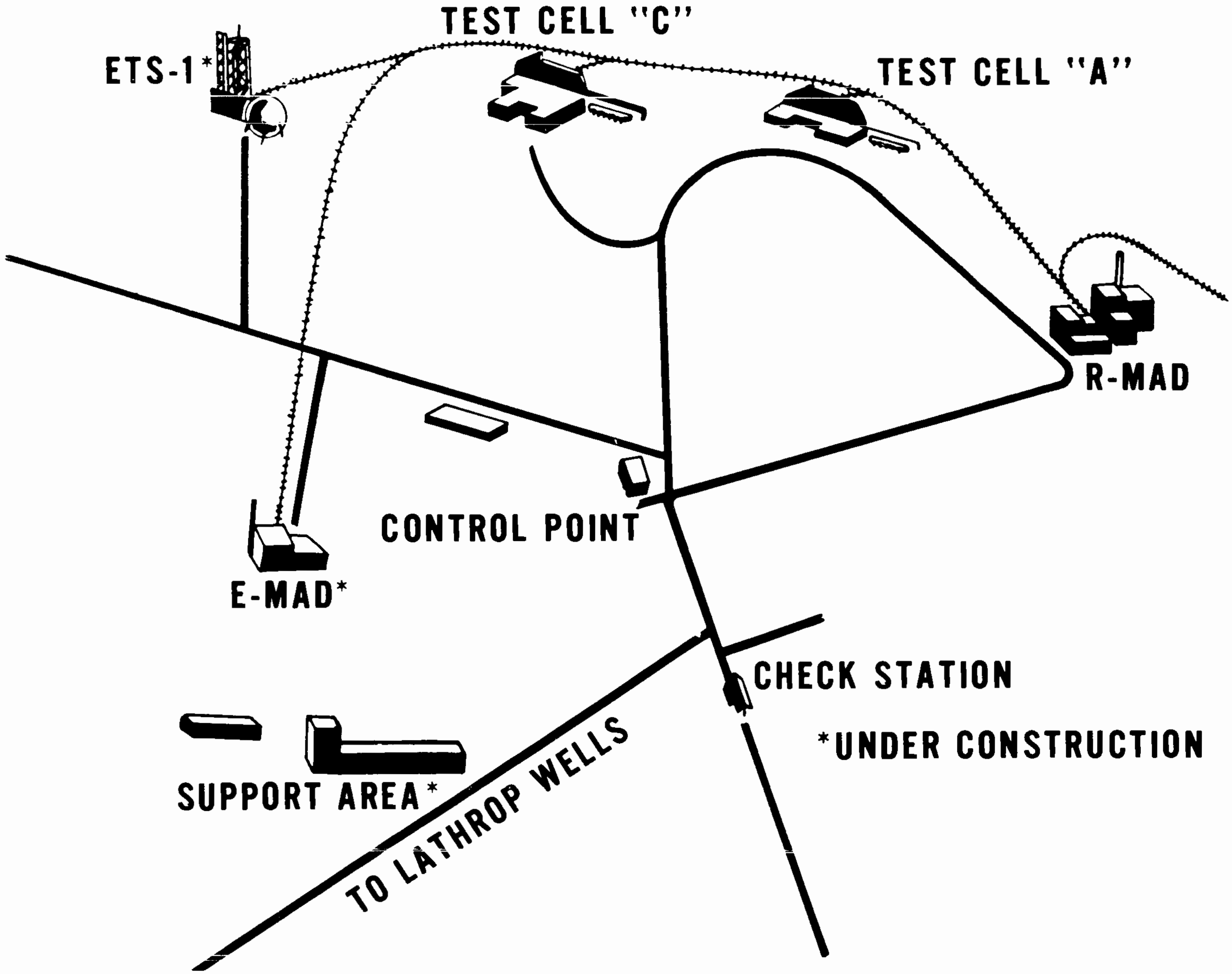
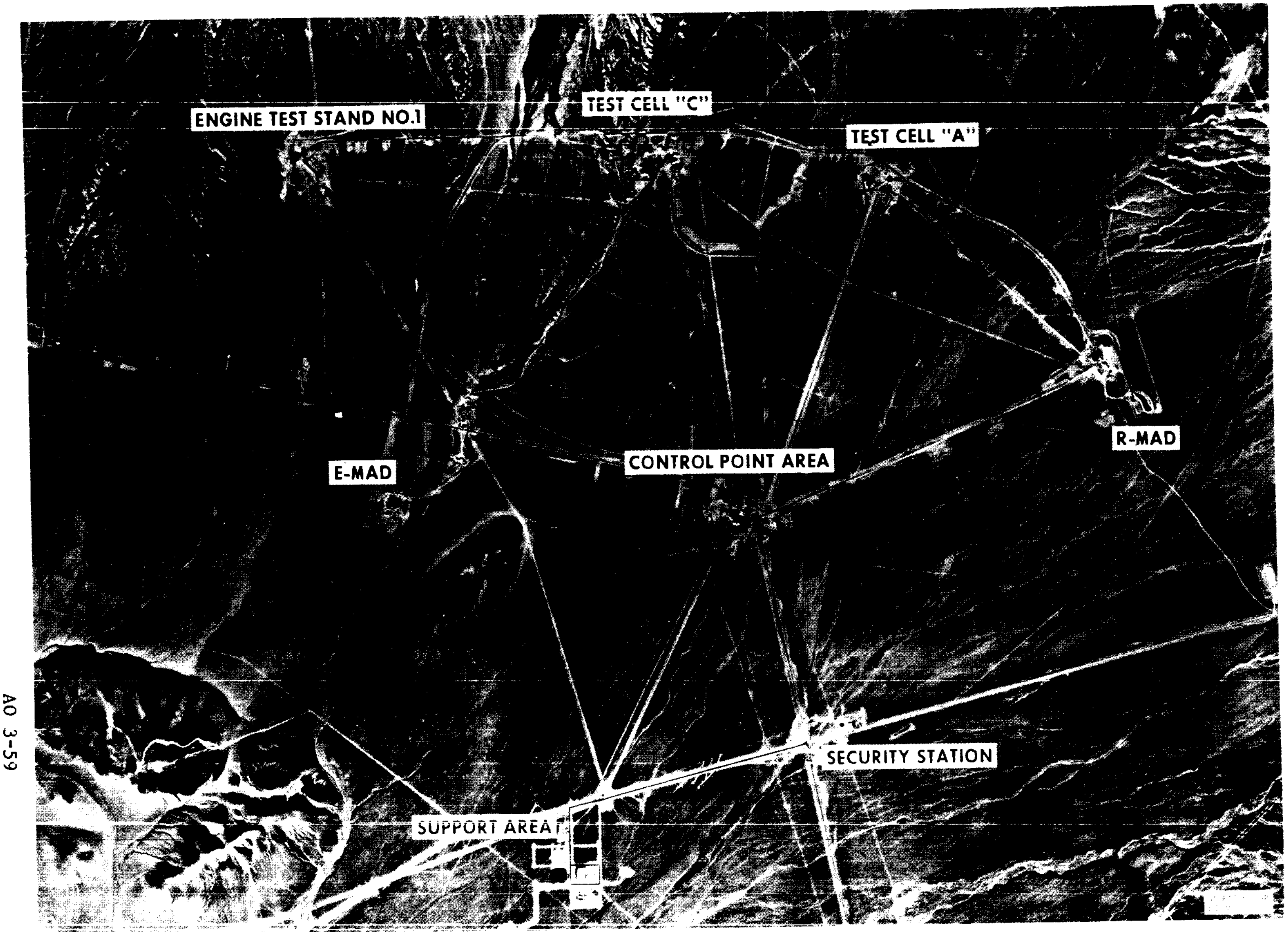

NUCLEAR ROCKET DEVELOPMENT
STATION
SITE PLAN
N
ENGINE TEST STAND NO. 1 (A.E.C.)
TEST CELL "C" COMPLEX (A.E.C.)
TEST CELL "A" COMPLEX (A.E.C.)
PUMPING PLANT (AEC)
RADIOACTIVE MATERIALS STORAGE AREA (NASA)
FUTURE RESERVOIR
R-MAD FACILITY AREA (A.E.C.)
WELL J-13
PUMPING PLANT TANK (AEC)
E-MAD FACILITY AREA (NASA)
REACTOR CONTROL POINT AREA (A.E.C.)
TO PROJECT 401
STORAGE RESERVOIR (AEC)
SUPPORT AREA (AEC & NASA)
WELL J-14
WELL J-12
PUMPING PLANT TANK (AEC)
WELL J-16
SUBSTATION
RADIO REPEATER STATIONS (AEC)
TO LATHROP WELLS
MAIN SECURITY ENTRANCE POST (AEC)
TO MERCURY
NRDS BOUNDARY
69 KV
12.5 KV
138 KV
N 760,000
N 755,000
N 750,000
N 745,000
N 740,000
N 735,000
N 730,000
E 565,000
E 570,000
E 575,000
E 580,000
E 585,000
E 590,000
E 595,000
E 600,000
E 605,000
E 610,000
E 615,000
E 620,000
E 625,000
E 630,000
E 635,000
E 640,000
LEGEND
FACILITIES
EXISTING
AUTHORIZED OR UNDER CONSTRUCTION
ROADS & UTILITIES
W - WATER
SCALE 1"=2000'
VICINITY MAP
NO SCALE
WARM SPRINGS
CRYSTAL SPRINGS
NTS
NRDS
BEATTY
LATHROP WELLS
INDIAN SPRINGS
LINCOLN CO.
CLARK CO.
LAS VEGAS
AO 3-57

NUCLEAR ROCKET DEVELOPMENT STATION LAYOUT



AO 3-58

NUCLEAR ROCKET DEVELOPMENT STATION



AO 3-59

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ORGANIZATION AND STAFFING CHART

SPACE NUCLEAR PROPULSION OFFICE

STAFFING SUMMARY

	66	67
Excepted	2	2
GS-16	6	6
GS-15	25	25
GS-14	17	17
All other GS	67	65
Total Permanent	117	115
Temporary	-	-
Total Positions	117	115

OFFICE OF THE MANAGER

	66	67
Excepted	1	1
GS-16	-	-
GS-15	1	1
GS-14	-	-
All other GS	4	4
Total Permanent	6	6

ALBUQUERQUE EXTENSION

	66	67
Excepted	-	-
GS-16	-	-
GS-15	-	-
GS-14	1	1
All other GS	-	-
Total Permanent	1	1

NERVA BRANCH

	66	67
Excepted	-	-
GS-16	1	1
GS-15	3	3
GS-14	-	-
All other GS	1	1
Total Permanent	5	5

CLEVELAND EXTENSION

	66	67
Excepted	1	1
GS-16	2	2
GS-15	15	15
GS-14	11	11
All other GS	40	40
Total Permanent	69	69

ADVANCED ENGINE BRANCH

	66	67
Excepted	-	-
GS-16	1	1
GS-15	1	1
GS-14	-	-
All other GS	-	-
Total Permanent	2	2

NEVADA EXTENSION

	66	67
Excepted	-	-
GS-16	1	1
GS-15	4	4
GS-14	5	5
All other GS	21	19
Total Permanent	31	29

FACILITIES BRANCH

	66	67
Excepted	-	-
GS-16	1	1
GS-15	1	1
GS-14	-	-
All other GS	1	1
Total Permanent	3	3

ADMINISTRATIVE OPERATIONS

FISCAL YEAR 1967 ESTIMATES

SPACE NUCLEAR PROPULSION OFFICE

MISSION AND CAPABILITIES:

The mission of the Space Nuclear Propulsion Office is to provide the necessary research, design and engineering data, test hardware, and general technology required to develop nuclear rocket systems with power levels, operating times, restart conditions, and specific impulse values suitable for advanced space exploration missions. Through the use of nuclear rocket propulsion, significant performance advantages accrue to such missions as lunar base logistics operations, deep space probing with heavy complex spacecraft, and manned exploration of the planets.

The major areas of effort are the research and engineering of the nuclear reactor, and the development of certain nonnuclear components into a complete experimental engine system. Because of progress in developing the graphite solid core reactor, the current emphasis is moving to the engine system phase which includes development of the nonnuclear components and their integration with the reactor.

SUMMARY OF RESOURCES REQUIREMENTS:

	1965	1966	1967
Authorized Positions, end of year...	117	117	115
Average Number of All Employees.....	102	111	112
Administrative Operations..........	$1,669,000	$1,824,000	$1,847,000

INSTALLATION DESCRIPTION:

The nuclear rocket program is a joint AEC-NASA undertaking. To ensure an integrated program, the Space Nuclear Propulsion Office, established by an interagency agreement between AEC and NASA, manages all aspects of the program.

The Office consists of a headquarters office located at Germantown, Maryland, and three field extensions located in Ohio, New Mexico, and Nevada. At the Nevada location, the Nuclear Rocket Development Station (NRDS) was established to provide a site for ground static testing of the reactors, engines, and eventually, vehicles associated with nuclear rocket development. The NRDS consists of a 90,000 acre site approximately 90 miles northwest of Las Vegas. The total capital investment of NASA funded facilities as of June 30, 1965 was $15,194,052.

ANALYSIS OF RESOURCES REQUIREMENTS BY OBJECT CLASSIFICATION:

		1965	1966	1967
11.	Personnel Compensation.......	$1,318,000	$1,460,000	$1,483,000
12.	Personnel Benefits...........	94,000	106,000	108,000
	Total, personnel costs.....	$1,412,000	$1,566,000	$1,591,000
21.	Travel and Transportation of Persons.................	199,000	200,000	198,000
22.	Transportation of Things.....	4,000	3,000	3,000
23.	Rent, Communications, and Utilities..............	---	---	---
24.	Printing and Reproduction....	---	---	---
25.	Other Services...............	37,000	38,000	38,000
	Services of other agencies.	17,000	17,000	17,000
26.	Supplies and Materials.......	---	---	---
31.	Equipment....................	---	---	---
32.	Lands and Structures.........	---	---	---
42.	Insurance Claims and Indemnities................	---	---	---
	Total.....................	$1,669,000	$1,824,000	$1,847,000

JUSTIFICATION BY OBJECT CLASSIFICATION:

Personnel Distribution

	1965	1966	1967
Direct Personnel by Program			
Advanced Research and Technology			
Nuclear Rockets.....................	110	110	108
Support personnel			
Director and Staff....................	2	2	2
Administration........................	2	2	2
Research and development support.......	3	3	3
Sub-total, support positions.........	7	7	7
Total, permanent positions...........	117	117	115
Other positions......................	---	---	---
Total, all positions....................	117	117	115

Personnel requirements

The total manpower level in FY 1967 will be decreased by two positions. The increase in personnel costs amounting to $25,000 is required to fund for a full year cost of the Federal Employees Salary Act of 1965 effective October 1, 1965.

Personnel Costs

	1965	1966	1967
Total Positions	117	117	115
Permanent	117	117	115
Other	---	---	---
Personnel Compensation:			
Annual cost of permanent positions	$1,419,000	$1,510,000	$1,501,000
Pay above the stated annual rate	5,000	5,000	5,000
Lapses (deduct)	-115,000	-64,000	-32,000
Net cost of permanent positions	1,309,000	1,451,000	1,474,000
Other personnel compensation	9,000	9,000	9,000
Total compensation	1,318,000	1,460,000	1,483,000
NASA funded	1,318,000	1,460,000	1,483,000
Reimbursable	---	---	---
Personnel benefits	94,000	106,000	108,000
NASA funded	94,000	106,000	108,000
Reimbursable	---	---	---
Total personnel costs	1,412,000	1,566,000	1,591,000
NASA funded	1,412,000	1,566,000	1,591,000
Reimbursable	---	---	---
Average Number of All Employees (Man Years)	102	111	112

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ORGANIZATION AND STAFFING CHART

NASA HEADQUARTERS

STAFFING SUMMARY

	66	67
Excepted	191	191
GS-16	65	65
GS-15	377	399
GS-14	300	321
All other GS	1,211	1,141
Wage Board	18	18
Total Permanent	2,162	2,135
Temporary	65	65
Total Positions	2,227	2,200

ADMINISTRATOR

	66	67
Excepted	11	11
GS-16	-	-
GS-15	1	1
GS-14	2	2
All other GS	5	5
Wage Board	-	-
Total Permanent	19	19

EXECUTIVE SECRETARY

	66	67
Excepted	1	1
GS-16	-	-
GS-15	3	3
GS-14	3	3
All other GS	55	55
Wage Board	2	2
Total Permanent	64	64

ADMINISTRATION NASA-Wide

	66	67
Excepted	16	16
GS-16	1	1
GS-15	42	42
GS-14	47	48
All other GS	142	137
Wage Board	-	-
Total Permanent	248	244

HEADQUARTERS OPERATIONS

	66	67
Excepted	1	1
GS-16	-	-
GS-15	4	4
GS-14	6	6
All other GS	227	225
Wage Board	15	15
Total Permanent	253	251

DEFENSE AFFAIRS

	66	67
Excepted	3	3
GS-16	-	-
GS-15	1	2
GS-14	1	-
All other GS	5	5
Wage Board	-	-
Total Permanent	10	10

GENERAL COUNSEL

	66	67
Excepted	6	6
GS-16	-	-
GS-15	11	11
GS-14	6	6
All other GS	29	28
Wage Board	-	-
Total Permanent	52	51

INDUSTRY AFFAIRS

	66	67
Excepted	10	10
GS-16	1	1
GS-15	17	18
GS-14	36	37
All other GS	84	80
Wage Board	-	-
Total Permanent	148	146

INTERNATIONAL AFFAIRS

	66	67
Excepted	2	2
GS-16	1	1
GS-15	3	3
GS-14	-	-
All other GS	21	21
Wage Board	-	-
Total Permanent	27	27

LEGISLATIVE AFFAIRS

	66
Excepted	2
GS-16	-
GS-15	4
GS-14	2
All other GS	20
Wage Board	1
Total Permanent	29

POLICY ANALYSIS

	66	67
Excepted	3	3
GS-16	-	-
GS-15	2	2
GS-14	2	2
All other GS	10	10
Wage Board	-	-
Total Permanent	17	17

PROGRAMMING

	66	67
Excepted	7	7
GS-16	-	-
GS-15	13	14
GS-14	12	12
All other GS	39	37
Wage Board	-	-
Total Permanent	71	70

PUBLIC AFFAIRS

	66	67
Excepted	4	4
GS-16	-	-
GS-15	14	14
GS-14	20	20
All other GS	80	78
Wage Board	-	-
Total Permanent	118	116

TECHNOLOGY UTILIZATION

	66	67
Excepted	6	6
GS-16	-	-
GS-15	8	8
GS-14	13	13
All other GS	51	50
Wage Board	-	-
Total Permanent	78	77

MANNED SPACE FLIGHT

	66	67
Excepted	39	39
GS-16	12	12
GS-15	116	124
GS-14	88	97
All other GS	198	175
Wage Board	-	-
Total Permanent	453	447

SPACE SCIENCE AND APPLICATIONS

	66	67
Excepted	38	38
GS-16	23	23
GS-15	60	68
GS-14	28	38
All other GS	147	125
Wage Board	-	-
Total Permanent	296	292

TRACKING AND DATA ACQUISITION

	66	67
Excepted	6	6
GS-16	5	5
GS-15	19	20
GS-14	10	10
All other GS	22	20
Wage Board	-	-
Total Permanent	62	61

ADVANCED RESEARCH AND TECHNOLOGY

	66	67
Excepted	36	36
GS-16	22	22
GS-15	59	61
GS-14	24	25
All other GS	76	70
Wage Board	-	-
Total Permanent	217	214

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ORGANIZATION AND STAFFING CHART

NASA HEADQUARTERS

STAFFING SUMMARY

	66	67
Excepted	191	191
GS-16	65	65
GS-15	377	399
GS-14	300	321
All other GS	1,211	1,141
Wage Board	18	18
Total Permanent	2,162	2,135
Temporary	65	65
Total Positions	2,227	2,200

ADMINISTRATOR

	66	67
Excepted	11	11
GS-16	-	-
GS-15	1	1
GS-14	2	2
All other GS	5	5
Wage Board	-	-
Total Permanent	19	19

EXECUTIVE SECRETARY

	66	67
Excepted	1	1
GS-16	-	-
GS-15	3	3
GS-14	3	3
All other GS	55	55
Wage Board	2	2
Total Permanent	64	64

ADMINISTRATION NASA-Wide

	66	67
Excepted	16	16
GS-16	1	1
GS-15	42	42
GS-14	47	48
All other GS	142	137
Wage Board	-	-
Total Permanent	248	244

HEADQUARTERS OPERATIONS

	66	67
Excepted	1	1
GS-16	-	-
GS-15	4	4
GS-14	6	6
All other GS	227	225
Wage Board	15	15
Total Permanent	253	251

DEFENSE AFFAIRS

	66	67
Excepted	3	3
GS-16	-	-
GS-15	1	2
GS-14	1	-
All other GS	5	5
Wage Board	-	-
Total Permanent	10	10

GENERAL COUNSEL

	66	67
Excepted	6	6
GS-16	-	-
GS-15	11	11
GS-14	6	6
All other GS	29	28
Wage Board	-	-
Total Permanent	52	51

INDUSTRY AFFAIRS

	66	67
Excepted	10	10
GS-16	1	1
GS-15	17	18
GS-14	36	37
All other GS	84	80
Wage Board	-	-
Total Permanent	148	146

INTERNATIONAL AFFAIRS

	66	67
Excepted	2	2
GS-16	1	1
GS-15	3	3
GS-14	-	-
All other GS	21	21
Wage Board	-	-
Total Permanent	27	27

LEGISLATIVE AFFAIRS

	66	67
Excepted	2	2
GS-16	-	-
GS-15	4	4
GS-14	2	2
All other GS	20	20
Wage Board	1	1
Total Permanent	29	29

POLICY ANALYSIS

	66	67
Excepted	3	3
GS-16	-	-
GS-15	2	2
GS-14	2	2
All other GS	10	10
Wage Board	-	-
Total Permanent	17	17

PROGRAMMING

	66	67
Excepted	7	7
GS-16	-	-
GS-15	13	14
GS-14	12	12
All other GS	39	37
Wage Board	-	-
Total Permanent	71	70

PUBLIC AFFAIRS

	66	67
Excepted	4	4
GS-16	-	-
GS-15	14	14
GS-14	20	20
All other GS	80	78
Wage Board	-	-
Total Permanent	118	116

TECHNOLOGY UTILIZATION

	66	67
Excepted	6	6
GS-16	-	-
GS-15	8	8
GS-14	13	13
All other GS	51	50
Wage Board	-	-
Total Permanent	78	77

MANNED SPACE FLIGHT

	66	67
Excepted	39	39
GS-16	12	12
GS-15	116	124
GS-14	88	97
All other GS	198	175
Wage Board	-	-
Total Permanent	453	447

SPACE SCIENCE AND APPLICATIONS

	66	67
Excepted	38	38
GS-16	23	23
GS-15	60	68
GS-14	28	38
All other GS	147	125
Wage Board	-	-
Total Permanent	296	292

TRACKING AND DATA ACQUISITION

	66	67
Excepted	6	6
GS-16	5	5
GS-15	19	20
GS-14	10	10
All other GS	22	20
Wage Board	-	-
Total Permanent	62	61

ADVANCED RESEARCH AND TECHNOLOGY

	66	67
Excepted	36	36
GS-16	22	22
GS-15	59	61
GS-14	24	25
All other GS	76	70
Wage Board	-	-
Total Permanent	217	214

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ADMINISTRATIVE OPERATIONS

FISCAL YEAR 1967 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 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 extravehicular activity; Apollo - to provide a broad national capability for manned space exploration, including earth-orbital, lunar orbital, and lunar surface operations and to achieve the specific objective of manned lunar landing and return within this decade; and Advanced Missions - to plan a broad program of exploration which will achieve and maintain a position of space leadership for the United States. The Office of Manned Space Flight has launch responsibility for all major manned and unmanned missions utilizing NASA launch vehicles. This Office also has over-all institutional responsibility for the three installations primarily concerned with the manned space flight programs. These installations are: the George C. Marshall Space Flight Center, including Mississippi Test Facility, Michoud Assembly Facility, and Slidell where a computer facility is located; the Manned Spacecraft Center, including NASA activities at the White Sands Test Facility; and the John F. Kennedy Space Center, NASA, including NASA activities at the Eastern and Western Test Ranges.

The Office of Space Science and Applications - Responsible for NASA programs involving the unmanned scientific investigation of the space environment including the moon, planets, and interplanetary space utilizing ground-based, airborne, and space techniques such as sounding rockets, earth satellites, and deep space probes (e.g., Voyager); for scientific experiments to be conducted by man in space and selection and training of astronaut-scientists; for the research and development of space flight applications in such areas as meteorology, communications, navigation, geodesy, and economic geographic surveys, and for the support of operational systems using these developments; for the development, procurement, and use of light and medium class launch vehicles, such as Centaur; and for the sustaining university program.

The Office of Space Science and Applications has an over-all institutional responsibility for those NASA installations primarily involved in space science and applications programs. These are the Goddard Space Flight Center, Wallops Station, and the Jet Propulsion Laboratory, including the NASA Resident Office which administers the 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 over-all institutional responsibility for the research centers primarily involved in carrying out NASA's advanced research programs. These installations are: the Ames Research Center, the Electronics Research Center, the Flight Research Center, the Langley Research Center, the 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 agency-wide coordination of the management of automatic data processing systems and services.

SUMMARY OF RESOURCES REQUIREMENTS:

	1965	1966	1967
Authorized Positions, end of year.	2,263	2,227	2,200
Average Number of All Employees...	1,989	2,063	2,043
Administrative Operations.........	$51,516,000	$56,286,000	$58,667,000

INSTALLATION DESCRIPTION:

The NASA Headquarters is located at 400 Maryland Avenue, S. W., Washington, D. C., and also occupies two other buildings in the southwest area of the District of Columbia, as well as storage facilities in nearby Arlington, Virginia. With the exception of the space leased in the Reporter's Building and the warehousing space, personnel occupy government-owned buildings.

ANALYSIS OF RESOURCES REQUIREMENTS BY OBJECT CLASSIFICATION:

		1965	1966	1967
11.	Personnel Compensation......	$25,311,000	$27,281,000	$27,946,000
12.	Personnel Benefits..........	1,959,000	2,167,000	2,373,000
	Total, personnel costs....	$27,270,000	$29,448,000	$30,319,000
21.	Travel and Transportation of Persons................	2,550,000	2,642,000	2,642,000
22.	Transportation of Things....	341,000	295,000	295,000
23.	Rent, Communications, and Utilities.............	1,899,000	2,341,000	2,390,000
24.	Printing and Reproduction...	1,580,000	1,925,000	2,075,000
25.	Other Services..............	12,654,000	15,048,000	16,024,000
	Services of other agencies	2,778,000	2,472,000	2,807,000
26.	Supplies and Materials......	500,000	555,000	555,000
31.	Equipment...................	1,936,000	1,550,000	1,550,000
32.	Lands and Structures........	---	---	---
42.	Insurance Claims and Indemnities...............	8,000	10,000	10,000
	Total.....................	$51,516,000	$56,286,000	$58,667,000

The above estimates for FY 1966 and FY 1967 are distributed between NASA-wide support functions, conducted or administered centrally, which provide service to all centers; and for Headquarters operations which are for the support of the day-to-day operations of all Headquarters offices. The following table shows this comparison by object classification:

Analysis of Funding for NASA-wide Support and Headquarters Operations

Object Classification	FY 1966 Total	FY 1966 NASA-wide Support	FY 1966 Hdqtrs. Operat.	FY 1967 Total	FY 1967 NASA-wide Support	FY 1967 Hdqtrs. Operat.
	(In thousands of dollars)					
11. Personnel Comp...	$27,281	$25,004	$2,277	$27,946	$25,563	$2,383
12. Personnel Benef..	2,167	2,012	155	2,373	2,209	164
21. Travel and Trans of Persons.....	2,642	2,588	54	2,642	2,588	54
22. Trans. of Things.........	295	234	61	295	234	61
23. Rent, Communic. & Utilities....	2,341	1,261	1,080	2,390	1,319	1,071
24. Printing & Repro	1,925	1,772	153	2,075	1,922	153
25. Other Services...	17,520	15,638	1,882	18,831	16,818	2,013
26. Supplies & Mat...	555	15	540	555	15	540
31. Equipment........	1,550	1,345	205	1,550	1,345	205
32. Land & Structures	---	---	---	---	---	---
42. Ins. Claims and Indemnities....	10	---	10	10	---	10
Total..........	$56,286	$49,869	$6,417	$58,667	$52,013	$6,654

JUSTIFICATION BY OBJECT CLASSIFICATION:

Personnel Distribution

	1965	1966	1967
Direct Personnel by Program			
Manned Space Flight			
Gemini......................	103	75	43
Apollo......................	249	291	321
Advanced missions...........	101	87	83

	1965	1966	1967
Space Science and Applications			
Physics and astronomy................	57	57	56
Lunar and planetary exploration......	76	76	74
Sustaining university program........	71	71	71
Launch vehicle development...........	10	6	4
Launch vehicle procurement...........	15	19	20
Bioscience...........................	26	26	26
Meteorological satellites............	20	20	20
Communication and applications technology satellites..............	21	21	21
Advanced Research and Technology			
Basic research.......................	31	31	31
Space vehicle systems................	44	44	43
Electronics systems..................	37	37	37
Human factor systems.................	22	22	22
Space power and electric propulsion systems..........................	31	31	30
Nuclear rockets......................	3	3	3
Chemical propulsion..................	22	22	22
Aeronautics..........................	27	27	26
Tracking and Data Acquisition	60	62	61
Technology Utilization	14	14	14
Sub-total, direct positions........	1,040	1,042	1,028
Support personnel			
*Director and Staff....................	617	618	611
Administration (Headquarters)..........	258	253	251
*Research and development support.......	248	249	245
Sub-total, support positions.........	1,123	1,120	1,107
Total, permanent positions...........	2,163	2,162	2,135
Other positions:			
Positions under cooperative training agreements...........................	---	---	---
Other temporary positions..............	100	65	65
Total, all positions....................	2,263	2,227	2,200
*NASA-wide support.	(865)	(867)	(856)

Personnel requirements

The FY 1967 budget request includes a total of 2,200 civilian positions for NASA Headquarters, a reduction of 27 positions below the current fiscal year.

Of the 2,135 permanent positions shown in the above table, 1,028 are directly related to the staffing of the scientific and technical program areas in the Office of Manned Space Flight, the Office of Space Science and Applications, the Office of Advanced Research and Technology, the Office of Tracking and Data Acquisition, and the Office of Technology Utilization. Of the remaining 1,107 permanent positions, 856 are for NASA-wide support functions relating to the review, coordination, direction and planning of activities such as procurement, financial management, audit, acquisition and dissemination of scientific and technical information, and the balance of 251 are for Headquarters operations concerned with administrative services, personnel, security, accounts and reports, and contracts.

Personnel Costs

	1965	1966	1967
Total Positions..................	2,263	2,227	2,200
Permanent......................	2,163	2,162	2,135
Other..........................	100	65	65
Personnel Compensation:			
Annual cost of permanent positions....................	$26,308,000	$27,849,000	$27,945,000
Pay above the stated annual rate.........................	101,000	107,000	107,000
Lapses (deduct)................	-2,464,000	-2,165,000	-1,538,000
Net cost of permanent positions	23,945,000	25,791,000	26,514,000
Other personnel compensation...	1,366,000	1,490,000	1,432,000
Total compensation...........	25,311,000	27,281,000	27,946,000
NASA funded................	25,311,000	27,281,000	27,946,000
Reimbursable...............	---	---	---
Personnel benefits...............	1,959,000	2,167,000	2,373,000
NASA funded....................	1,959,000	2,167,000	2,373,000
Reimbursable...................	---	---	---
Total personnel costs............	27,270,000	29,448,000	30,319,000
NASA funded....................	27,270,000	29,448,000	30,319,000
Reimbursable...................	---	---	---
Average Number of All Employees (Man Years)....................	1,989	2,063	2,043

Personnel Costs - $30,319,000

The personnel costs for FY 1967 are estimated to be $30,319,000 covering 2,043 manyears of employment. Of this amount, $27,946,000 is requested for personnel compensation and $2,373,000 for personnel benefits. The FY 1967 estimate is $871,000 over the amount for the current fiscal year. This increase is required to cover the cost of the Federal Employees Salary Act of 1965 on a full year basis, for within-grade step increases and career development, for retirement contributions and other benefits, and for increased costs payable to the Department of Labor for benefits and other payments made from the Employees' Compensation Fund during FY 1965.

The following table shows the major items which are included in the estimate for personnel costs:

	FY 1967 Estimate	Increase or Decrease from FY 1966
Personnel compensation:		
Net cost of permanent positions.....	$26,514,000	$+723,000
Other personnel compensation........	1,432,000	-58,000
Sub-total........................	$27,946,000	$+665,000
Personnel benefits:		
Retirement contributions............	1,749,000	+56,000
Other benefits......................	365,000	+61,000
Employees' Compensation Fund........	259,000	+89,000
Sub-total........................	2,373,000	+206,000
Total personnel costs............	$30,319,000	$+871,000

Of the $30,319,000 requested for personnel costs, $27,772,000 is estimated for salaries and benefits of employees engaged in NASA-wide programs and activities which are conducted or administered centrally for the benefit of all centers, and $2,547,000 for personnel engaged in Headquarters operations.

Travel and Transportation of Persons - $2,642,000

The FY 1967 estimate of $2,642,000 for travel and transportation of persons is the same level as FY 1966 requirements. Of this amount, $2,425,000 is for NASA employee travel and transportation and $217,000 for non-NASA employee travel costs of technical and research advisory committees, and for costs of local transportation.

The amount requested includes $2,588,000 in support of NASA-wide programs and activities; and the remainder of $54,000 is related to Headquarters operations.

Transportation of Things - $295,000

The FY 1967 amount of $295,000 requested for transportation of things is the same level required for the current fiscal year. The costs under this object classification include $195,000 for domestic and overseas shipments of exhibits and spacemobiles; $56,000 for transportation of household goods and personal effects; and $44,000 for freight, express, drayage and parcel post costs of shipments to NASA installations, and rental of trucks from the General Services Administration.

Of the $295,000 requested in FY 1967, $234,000 is for support of NASA-wide activities and $61,000 for Headquarters operations.

Rent, Communications, and Utilities - $2,390,000

The FY 1967 estimate of $2,390,000 under this object classification includes: $590,000 for rents, a net increase of $49,000 over FY 1966, which provides for an increase of $58,000 required for rental of space to house the NASA Scientific and Technical Information Facility on a full year basis in FY 1967 and a decrease of $9,000 for rental of ADP equipment; and $1,800,000 for communications costs which are projected at the same level as the current fiscal year requirements.

The following table reflects the items included in the FY 1967 estimates for rents and communications:

	FY 1967 Estimate	Increase or Decrease from FY 1966
Rents:		
Space	$367,000	$+58,000
ADP and EAM equipment	89,000	-9,000
Office duplicating equipment	134,000	---
Total, rents	$590,000	$+49,000
Communications:		
Leased lines	366,000	---
Local telephone & exchange service	451,000	---
Long distance tolls	295,000	---
Postage and TWX	688,000	---
Total, communications	$1,800,000	---
Total, rents and communications	$2,390,000	$+49,000

Of the $2,390,000 requested for FY 1967 for rents and communications, $1,319,000 is estimated for NASA-wide support and $1,071,000 for Headquarters operations.

Printing and Reproduction - $2,075,000

The FY 1967 estimate for these services is $2,075,000, an increase of $150,000 above the FY 1966 level. Over 90 per cent, or $1,915,000 of the FY 1967 estimate is for printing and related services which will be performed through government sources. The remaining $160,000 is for printing and photostating to be done by commercial sources. The major activities funded under this object classification are as follows:

	FY 1967 Estimate	Increase over FY 1966
Scientific and technical information publications........................	$1,100,000	$+150,000
Educational and information publications........................	350,000	---
Printing and reproduction of administrative issuances, forms, etc.......	625,000	---
Total, printing and reproduction.....	$2,075,000	$+150,000

The increase of $150,000 requested in FY 1967 in the scientific and technical information activity includes $50,000 for NASA's abstracting and indexing journal "Scientific and Technical Aerospace Reports," $60,000 for printing of technical reviews, monographs, handbooks and data compliations, and $40,000 for special publications on selected aerospace topics.

Of the $2,075,000 requested in FY 1967, $1,922,000 is for printing and reproduction services for NASA-wide support activities and $153,000 for Headquarters operations.

Other Services - $18,831,000

The FY 1967 request for other services is $18,831,000, a net increase of $1,311,000 above the FY 1966 level. Listed in the following table are the major items which are funded under this object classification:

	FY 1967 Estimate	Increase or Decrease over FY 1966
Scientific and technical information facility..............................	$5,308,000	$+341,000
Documentation journal literature........	1,810,000	+300,000
Translation services....................	350,000	+75,000

	FY 1967 Estimate	Increase or Decrease over FY 1966
Scientific information systems development	$355,000	---
Technical publications preparation	885,000	$+238,000
Dissemination of information through educational institutions and other channels	1,305,000	---
Educational and information media services	1,725,000	---
Educational exhibit services	745,000	---
Security investigations	1,300,000	---
Reliability and quality assurance studies	500,000	+60,000
Incentive contracting study	197,000	+197,000
Training programs	400,000	+50,000
Miscellaneous studies and services	1,938,000	-131,000
Headquarters operations	2,013,000	+131,000
Total, other services	$18,831,000	$+1,311,000

Of the net increase of $1,311,000 for other services, over 75%, or $1,004,000, is requested for the NASA-wide scientific and technical information program. This includes:

1. $341,000 to provide increased support for operation of NASA's contractor operated Scientific and Technical Information Facility. The workload of the facility has been increasing between 20 and 30% each year over the past several years. It is anticipated that this trend will continue in FY 1967. The increased workload is caused by the additional number of scientific and technical reports which are becoming available from NASA supported research and development programs, and from interagency agreements and exchange arrangements with domestic and foreign organizations.

2. $300,000 for documentation of world-wide journal literature to process the increased volume of significant foreign aerospace literature for immediate use in the U. S. aerospace programs.

3. $75,000 for additional translation services required to handle the rise in world-wide journal activity in the aerospace sciences and the availability of a continually increasing volume of material originally published in foreign languages.

4. $288,000 for preparation of manuscript material for specialized scientific and technical publications. This includes $163,000 for handbook and data compilations on selected aerospace subjects, and $125,000 increased support of the Langley Research Center printing plant operations for specialized services such as editing, verification of references, and preparation of graphs and tables.

The remaining increase of $307,000 is required for the other NASA-wide support functions and for Headquarters operations, as follows:

For other NASA-wide requirements, a net increase of $176,000 consisting of increases of: (1) $60,000 for reliability and quality assurance studies relating to subjects such as systems design trade-off studies, quality assurance methodology and development of publications on special topics; (2) $197,000 for initiation of an incentive contracting effectiveness study; and (3) $50,000 for agency-wide training of personnel in technical management, supervisory and administrative areas common to several NASA centers with emphasis on training programs relating to supervisory management, incentive contracting, financial management, and contract administration. The foregoing increases are partially offset by decreases amounting to $131,000 in a variety of miscellaneous studies and services.

For Headquarters operations, an increase of $131,000 consisting of: (1) $110,000 for computer operation, programming and systems design services; and (2) $21,000 for contract administration and security guard services.

Supplies and Materials - $555,000

The FY 1967 estimate of $555,000 for supplies and materials is the same level required for FY 1966. The items under this object classification primarily include the purchase of pamphlets and documents for the scientific and technical information program, office and photographic supplies and materials, and subscriptions and technical books for the law and technical libraries.

Of the amount estimated for FY 1967, $15,000 is for NASA-wide support and $540,000 for Headquarters operations.

Equipment - $1,550,000

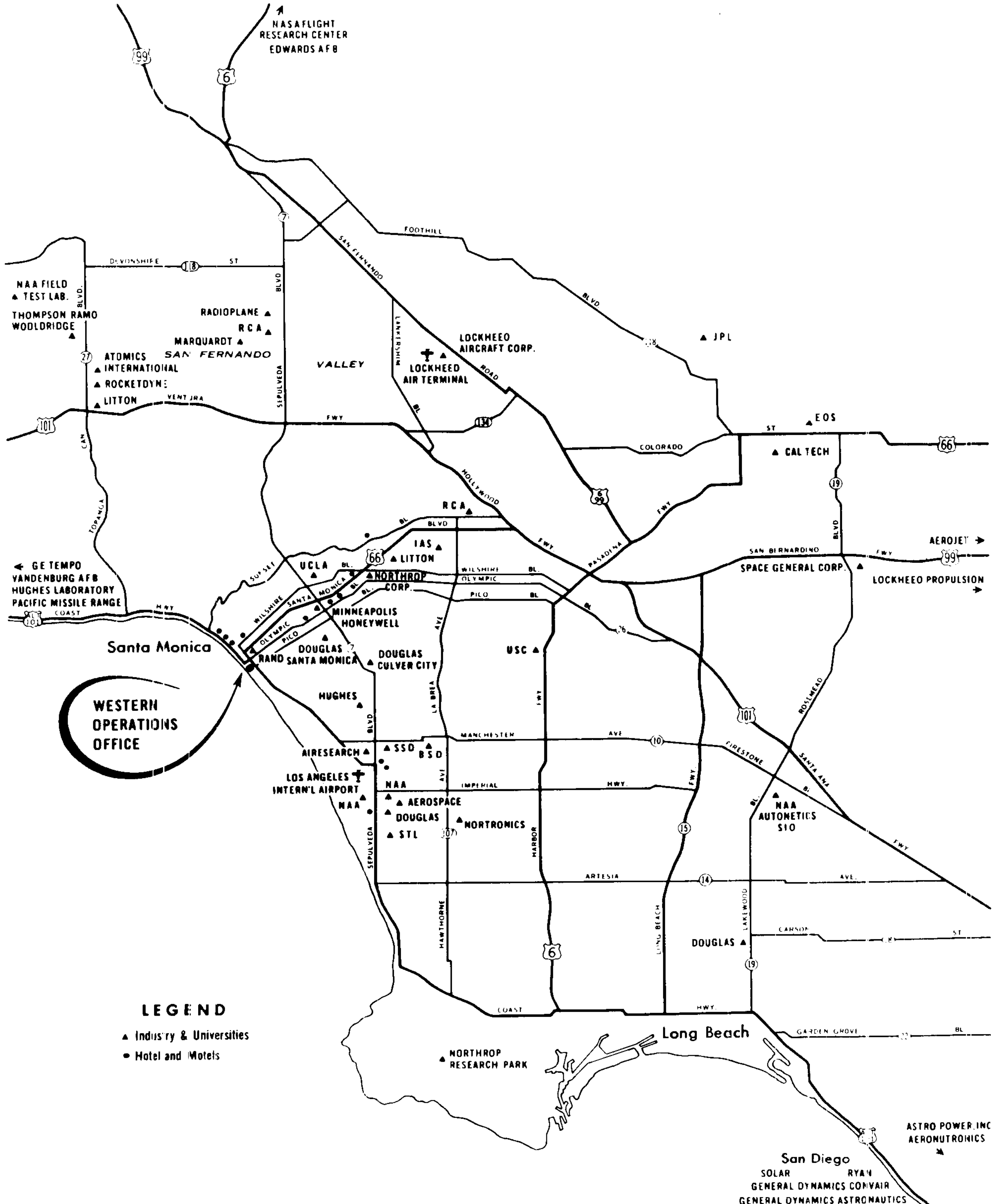
The FY 1967 estimate for equipment is the same level required for the current fiscal year. The items for FY 1966 and FY 1967 under this object classification include $205,000 for purchase of mechanical, photographic and miscellaneous office equipment; $155,000 for procurement of replacement vehicles for the existing spacemobile fleet which will exceed the 80,000 mile mark in FY 1966 and will become uneconomical to maintain and repair, and for updating of model inventory and equipment to be placed in these spacemobiles;

$80,000 for purchase of miscellaneous equipment for the Scientific and Technical Information Facility; and $1,110,000 for procurement of educational exhibits and materials which will provide up-to-date coverage of NASA programs in the manned and unmanned exploration of space, and to up-date the exhibit inventory to keep abreast of technical programs. These exhibits are designed for use in educational institutions, teachers and students fairs and workshops, professional and technical organizations and display before the general public, both domestic and foreign.

Of the $1,550,000 required in FY 1967 for equipment described above $1,345,000 is for support of NASA-wide activities and $205,000 for Headquarters operations.

Insurance Claims and Indemnities - $10,000

The FY 1967 requirement is estimated at the same level as for the current fiscal year. These funds cover payment of claims of $2,500 or less under the provisions of 28 U.S.C. 2672 for injury, death, or loss of property 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.


NASA FLIGHT RESEARCH CENTER
EDWARDS AFB
FOOTHILL
SAN FERNANDO
BLVD
ROAD
NAA FIELD TEST LAB.
THOMPSON RAMO WOOLDRIDGE
RADIOPLANE
RCA
MARQUARDT
SAN FERNANDO
VALLEY
ATOMICS INTERNATIONAL
ROCKETDYNE
LITTON
LOCKHEED AIRCRAFT CORP.
LOCKHEED AIR TERMINAL
JPL
EOS
CAL TECH
COLORADO
HOLLYWOOD
SEPULVEDA
FWY
ST
RCA
IAS
LITTON
UCLA
NORTHROP CORP.
MINNEAPOLIS HONEYWELL
DOUGLAS SANTA MONICA
RAND
DOUGLAS CULVER CITY
USC
GE TEMPO
VANDENBURG AFB
HUGHES LABORATORY
PACIFIC MISSILE RANGE
Santa Monica
WESTERN OPERATIONS OFFICE
HUGHES
AIRESEARCH
SSD
BSD
LOS ANGELES INTERN'L AIRPORT
NAA
AEROSPACE
DOUGLAS
STL
NORTRONICS
MANCHESTER
IMPERIAL
ARTESIA
HARBOR
HAWTHORNE
LA BREA
SAN BERNARDINO
SPACE GENERAL CORP.
LOCKHEED PROPULSION
AEROJET
SANTA ANA
FIRESTONE
ROSEMEAD
NAA AUTONETICS SIO
DOUGLAS
CARSON
LAKEWOOD
LONG BEACH
COAST
HWY.
Long Beach
GARDEN GROVE
NORTHROP RESEARCH PARK
ASTRO POWER, INC
AERONUTRONICS
San Diego
SOLAR
RYAN
GENERAL DYNAMICS CONVAIR
GENERAL DYNAMICS ASTRONAUTICS
LEGEND
▲ Industry & Universities
● Hotel and Motels

AO 4-14

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ORGANIZATION AND STAFFING CHART

WESTERN OPERATIONS OFFICE

STAFFING SUMMARY

	66	67
Excepted	4	4
GS-16	1	1
GS-15	12	12
GS-14	47	47
All other GS	322	317
Total Permanent	386	381
Temporary	5	5
Total Positions	391	386

DIRECTOR

	66	67
Excepted	2	2
All other GS	3	3
Total Permanent	5	5

NASA RESIDENCY OFFICE - JPL

	66	67
GS-15	2	2
GS-14	6	6
All other GS	13	13
Total Permanent	21	21

LEGAL DIVISION

	66	67
GS-15	2	2
GS-14	3	3
All other GS	6	5
Total Permanent	11	10

ADMINISTRATIVE SERVICES DIVISION

	66	67
All other GS	36	35
Total Permanent	36	35

PUBLIC AFFAIRS DIVISION

	66	67
All other GS	8	8
Total Permanent	8	8

PERSONNEL DIVISION

	66
All other GS	9
Total Permanent	9

NASA-O DOWNEY

	66	67
Excepted	1	1
GS-15	1	1
GS-14	6	6
All other GS	125	124
Total Permanent	133	132

TECHNICAL DIVISION

	66	67
GS-16	1	1
GS-15	6	6
GS-14	25	25
All other GS	50	49
Total Permanent	82	81

CONTRACTS DIVISION

	66	67
Excepted	1	1
GS-15	1	1
GS-14	6	6
All other GS	47	46
Total Permanent	55	54

FINANCE DIVISION

	66
GS-14	1
All other GS	25
Total Permanent	26

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ORGANIZATION AND STAFFING CHART

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ADMINISTRATIVE SERVICES DIVISION

	66	67
All other GS	36	35
Total Permanent	36	35

PUBLIC AFFAIRS DIVISION

	66	67
All other GS	8	8
Total Permanent	8	8

PERSONNEL DIVISION

	66	67
All other GS	9	9
Total Permanent	9	9

NASA-O DOWNEY

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Excepted	1	1
GS-15	1	1
GS-14	6	6
All other GS	125	124
Total Permanent	133	132

TECHNICAL DIVISION

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GS-14	25	25
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Total Permanent	82	81

CONTRACTS DIVISION

	66	67
Excepted	1	1
GS-15	1	1
GS-14	6	6
All other GS	47	46
Total Permanent	55	54

FINANCE DIVISION

	66	67
GS-14	1	1
All other GS	25	25
Total Permanent	26	26

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ADMINISTRATIVE OPERATIONS

FISCAL YEAR 1967 ESTIMATES

WESTERN OPERATIONS OFFICE

MISSION AND CAPABILITIES:

The primary mission of the Western Operations Office is to represent NASA in the southwestern area and 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, Colorado. The Western Operations Office functions as a field support activity in such areas as procurement, technical management, public affairs and educational programs, legal and patent reviews, financial management activities, and other administrative support.

Technical management support, as assigned by NASA Headquarters and field centers, encompasses advanced technology contracts and many research and development hardware contracts. Contract activity includes negotiations for advanced technology, hardware, basic agreements with major contractors, and procurement of pressurants and propellants for NASA and contractors requirements. The Western Operations Office mission also includes operation of an in-plant staff at the North American Aviation plant at Downey, California, to handle over-all contract administration and quality assurance for the Apollo and Saturn projects.

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:

	1965	1966	1967
Authorized Positions, end of year	405	391	386
Average Number of All Employees..	377	382	378
Administrative Operations........	$22,693,000*	$5,987,000	$6,149,000

*Includes $17,034,000 for purchase of computers for JPL.

INSTALLATION DESCRIPTION:

The main Western Operations Office is located at 150 Pico Boulevard, Santa Monica, California. The Office occupies a group of buildings under commercial lease and no government investment in buildings or acreage is involved at this location.

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., mainly for Apollo and Saturn work. 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 $45 million as of June 30, 1965. The responsibility for management of property and facilities valued at $39.5 million was transferred from the Air Force to NASA on July 1, 1964. A few additional Western Operations Office personnel are assigned to other contractor locations within the Los Angeles area where full time project support is required.

ANALYSIS OF RESOURCES REQUIREMENTS BY OBJECT CLASSIFICATION:

		1965	1966	1967
11.	Personnel Compensation...	$4,115,000	$4,289,000	$4,426,000
12.	Personnel Benefits.......	289,000	309,000	317,000
	Total, personnel costs.	$4,404,000	$4,598,000	$4,743,000
21.	Travel and Transportation of persons.............	247,000	282,000	282,000
22.	Transportation of Things.	8,000	45,000	50,000
23.	Rent, Communications, and Utilities..............	349,000	402,000	402,000
24.	Printing and Reproduction	15,000	15,000	15,000
25.	Other Services...........	522,000	514,000	517,000
	Services of other agencies.................	12,000	14,000	58,000
26.	Supplies and Materials...	51,000	53,000	53,000
31.	Equipment................	17,085,000	64,000	29,000
32.	Lands and Structures.....	---	---	---
42.	Insurance Claims and Indemnities............	---	---	---
	Total................	$22,693,000	$5,987,000	$6,149,000

JUSTIFICATION BY OBJECT CLASSIFICATION:

Personnel Distribution

	1965	1966	1967
Direct Personnel by Program			
Manned Space Flight			
Gemini	4	2	-
Apollo	161	162	163
Advanced missions	8	10	10
Space Science and Applications			
Physics and astronomy	15	15	14
Lunar and planetary exploration	15	14	14
Launch vehicle procurement	5	4	5
Bioscience	-	2	2
Communication and applications technology satellites	7	7	6
Advanced Research and Technology			
Space vehicle systems	3	3	3
Electronics systems	23	21	20
Space power and electric propulsion systems	2	2	2
Chemical propulsion	4	4	4
Technology Utilization	3	3	3
Sub-total, direct positions	250	249	246
Support personnel			
Director and Staff	9	9	9
Administration	63	63	62
Research and Development support	64	65	64
Sub-total, support positions	136	137	135
Total, permanent positions	386	386	381

	1965	1966	1967
Other positions			
Positions under cooperative training agreements...............	-	-	-
Other temporary positions...........	19	5	5
Total, all positions....................	405	391	386

Personnel Costs

	1965	1966	1967
Total Positions.................	405	391	386
Permanent......................	386	386	381
Other..........................	19	5	5
Personnel Compensation:			
Annual cost of permanent positions.......................	$3,985,000	$4,193,000	$4,221,000
Pay above the stated annual rate........................	15,000	16,000	16,000
Lapses (deduct)................	- 170,000	- 228,000	- 111,000
Net cost of permanent positions	3,830,000	3,981,000	4,126,000
Other personnel compensation...	285,000	308,000	300,000
Total Compensation.........	4,115,000	4,289,000	4,426,000
NASA funded..............	4,115,000	4,289,000	4,426,000
Reimbursable............	---	---	---
Personnel benefits			
NASA funded...................	289,000	309,000	317,000
Reimbursable..................	289,000	309,000	317,000
Total personnel costs...........	4,404,000	4,598,000	4,743,000
NASA funded....................	4,404,000	4,598,000	4,743,000
Reimbursable..................	---	---	---
Average Number of All Employees (Man Years)....................	377	382	378

Personnel Compensation and Benefits - $4,743,000

Personnel costs in FY 1967 are estimated to be $145,000 higher than in FY 1966, of which $137,000 is for personnel compensation and $8,000 is for personnel benefits. The estimate reflects the additional cost resulting from higher pay scales in effect for a full year, and for within-grade step increases, retirement contributions and other benefits.

Travel and Transportation of Persons - $282,000

Travel and transportation requirements in FY 1967 are expected to remain at the FY 1966 level. The total estimate includes $230,000 needed for employee travel to direct and coordinate technical program and administrative activities; to attend NASA technical meetings and working panels; and for the cost of temporary assignments and transfers. The balance of $52,000 will be used for the expense of local transportation and toll charges, and the rental of passenger motor vehicles from the General Services Administration.

Transportation of Things - $50,000

Transportation of things is estimated to increase $5,000 in FY 1967. This increase is related to the movement of household goods to accommodate the personnel turnover anticipated in FY 1967. The estimate also includes $38,000 for transportation of NASA exhibits in the western area of the United States.

Rent, Communications, and Utilities - $402,000

Fiscal year 1967 requirements in this area are estimated to remain unchanged from FY 1966.

The estimate includes $192,000 required for the commercial lease of real property and the rental of equipment, of which $168,000 is to continue the lease of 46,800 square feet of office space at an average annual cost of $3.60 per square foot. The remaining amount of $24,000 covers the rental of office and other equipment on a term basis.

The FY 1967 requirement of $205,000 for communications services is composed of the following items:

Leased lines..................................	$4,000
Long distance tolls...........................	39,000
Local telephone and exchange..................	71,000
All other communications......................	91,000

The balance of the FY 1967 estimate, amounting to $5,000, is required for utilities, primarily electric power.

Printing and Reproduction - $15,000

The FY 1967 cost of printing and reproducing technical and administrative reports, publications and forms is estimated to continue at the FY 1966 level. The estimate includes $3,000 to cover the printing of administrative materials by other government agencies, and $12,000 for the commercial printing of technical documents and related publications.

Other Services - $575,000

Requirements for other services in FY 1967 indicate a net increase of $47,000 over FY 1966. This results from planned expansion of the Reliable Electrical Connections School facilities at an additional cost of $12,000, in order to accelerate quality assurance certification of contractor personnel in time to assure adherence to space hardware production schedules; the augmentation of the technical reference library staff at an increased amount of $8,000 to serve the progressively larger use of these services by industry in the western area; and the assistance of Defense Contracts Administration Services Regions (DCASR) in providing contract administration services, which will require $44,000 of additional funding. These estimated increases are partially offset by the expected reduction of $17,000 in the cost of leasing, maintenance and operation of administrative aircraft at the Jet Propulsion Laboratory because of the disposal of a NASA-owned aircraft.

The following table indicates estimated FY 1967 funding for this area by the major requirements:

ADP equipment operation........................	$30,000
Custodial services.............................	18,000
JPL administrative aircraft lease, maintenance and operation..............................	245,000
Technical reference library....................	80,000
Reliable electrical connections school..........	120,000
Contract administration services................	50,000
Miscellaneous minor services....................	32,000
Total..	$575,000

Supplies and Materials - $53,000

The cost of supplies and materials for FY 1967 is expected to remain at the FY 1966 level. The estimate includes $48,000 for replacement of office supplies and $5,000 for purchase of expendable photographic, maintenance and operating supplies.

Equipment - $29,000

The FY 1967 estimate of $29,000 is $35,000 below FY 1966. The estimate includes $16,000 for the procurement of two replacement engines for leased administrative aircraft supporting the Jet Propulsion Laboratory; $4,000 to purchase two passenger motor vehicles (for replacement); and $9,000 for acquisition of photographic and non-capitalized equipment, and replacement of office furniture and equipment.