National Aeronautics and Space Administration

BUDGET ESTIMATES

FISCAL YEAR 1965

Volume VII

ADVANCED RESEARCH AND TECHNOLOGY PROGRAMS

TRACKING AND DATA ACQUISITION PROGRAMS

RESEARCH AND DEVELOPMENT

CONSTRUCTION OF FACILITIES

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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ADVANCED RESEARCH AND TECHNOLOGY PROGRAMS

TRACKING AND DATA ACQUISITION PROGRAMS

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RESEARCH AND DEVELOPMENT
SUMMARY BY BUDGET ACTIVITY

Budget Activities and Programs	Fiscal Year 1963	Fiscal Year 1964	Fiscal Year 1964 Supplemental	Fiscal Year 1965
MANNED SPACE FLIGHT..	$1,503,583,000	$2,649,800,000	$141,000,000	$3,011,900,000
Gemini.............	288,090,000	383,800,000	---	308,400,000
Apollo.............	1,183,965,000	2,243,900,000	141,000,000	2,677,500,000
Advanced missions..	11,391,000	22,100,000	---	26,000,000
Completed missions.	20,137,000	---	---	---
SPACE APPLICATIONS...	$96,958,000	$103,300,000	---	$86,100,000
Meteorology........	54,051,000	67,800,000	---	37,500,000
Communications.....	32,075,000	13,500,000	---	12,600,000
Other applications.	10,832,000	22,000,000	---	36,000,000
UNMANNED INVESTIGATIONS IN SPACE.....	$489,951,000	$602,700,000	---	$649,800,000
Spacecraft development and operations...........	384,222,000	477,600,000	---	521,600,000
Launch vehicle development.....	105,729,000	125,100,000	---	128,200,000
SPACE RESEARCH AND TECHNOLOGY..........	$255,962,000	$298,100,000	---	$283,300,000
Launch vehicles and spacecraft........	88,547,000	111,900,000	---	104,400,000
Propulsion and space power......	167,415,000	186,200,000	---	178,900,000
AIRCRAFT TECHNOLOGY..	$15,598,000	$22,100,000	---	$37,000,000
SUPPORTING OPERATIONS	$152,742,000	$250,000,000	---	$313,900,000
Tracking and data acquisition......	122,142,000	210,000,000	---	267,900,000
Facility training, and research grants............	30,600,000	40,000,000	---	46,000,000
TOTAL PLAN...........	$2,514,794,000	$3,926,000,000	$141,000,000	$4,382,000,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1965 ESTIMATES

RESEARCH AND DEVELOPMENT SUMMARY OF BUDGET ACTIVITIES BY PROGRAM

Budget Activities and Programs	Fiscal Year 1963	Fiscal Year 1964	Fiscal Year 1964 Supplemental	Fiscal Year 1965
MANNED SPACE FLIGHT	$1,503,583,000	$2,649,800,000	$141,000,000	$3,011,900,000
Gemini...........	288,090,000	383,800,000	---	308,400,000
Apollo...........	1,183,965,000	2,243,900,000	141,000,000	2,677,500,000
Advanced missions	11,391,000	22,100,000	---	26,000,000
Completed missions	20,137,000	---	---	---
SPACE APPLICATIONS	$96,958,000	$103,300,000	---	$86,100,000
Meteorology......	54,051,000	67,800,000	---	37,500,000
Communications...	32,075,000	13,500,000	---	12,600,000
Other applications	10,832,000	22,000,000	---	36,000,000
Advanced technological satellites...	(8,668,000)	(18,500,000)	---	(31,000,000)
Technological utilization..	(2,164,000)	(3,500,000)	---	(5,000,000)
UNMANNED INVESTIGATIONS IN SPACE	$489,951,000	$602,700,000	---	$649,800,000
Spacecraft development and operations.....	384,222,000	477,600,000	---	521,600,000
Geophysics and astronomy....	(147,689,000)	(186,200,000)	---	(190,200,000)
Lunar and planetary exploration..	(222,802,000)	(270,800,000)	---	(300,400,000)
Bioscience.....	(13,731,000)	(20,600,000)	---	(31,000,000)
Launch vehicle development....	105,729,000	125,100,000	---	128,200,000

Budget Activities and Programs	Fiscal Year 1963	Fiscal Year 1964	Fiscal Year 1964 Supplemental	Fiscal Year 1965
SPACE RESEARCH AND TECHNOLOGY	$255,962,000	$298,100,000	---	$283,300,000
Launch vehicles and spacecraft.	88,547,000	111,900,000	---	104,400,000
Space vehicle systems.......	$(43,990,000)	$(49,000,000)	---	$(38,800,000)
Electronic systems.......	(17,071,000)	(28,700,000)	---	(28,400,000)
Human factor systems.......	(9,790,000)	(13,200,000)	---	(16,200,000)
Basic research..	(17,696,000)	(21,000,000)	---	(21,000,000)
Propulsion and space power.....	167,415,000	186,200,000	---	178,900,000
Nuclear-electric systems.......	(39,893,000)	(44,700,000)	---	(48,100,000)
Nuclear rockets.	(69,465,000)	(82,700,000)	---	(58,000,000)
Chemical propulsion....	(49,722,000)	(45,800,000)	---	(59,800,000)
Space power.....	(8,335,000)	(13,000,000)	---	(13,000,000)
AIRCRAFT TECHNOLOGY	$15,598,000	$22,100,000	---	$37,000,000
SUPPORTING OPERATIONS	$152,742,000	$250,000,000	---	$313,900,000
Tracking and data acquisition......	(122,142,000)	(210,000,000)	---	(267,900,000)
Sustaining university program	(30,600,000)	(40,000,000)	---	(46,000,000)
TOTAL..........	$2,514,794,000	$3,926,000,000	$141,000,000	$4,382,000,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1965 ESTIMATES

SUMMARY OF RESEARCH AND DEVELOPMENT BUDGET PLAN BY PROGRAM

	Fiscal Year 1963	Fiscal Year 1964	Fiscal Year 1964 Supplemental	Fiscal Year 1965
MANNED SPACE FLIGHT..	$1,503,583,000	$2,649,800,000	$141,000,000	$3,011,900,000
Gemini.............	288,090,000	383,800,000	---	308,400,000
Apollo.............	1,183,965,000	2,243,900,000	141,000,000	2,677,500,000
Advanced missions..	11,391,000	22,100,000	---	26,000,000
Completed missions.	20,137,000	---	---	---
SPACE SCIENCE AND APPLICATIONS.......	$615,345,000	$742,500,000	---	$776,900,000
Geophysics and astronomy........	147,689,000	186,200,000	---	190,200,000
Lunar and planetary exploration......	222,802,000	270,800,000	---	300,400,000
Sustaining university program.....	30,600,000	40,000,000	---	46,000,000
Launch vehicle development......	105,729,000	125,100,000	---	128,200,000
Bioscience.........	13,731,000	20,600,000	---	31,000,000
Meteorological satellites.......	54,051,000	67,800,000	---	37,500,000
Communications satellites.......	32,075,000	13,500,000	---	12,600,000
Advanced technological satellites..	8,668,000	18,500,000	---	31,000,000
ADVANCED RESEARCH AND TECHNOLOGY.........	$271,560,000	$320,200,000	---	$320,300,000
Basic research.....	17,696,000	21,000,000	---	21,000,000
Space vehicle systems...........	43,990,000	49,000,000	---	38,800,000
Electronic systems.	17,071,000	28,700,000	---	28,400,000
Human factor systems...........	9,790,000	13,200,000	---	16,200,000
Nuclear-electric systems...........	39,893,000	44,700,000	---	48,100,000
Nuclear rockets....	69,465,000	82,700,000	---	58,000,000
Chemical propulsion	49,722,000	45,800,000	---	59,800,000
Space power........	8,335,000	13,000,000	---	13,000,000
Aeronautics........	15,598,000	22,100,000	---	37,000,000

	Fiscal Year 1963	Fiscal Year 1964	Fiscal Year 1964 Supplemental	Fiscal Year 1965
TRACKING AND DATA ACQUISITION.......	$122,142,000	$210,000,000	$141,000,000	$267,900,000
TECHNOLOGY UTILIZATION.......	$2,164,000	$3,500,000	---	$5,000,000
TOTAL PLAN......	$2,514,794,000	$3,926,000,000	$141,000,000	$4,382,000,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
FISCAL YEAR 1965 ESTIMATES

SUMMARY OF CONSTRUCTION OF FACILITIES BUDGET PLAN BY BUDGET ACTIVITY

	Budget Activity	Fiscal Year 1963	Fiscal Year 1964	Fiscal Year 1965
1.	Manned Space Flight..........	$543,809,100	$495,179,000	$234,330,000
2.	Space Applications...........	193,605	3,933,000	---
3.	Unmanned Investigations in Space......................	47,261,650	18,574,200	7,018,000
4.	Space Research and Technology	106,849,300	56,832,800	26,620,000
5.	Aircraft Technology..........	1,697,000	100,000	4,001,000
6.	Supporting Operations........	42,608,495	98,881,000	9,031,000
	Total Plan.................	$742,419,150	$673,500,000	$281,000,000

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1965 ESTIMATES

SUMMARY OF CONSTRUCTION OF FACILITIES BUDGET PLAN BY LOCATION BY PROGRAM OFFICE

	Fiscal Year 1963	Fiscal Year 1964	Fiscal Year 1965
Office of Manned Space Flight...	$543,809,100	$488,315,000	$224,910,000
John F. Kennedy Space Center, NASA........................	296,479,100	279,236,000	89,520,000
Manned Spacecraft Center......	25,369,500	35,172,000	25,166,000
Marshall Space Flight Center..	41,740,500	28,980,000	15,288,000
Michoud Plant.................	28,910,000	8,688,000	6,534,000
Mississippi Test Facility.....	78,407,000	93,656,000	61,991,000
Various Locations.............	72,903,000	42,583,000	26,411,000
Office of Space Science and Applications..................	$47,455,255	$21,710,700	$7,359,000
Ames Research Center..........	930,000	---	---
Goddard Space Flight Center...	18,902,355	17,032,500	500,000
Jet Propulsion Laboratory.....	10,208,050	2,998,200	3,314,000
John F. Kennedy Space Center, NASA........................	8,659,000	1,680,000	1,741,000
Lewis Research Center.........	1,186,500	---	---
Various Locations.............	6,799,350	---	---
Wallops Station...............	770,000	---	1,804,000
Office of Advanced Research and Technology....................	$110,378,650	$56,179,300	$27,591,000
Ames Research Center..........	13,711,000	11,044,000	6,081,000
Electronics Research Center...	---	---	10,000,000
Flight Research Center........	1,757,000	1,157,000	---
Jet Propulsion Laboratory.....	---	---	400,000
Langley Research Center.......	10,094,300	8,204,300	4,454,000
Lewis Research Center.........	44,630,000	18,634,000	810,000
Nuclear Rocket Development Station.....................	14,835,000	3,240,000	---
Various Locations.............	25,351,350	13,900,000	5,846,000

	Fiscal Year 1963	Fiscal Year 1964	Fiscal Year 1965
Office of Tracking and Data Acquisition..................	$40,776,145	$96,805,000	$6,140,000
Goddard Space Flight Center..	2,915,000	---	800,000
John F. Kennedy Space Center, NASA.....................	---	4,000,000	---
Various Locations............	34,470,395	92,300,000	5,340,000
Wallops Station..............	3,390,750	505,000	---
Facility Planning and Design...	---	10,490,000	15,000,000
TOTAL PLAN................	$742,419,150	$673,500,000	$281,000,000

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 to obtain basic knowledge for our rapidly advancing technology. In order to improve our technological knowledge and techniques, NASA will conduct basic research in the physical and mathematical sciences. Work in the mechanisms of energy conversion in atoms will be helpful in fabricating new gaseous and solid state lasers for use in space communication and tracking; mathematical research is leading toward an improved capability of predicting the motion of a space vehicle; explorations in plasma behavior will provide information helpful to the development of space power systems and electrical engines for spacecraft propulsion; and research devoted to materials will provide techniques to develop newer and lighter materials operating at higher temperatures for space vehicles and supersonic aircraft.

SUMMARY OF RESOURCES REQUIREMENTS:

	1963	1964	1965
Supporting research and technology	$17,696,000	$21,000,000	$21,000,000
Total costs	$17,696,000	$21,000,000	$21,000,000

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

	1963	1964	1965
Fluid physics	$6,716,000	$7,820,000	$7,800,000
Electrophysics	3,160,000	3,960,000	4,000,000
Materials	7,080,000	8,020,000	8,000,000
Applied mathematics	740,000	1,200,000	1,200,000
Total costs	$17,696,000	$21,000,000	$21,000,000

Fluid Physics

Fluid physics research provides a fundamental understanding of the flow processes of liquid and gas mixtures involved in aircraft, spacecraft, and advanced propulsion systems. This research is concerned with the flow of gases at very high temperatures (up to 40,000° Fahrenheit in the case of spacecraft entry). At these temperatures, gas mixtures are composed not only of electrically-neutral molecules, but also of atoms, ions and electrons with varying characteristics and accelerated chemical reactions. Thus, theoretical work in fluid physics cuts across conventional disciplinary lines of fluid mechanics, chemistry and physics, and experimentally requires the use of advanced laboratory facilities and instrumentation techniques for producing and measuring high speed and high temperature phenomena. As in most basic research efforts, the work is performed on a continuing basis over a time span of many years.

Examples of some of the projects and the particular emphasis to be given to them in fiscal year 1965 include: the measurement of radiation characteristics, and the heat, viscous, and electrical conductivities and chemical reaction rates of planetary gas mixtures at temperatures up to 40,000° Fahrenheit; the experimental measurement of convective and radiant heat transfer on spacecraft nose shapes for Earth, Venus and Mars entry, and the assessment of the effects of ablation products on conventive and radiant heat transfer; application of fluid physics principles to understand the mechanism of combustion instability of liquid fuel rocket engines; the development of the physics of accelerating and decelerating ionized gas flows by means of magnetic and electric fields; and the extension of knowledge of flow reactions at very low gas densities.

Electrophysics

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

Research is underway to determine and explain the mechanisms of energy transfer in the atomic levels of solids and gases. This will lead to new sources for the stimulated emission of coherent electromagnetic waves (lasers) in the region from gamma ray to millimeter wavelengths. Such signal sources may be applicable to electronic communication and navigation for spacecraft.

Theoretical and experimental superconductivity research will find ways to increase the critical temperature and magnetic field strength of superconductors. Superconducting coils offer a superior method for obtaining magnetic fields which may conceivably be used to shield spacecraft from undesired solar particle radiation.

Investigation is underway to reduce the energy losses in superconducting fields which would make them particularily attractive for use with gyroscope rotors. If the losses can be reduced to an acceptable level, then a new engineering technique will be available for further work on an improved gyroscope for spacecraft guidance.

Also, experimental research is being conducted on the fission-electric cell. This new technique, if successful, will use the neutron flux of a fission reactor to initiate action of the fission-electric cell thereby directly producing electric power. The work includes high voltage breakdown phenomena, current leakage, secondary electron control and design and fabrication of laboratory units.

For fiscal year 1965, basic research will be continued on the mechanisms of energy transfer in atoms of solids and gases, on the reaction between ionized gases and magnetic fields, and on superconductivity theory and practice.

Materials

Space vehicles and high speed aircraft require superior light-weight materials resistant to heat, stresses, corrosion, erosion, radiations, and the vacuum of space. This program supports integrated basic research and technological developments in materials to help meet the demand.

Basic materials research involves the study of the chemistry and physics of solids and the nature and behavior of metals, ceramics, and polymers. Research and development of new production processes and forming and joining techniques are required for the translation of basic and applied research to reproducible and economical engineering materials.

In fiscal year 1965 a vigorous materials program ranging from the studies of fundamental characteristics to advaneed technology will be pursued and should result in alloys, ceramics, and polymers better able to perform required functions in space vehicles. Particular emphasis will be placed: on gaining an understanding of the behavior of materials in the space environment, particularly looking for the synergistic effects produced by the different components of that environment; and on the NASA polymer chemistry research program to yield polymers capable of desirable structural properties at low temperatures, superior polymers capable for use as adhesives in honeycombs and laminates and as binder in paints, elastomers for use as elastic structure at low temperature, and polymers which appear useful for electronic application.

Applied Mathematics

Work in applied mathematics includes research in mathematical techniques necessary or relevant for application to aeronautic and space problems in science or engineering. A mathematical approach is sometimes the only one possible for rapid and economic consideration of conditions not yet achieved.

In fiscal year 1965 the applied mathematics program will sponsor contracts or grants for investigations in aerodynamic mathematics for predicting vehicle motions within planetary atmospheres; for mathematical work seeking theoretical solutions to problems connected with rocket propulsion; and for research on control of motion and attitude of vehicles in orbit. Research is also planned in the areas of new procedures for improvement of orbit prediction, and abstract numerical analyses aimed at more efficient exploitation of expensive computing facilities.

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY — SPACE VEHICLE SYSTEMS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objectives of the Space Vehicle Systems program are to identify and solve critical technical problems bearing on present generation space vehicles, and to advance the state- of-the-art to enable the development of more advanced space vehicles.

The space vehicle represents a system of enormous complexity in which the major elements must be brought together and integrated in such a way as to insure reliable and efficient performance. The space vehicle research and technology program reflects the broad scope of mission and operational requirements.

Comprehensive knowledge must be obtained on atmospheric winds and turbulence, aerodynamic forces and moments buffeting and flutter, aerodynamic heating of the vehicle during ascent, and heating of the base and afterbody due to the high-temperature exhaust. The refinement of structural design requires knowledge of the dynamic behavior of the large, highly stressed and flexible vehicles and requires further evolution and development of new and advanced structural materials and principles of structural design.

Comprehensive knowledge of the space environment is required. NASA will study: high-energy charged particle radiations and the interactions of the radiation with matter and new means of shielding; the distribution and population of hazardous particles, and the phenomena of hypervelocity impact and penetration, and means for protection of spacecraft from penetration; the high vacuum of space; thermal radiation from the sun; weightlessness which influences the behavior and control of propellants and other fluids; and the control of spacecraft temperatures.

Atmosphere entry and soft landing of unmanned and manned spacecraft pose continuing vehicle design problems. A broad research program in the areas of aerothermodynamics, fluid physics, structures and materials is required to produce basic understanding of high-temperature gas properties, flow fields, distribution of radiative and convective heating, stability and control, ablative materials and thermal protection systems, and high-temperature structural design.

To guide the overall program of theoretical and experimental research, continuing studies are being conducted of advanced space missions and vehicle concepts. These studies have the specific objectives of assessing new missions or flight operations, providing ideas and innovation in space vehicle concepts, and identifying technical problems requiring long-lead-time research.

Another responsibility of the space vehicle research and technology program is application of promising new results and of the best current knowledge to the formulation of space vehicle design criteria.

SUMMARY OF RESOURCES REQUIREMENTS:

	1963	1964	1965
Supporting research and technology..............	$20,226,000	$26,300,000	$26,300,000
Scout reentry heating experiments..............	1,383,000	1,500,000	2,000,000
FIRE........................	13,912,000	8,000,000	3,000,000
Saturn-launched meteoroid experiments..............	3,940,000	8,000,000	2,600,000
Small space vehicle flight experiments..............	1,724,000	2,800,000	3,000,000
Lifting body flight and landing tests............	---	900,000	1,900,000
Scout-launched meteoroid experiments (S-55).......	2,805,000	1,500,000	---
Total costs..............	$43,990,000	$49,000,000	$38,300,000

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

	1963	1964	1965
Spacecraft aerothermodynamic.....	$ 5,126,000	$ 5,432,000	$ 5,432,000
Spacecraft loads and structures..	3,306,000	5,177,000	5,177,000
Launch vehicle aerothermodynamics.........................	879,000	914,000	1,214,000
Launch vehicle loads and structures.........................	2,467,000	3,797,000	3,797,000
Space vehicle environmental factors.......................	6,847,000	7,030,000	7,030,000
Advanced space vehicle concepts..	1,501,000	2,650,000	2,350,000
Space vehicle design criteria....	100,000	1,300,000	1,300,000
Total costs...................	$20,226,000	$26,300,000	$26,300,000

Considerable progress has been made during fiscal year 1964 to establish the heating distribution on the front face of blunt shaped spacecraft at lunar return speeds. Extensive testing has been accomplished to define the heating on the afterbodies of Apollo-like configurations where complex flow phenomena make prediction and wind-tunnel testing difficult. A free-flight model technique has been devised for high-heating rate shock tunnels which should enable a much better determination of the afterbody heating. Research on this problem will receive continued emphasis in fiscal year 1965.

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Research will also be continued on the aerothermochemical properties of air and various predicted atmospheres of Mars and Venus at the very high temperatures associated with entry flight. More refined theoretical and experimental research on reentry heating will be continued in fiscal year 1965, particularly for the very high speeds associated with Earth reentry upon return from interplanetary flight where the radiative heating becomes increasingly important.

Recent research has shown that zero- or low-lift spacecraft configurations can be achieved to reduce the hot gas radiative and total heating at very high entry speeds (25,000 to 45,000 mph). It is difficult to maintain in the hot environment the relatively sharp nose required on these configurations. Some promising techniques will be studied further in fiscal year 1965.

Significant progress was made in the past year to improve the aerodynamic performance, stability, control and general flying characteristics of advanced "lifting body" type spacecraft throughout the speed range from reentry to landing. Such spacecraft offer considerably improved maneuverability during reentry flight and approach to landing compared to spacecraft of the Apollo and Gemini types. These spacecraft also permit horizontal landing much like the X-15. Some weight penalties for these desirable features and a more difficult problem of assuring adequate reentry heat protection are imposed. The heating is aggravated by complex flow phenomena for these configurations with canopies, aerodynamic control surfaces and other protuberances that are only partially understood. Research on the heating and aerodynamics will continue to be an important part of this work. Also, research will be continued on emergency landing and abort flight problems for this class of vehicle.

Last year evidence indicated the heating of a probe in a Venus atmosphere at speeds above 20,000 miles per hour may be less than previously indicated. This will be examined in greater detail in fiscal year 1965. New evidence on the composition of the Mars atmosphere has also changed the views on a probe shape suitable for Mars entry flight. Such a probe shape will have greater aerodynamic heating and stability problems than previously expected and will require considerable research in order to provide adequate data on heat protection and control during entry.

In fiscal year 1965 research on landing and recovery aids for ballistic type spacecraft will concentrate on aerodynamic and deployment problems of steerable parachutes, paragliders, aerodynamic decelerators, rotors, retrorockets and combinations of such devices.

Spacecraft Loads and Structures

The program provides the technology for improved and reliable structural performance of flight vehicles. The trend toward more thorough ground qualification is a direct consequence of more stringent mission requirements involving performance improvement and longer operating times. Applied research to assure the timely acquisition of appropriate analytical methods and experimental facilities will be continued.

Work will continue on obtaining research information for the design of thermal protection systems for spacecraft atmospheric entry. Current effort is directed toward retaining the high thermal efficiency of ablating materials, while improving their structural properties to an acceptable level.

Research will be continued on the structural advantages of composite materials. Filament reinforced composites exhibit superior strength characteristics and appear to be particularly advantageous for the containment of cryogenic fluids such as liquid hydrogen. The major problem limiting their immediate use centers about mechanical compatibility of liner materials. Primary effort is directed toward providing an acceptable solution to the liner problem. Additional research objectives in spacecraft loads and structures are concerned with environmental vibrations, analytical methods and landing impact.

Launch Vehicle Aerothermodynamics

This research effort is aimed at the solution of aerodynamic and thermodynamic problems of currently approved launch vehicles and provides the necessary body of technological knowledge that will be required for the development of the more highly advanced launch vehicles of the future. The research effort in fiscal year 1965 will place emphasis on launch vehicle heating during flight with particular reference to the effect of nozzle clustering on base heating, improved experimental methods for the laboratory investigation of base heating, and measurements of the radiative heating component due to the incandescent rocket exhaust plumes. Research will also continue on trajectories and staging; launch vehicle static and dynamic stability; vehicle aerodynamic forces; loads, and flow phenomena; and hinge moments on gimballed rocket nozzles.

Research will also be continued on large rocket engine noise. This will include analytical and experimental studies on the generation, propagation, and effects of noise under a variety of operating conditions. This research will include studies of aerodynamic noise generation by boundary layers, wakes, and separated flow, and absorption of low frequency acoustic energy in atmospheres. With particular reference to the advanced vehicles of the future, emphasis will be placed on the aerothermodynamic problems of new and different launch vehicle concepts capable of recovery and re-use.

Launch Vehicle Loads and Structures

This NASA effort is directed toward increasing the efficiency and reliability of launch vehicle structures, through a better understanding of the loads imposed on the vehicle by atmospheric winds and buffet loads, and by striving for lighter structures capable of withstanding these loads. One of the significant accomplishments during fiscal year 1964 was the advance made in dynamic modeling technology attested to by the excellent correlation of the 1/5-scale Saturn I vibration data with the full-scale test data. The present level of effort will continue in most areas of structures research in fiscal year 1965 with an accelerated effort in a few areas.

In this regard, studies of large launch vehicle structural configurations will be made where novel design applications, such as the use of semi-toroidal tanks, will permit shorter vehicles with improved strength and rigidity characteristics. In order to provide adequate containment of low fuel temperatures with no leakage and low heat transfer, a detailed investigation of new materials and their application to lightweight tanks, liners, and insulation will be conducted. The prediction of design loads will receive additional impetus. Methods for the prediction of the dynamic response of structures to winds and other loads will continue to be studied. The increased use of models to aid these investigations will also be studied.

Space Vehicle Environmental Factors

This effort concerns environments encountered beyond the atmosphere that are important to space vehicle design, and the effects of these environmental factors on space vehicles. The five principle areas are high-energy space radiation effects and shielding, meteoroid environment and impact hazard, zero gravity fluid behavior, high-vacuum technology, and thermal radiation and temperature control.

In the high-energy radiation and shielding area, one of the major efforts is the transport of charged particle radiation through matter. A program yielding theoretical estimates of electron penetration will be continued with experimental verification being obtained for the theoretical results. A long-range program, now in its second year, for study of the interaction of protons with matter will continue. Studies of electromagnetic shielding concepts will be continued as a potentially lighter weight, more effective means of shielding. In the area of radiation effects on components and systems, two kinds of research effort are being undertaken. One will provide engineering data for immediate design use in radiation effects on specific components. Another effort of a more basic nature will provide a better understanding of the underlying mechanisms of radiation damage.

The problem of defining the meteoroid hazard to spacecraft is one of both immediate and long-range importance. With increased mission duration and hence increased time of exposure to the hazard, the danger from this source increases. Major research progress was made during the past year with the conclusion of the successful Explorer XVI satellite experiment in which the first direct meteoroid penetration measurements were made. The experiment marked the real beginning of a series of satellite experiments, discussed under flight projects, whose objective is to eliminate insofar as possible the large uncertainty that presently exists with regard to the population and penetrating power of hazardous meteoroids. In addition to the flight experiments, the radio meteor project will be continued in which meteors are observed and their properties measured by radio reflection techniques as they enter the Earth's atmosphere to determine their physical characteristics as well as their distribution in space and time. To properly assess the hazard from any given meteoroid distribution, the phenomena associated with high-velocity impact must be understood. Theoretical impact studies and laboratory experiments using the best available particle acceleration techniques will be continued. In addition, several approaches to the problem of obtaining the yet unattained true meteoroid velocities and masses in the laboratory will continue under development.

Some two years of comprehensive experimental research, using a modest sized drop tower facility, has recently been completed. Major current emphasis will be on research on the dynamics of fluid motion under small accelerations (near-weightlessness) in flight experiments and in available drop tower facilities.

The program in the vacuum area will be primarily concerned with the advancement of techniques for producing better vacuums in the laboratory and for measuring these vacuums with precision.

An important problem in the design of spacecraft is maintaining temperatures in the desired range. Research on active temperature control systems (i.e. those in which the thermal characteristics of a vehicle are varied during a mission) will be continued, as well as further development of improved passive systems which will not degrade in effectiveness during extended space flight for long times to the space environment. Solar radiation design studies will be continued to develop improved light sources, better techniques for calibration, improved optics and the possible use of thermal scale modeling.

Advanced Space Vehicle Concepts

This effort involves the study and analysis of advanced missions, spacecraft, and launch vehicles beyond presently approved projects. Principal objectives are to understand problems associated with advanced missions; to assist in guiding the overall research efforts of the Office of Advanced Research and Technology by the identification of critical and long-lead-time problem areas; and to provide for the innovation and invention of new concepts and vehicles.

In fiscal year 1964, research efforts identified research requirements and provided concepts in support of manned orbital laboratory and manned and unmanned planetary missions. Consideration was also given to the potential and problems of advanced nuclear and nuclear-electric vehicle systems.

Space Vehicle Design Criteria

This effort is directed toward the improvement of future NASA space vehicles by providing the designers with a basic and uniform set of conditions for use in designing launch vehicles, spacecraft, and entry and landing vehicles, as well as integrated space vehicles. Fiscal year 1965 funds will continue this effort.

A number of individual criteria monographs dealing with specific design topics are now in preparation at NASA Centers, some of which should be published in calendar year 1964. These will be coordinated with other Federal departments and with industry to obtain wide acceptance of the criteria and to aid the ultimate development of national criteria for designing space vehicles.

FLIGHT PROJECTS

Flight experiments are used when ground facilities cannot provide adequate simulation of the space environment, when information about the nature of the space environment is important to space design, or when data is needed to correlate or validate important results from ground facilities.

Scout Reentry Heating Experiments

	1963	1964	1965
Spacecraft and support services...	$1,383,000	$500,000	$1,000,000
Launch vehicles..................	---	1,000,000	1,000,000
Total costs.....................	$1,383,000	$1,500,000	$2,000,000

These tests measure the performance of promising heat shield materials. Ground facilities provide only partial simulation of the heating environment for bodies entering the atmosphere at velocities higher than ICBM speeds. The objective of the Scout reentry experiments is to obtain data on heat shield materials under flight conditions at entry speeds of 28,000 feet per second and higher. Early experiments developed and demonstrated the techniques for obtaining heating data at high entry velocities but did not achieve the expected velocity because of difficulties with the launch vehicle.

Beginning with the second flight planned in calendar year 1964, provisions for recovery will be incorporated in the Scout entry experiments. The funds requested for fiscal year 1965 will provide for one experiment in this series.

FIRE

	1963	1964	1965
Spacecraft and support services..	$ 9,912,000	$ 6,470,000	$ 1,890,000
Launch vehicle..................	4,000,000	1,530,000	1,110,000
Total costs..................	$13,912,000	$ 8,000,000	$ 3,000,000

The objective of this project is to investigate the heating environment and effects around a blunt Apollo-shaped vehicle during an actual reentry at 37,000 feet per second. The flight tests will provide critical anchor points for validating results from laboratory test facilities and will provide guidance for applying experimental and theoretical reentry data generated by laboratory research. The project provides two flight articles and a prototype spacecraft.

Fiscal year 1965 funds provide for changes in the second flight spacecraft arising from results of the first flight and check-out, launch, data reduction, and reporting of results.

Saturn-Launched Meteoroid Experiments

	1963	1964	1965
Spacecraft and support........	$ 3,940,000	$ 8,000,000	$ 2,600,000
Total costs................	$ 3,940,000	$ 8,000,000	$ 2,600,000

The experiments to be launched on development Saturn vehicles will expose an area almost 100 times that of the Scout-launched experiments to meteoroid penetration. This will permit measurements of the frequency of penetration of metal surfaces as thick as 0.015 inches, approaching nominal vehicle wall thicknesses used in propellant tanks for Apollo and other projects.

Small Space Vehicle Flight Experiments

	1963	1964	1965
Behavior and handling of cryogenic propellants at zero G..	$ 719,000	$ 1,050,000	$ 640,000
Wind shear measurements.........	113,000	200,000	200,000
Meteor simulation...............	535,000	750,000	610,000
Reentry detection...............	84,000	200,000	150,000
Meteoroid penetration probe.....	273,000	100,000	---
Secondary environmental experiments.........................	---	500,000	1,400,000
Total costs..................	$ 1,724,000	$ 2,800,000	$ 3,000,000

This project provides a number of ballistic trajectory flight experiments using small launch rockets to verify results obtained in ground facilities, and to investigate problems which can only be studied under actual space environmental conditions. Current objectives include: studies of the behavior and handling of cryogenic propellants (liquid hydrogen) and their associated systems in the zero gravity and near-zero gravity condition; measurements of wind shear profiles in the vicinity of major-rocket launching bases; simulation of meteors by firing pellets of known size into the atmosphere from reentry rockets to provide a basis for deducing the size of photographically observed natural meteors; measurement of radar cross-section of reentering objects as affected by the ionized air surrounding the object; and secondary experiments, flown on launch vehicles funded elsewhere, to establish the effects of the space environment on the physical characteristics of a wide variety of spacecraft materials.

Lifting Body Flight and Landing Tests

	1963	1964	1965
Flight vehicle & support services..	$ ---	$ 900,000	$ 1,900,000

Present manned spacecraft are of the blunt-body, ballistic or semi-ballistic type (Mercury, Gemini and Apollo), capable of coping with entry heating at speeds as high as lunar return velocity but with very limited maneuverability. Entry spacecraft of the lifting body class, intermediate between ballistic configurations and winged configurations, promise good maneuverability in the atmosphere coupled with ability to withstand the entry heating associated with lunar return or return from missions even beyond the Moon. However, before practical application can be made of the lifting body concept, it is essential to determine the flying characteristics and whether pilots can handle such vehicles.

A preliminary investigation of the approach and landing characteristics of one promising type of lifting body configuration has been accomplished by the Flight Research Center using a simple, inexpensive glide vehicle constructed of steel tubing and plywood. This lightweight vehicle was tested extensively by ground and air tow with release into free-flight. It has now been demonstrated that it can be flown and landed successfully.

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY — ELECTRONIC SYSTEMS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Electronic Systems program provides, through research and technology, the basis for developing reliable and efficient components, and flexible and proven techniques for ultimate use in guidance, control, communications, tracking, instrumentation and data processing systems. The spectrum of research activity ranges from laboratory and theoretical investigations which make possible new approaches, to flight experiments employed to examine the feasibility, or provide environmental verification of new devices or theories.

SUMMARY OF RESOURCES REQUIREMENTS:

	1963	1964	1965
Supporting research and technology	$15,535,000	$24,900,000	$25,400,000
Small flight projects	1,536,000	3,800,000	3,000,000
Total costs	$17,071,000	$28,700,000	$28,400,000

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

	1963	1964	1965
Guidance systems	$3,565,000	$5,265,000	$5,435,000
Control systems	2,858,000	4,850,000	5,460,000
Communications	2,802,000	4,315,000	4,455,000
Tracking and data acquisition	1,329,000	3,220,000	3,060,000
Data handling and processing	1,897,000	3,530,000	3,380,000
Instrumentation	3,084,000	3,720,000	3,560,000
Total costs	$15,535,000	$24,900,000	$25,400,000

Guidance Systems. The guidance system research and technology program is directed towards the derivation of information necessary to understand and design simple, reliable and lightweight sensors, reference elements and associated components which make up a guidance system. The program emphasizes technique and component research in inertial, optical, passive and active electromagnetic phenomena for principal use in the sensing and

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reference functions. Trajectory analysis provides the framework for examining energy requirements, error analyses, and sensor and data processing trade offs for any specified space mission.

The areas of research in which potential improvements appear most likely are in cryogenic (super-conducting magnetic) and electrostatic gyros, and in atomic and micron size particle gyros and accelerometers. The fiscal year 1965 program will continue these tasks where progress warrants and in addition proposals for gyros and accelerometers using atomic and micron size particles have been evaluated for initiation.

Various factors related to future missions such as range, duration, energy available and abort dictate the need for on-board, autonomous, navigation systems. NASA is emphasizing research in such passive devices as on-board optical space navigation instruments (similar to sextants) and on electro-optical sensors for use as star mappers. In addition, television techniques for data collection and closed-loop guidance systems are planned.

The current effort in active guidance phenomena such as radar and laser type devices and systems is research analysis oriented, and is directed towards examining the requirements and performance parameters from which conceptual designs can be formulated. In parallel with this activity a limited effort will be continued in exploring specific sub-systems and techniques to provide improved systems for later versions of existing spacecraft.

Control Systems. Control system research and development seeks to optimize flight control techniques for manned and unmanned vehicles. Analytical and experimental studies of sensors, controllers, and actuation mechanisms are conducted in order to devise combinations which maximize probability of over-all mission success.

Exploitation of phenomena inherent in the space environment is pursued for control purposes. In the on-going program, the utilization of solar radiation pressure in combination with a momentum exchange device will be investigated as a device for controlling the orientation of a vehicle. The Ames Research Center has completed ground-based studies of a gravity-gradient vehicle orientation system which uses a single passive damper. Bearings, rods, and dampers for such vehicles have been developed. A technological flight test will be proposed for fully demonstrating the feasibility of a passive vehicle orientation system.

The work in controls has also emphasized no-wearing part control sensors and actuation devices, in order to obtain the greatest vehicle life reliability. A research program has been undertaken to increase the sensitivity and accuracy of these devices.

A no-moving part gas valve is being developed for micro-thrusters in the 2-6 micropound range, as a result of research completed in the past year related to the diffusion of hydrogen through a palladium alloy. Theoretical control research will be conducted, in addition to application of adaptive and optimal controls to specific classes of vehicles.

A portion of the manned controls research is related to the investigation of the control and display requirements for future space vehicles, where new and unexplored mission tasks are involved, such as rendezvous, lunar landing, and mid-course attitude control.

Much of the control systems effort is related to understanding man's operation as a control element, and development of a rational design procedure for manned systems. In fiscal year 1965, emphasis will be placed on testing of electronic and mathematical models of control tasks. It is also planned in fiscal year 1965 to examine quantitatively the effects of display dynamics upon the analytical manual control system models developed to date.

Communications Systems. Communications systems research provides technology to minimize spacecraft volume, weight and power devoted to the transmission of data. Present communications systems are prime consumers of spacecraft power and account for a significant percentage of the weight of the spacecraft. The communications systems research effort is directed towards solving this problem by exploring new technologies heretofore not employed for space communications.

To achieve this objective, the research emphasis is placed on submillimeter and optical technology, which, due to its shorter wavelength allows considerable reduction in physical size and weight of the associated components. Also, in electronic components, emphasis is placed on thin film and microelectronics which show promise of smaller size, weight, and power, as well as improved reliability and considerable immunity to radiation.

A laser signal transmission measurement program was initiated in fiscal year 1964 and will be continued in fiscal year 1965. This program will identify the atmospheric effects on the coherence character of radiation and will determine which new techniques or procedures can be employed to minimize such effects.

Submillimeter electromagnetic radiation has received little research attention directed towards communications; however, these frequencies offer considerable promise for deep space communications. During fiscal year 1965, the effort to improve the state-of-the-art in sources and detectors will be continued. Also, an effort will be initiated in radiation transmission measurements under realistic aerospace conditions.

NASA has initiated studies in fiscal year 1964 to determine the feasibility of achieving microelectronic micropower devices; that is, extremely small active and passive devices which perform conventional functions such as amplification, switching and digital logic at power level orders of magnitude below those in use today. A program will be initiated in fiscal year 1965 to fabricate prototype devices.

In fiscal year 1965, studies will be conducted into the pertinent applications of microelectronics in the Saturn V vehicle. Three subsystems have been selected which will be converted to microelectronics. These systems will be thoroughly tested, evaluated, and compared with the existing subsystems to determine the advantages that application of microelectronic techniques offer.

Tracking and Data Acquisition Systems. This research covers the development of technology that will enable more accurate ground determination of spacecraft orbital parameters, such as range, range rate and angular position.

Emphasis is placed on two approaches: optical tracking, which, theoretically, will enable orders of magnitude improvement in both range rate and angular data concerning the spacecraft; and large effective aperture antenna technology which will afford an improvement in the range and data acquisition capability of the ground based system.

Development of real time optical tracking technology will provide an accurate means of tracking during reentry and development of techniques, and will enable a greater portion of the data acquisition equipment to be located at the ground terminal.

The size of ground antennas or radiating aperture has a direct relation to data acquisition capability -- the larger the aperture the greater the capability. During fiscal year 1964, experimentation related to "signal combining" confirmed that arraying of individual apertures can be accomplished with the threshold of detection of the array lower than that of the individual antennas. As a result, a study has been initiated to determine the type of experimental facility that will be required in order to fully evaluate the technique and uncover the effects of the atmosphere on the signal combining procedure. This effort will be continued during fiscal year 1965.

The S-66, Polar Ionosphere Beacon Satellite, has optical corner reflectors which will enable considerable experimentation to be conducted in fiscal year 1965 on both non-cooperative tracking and ground based data acquisition.

Also in fiscal year 1965, laboratory experiments will be conducted on the feasibility of acquiring data, via optical techniques, without the use of a transmitter aboard the spacecraft. If this research verifies the theoretical calculations, then it will be possible to consider earth orbital satellites without transmitters with the attendant increase in reliability and performance of the satellite.

Research will continue on two basic problems associated with optical tracking -- precision position sensing techniques and precision control of the direction of a laser beam. In the former, the effort will be concerned primarily with the interferometric angle measurement techniques, which show promise of at least an order of magnitude improvement in accuracy. Precision closed-loop control research will utilize electro-optical techniques, which will allow complete electronic control of the laser beam.

Data Handling and Processing. In fiscal year 1965 work will be initiated on additional kinds of computer memory systems, notably those using continuous sheets of "ferrite" (magnetic ceramic) plates. Such investigations will produce memory systems having the capacity to retain large amounts of information, and capable of rapid data recall. On-board data processing capabilities, particularly where the handling of television images is concerned, will accordingly be greatly improved.

Research concerning systems and computer programs for the handling of television images is continuing. Work was begun on a new type of TV image-forming device employing thousands of light sensitive elements called "phototransistors". The response of each phototransistor can be determined by electronic means much simpler than the complex switching and synchronizing systems required for conventional TV electron beam scanning.

Television systems will be analyzed, the intent being the reduction of the burden on the communications channel, with some improvement in the image itself. Expected TV system improvements should soon make practicable direct, immediate viewing of the lunar surface or of other nearby objects - for example, artificial satellites.

New, advanced devices which facilitate direct, rapid communication between men and data processing complexes will be developed and tested. These include special keyboard devices, special displays, and appropriate computer programming and other required system developments. In addition to man-machine links, devices which improve communication among computers will be studied and improved.

Instrumentation. Anticipated requirements involve the development of instruments utilizing minimum power and yielding information in a form suitable for immediate use or digital computer processing. These devices must be reliable and precise, have adequate response speed, and be able to operate despite extremes of temperature and radiation levels.

Instruments will be needed to determine the characteristics of the atmosphere, electromagnetic environment, and gravitational and particle fields which surround the major bodies in the solar system.

One of the most difficult measurements is the determination of atmospheric pressure as we move away from Earth. Available devices are accurate in the lower part of the Earth's atmosphere, but are of questionable accuracy in the hard vacuum of deep space.

Present electromagnetic radiation sensors cover only narrow frequency bands. A series of units must be used to cover the optical-to-infrared-range. Broad-band radiation sensors will be developed to cover the complete range.

The physical condition of personnel in spacecraft and the essential life support systems will be monitored by biomedical instruments of optimum design, and must be integrated into the over-all space vehicle instrumentation.

Recently striking results have been achieved in the area of design and fabrication of miniaturized, completely self-contained, medical sensors. These can be applicable to biomedical instrumentation since they are easily attached to astronauts or animals, are self-powered, and transmit their information - concerning heart-beat and respiration, for example - to radio receivers which may be yards away. Such units, occupying a volume of only a small fraction of a cubic inch, were successfully tested.

A laboratory micro-balance was developed at Ames of such sensitivity that it has detected the pulsations of the heart of a developing embryo within a quail egg.

In fiscal year 1965, in addition to improvements in the miniaturized wireless sensors, studies will be initiated in the general area of sensing of the presence of non-terrestrial living organisms.

Engineering instruments are those sensors needed to acquire information concerning the behavior of the space systems themselves - the ground test facilities, the prototype or final versions of spacecraft during checkout, the launch systems, and the spacecraft in flight. Such information must be made immediately available to ground operations personnel and spacecraft crews - where such exist - during pre-launch, launch, and all post-launch phases.

In fiscal year 1965, NASA will place special emphasis on measurements at high vacuum. Application of the mass spectrometer to the problem of determining the composition of gas mixtures at extremely low pressures will be studied. The lowest pressures at which a gas molecule damped diaphragm pressure-measuring device may be used will be greatly reduced.

In addition, reductions in size and weight and increases in speed of response of devices making use of the "gas chromatography" principle will be accomplished. This technique should be of great value in the analysis of manned spacecraft artificial atmospheres.

In light of its general applicability to all instrumentation programs, attention will be given to new concepts in the digital transducer area. Solid state transducers present encouraging possibilities and will be emphasized in fiscal year 1965.

While the foregoing developments represent specific steps to be taken in fiscal year 1965, research will also be continued on instrumentation for high and low temperature measurement, force and torque measurement, and on particle detection devices of enhanced performance.

Small Flight Projects

	1963	1964	1965
Radio attenuation measurements (RAM)	$1,305,000	$2,000,000	$2,000,000
Scanner	110,000	1,800,000	1,000,000
Spacecraft orientation control system (SOCS)	121,000	---	---
Total costs	$1,536,000	$3,800,000	$3,000,000

Radio Attenuation Measurements (RAM). This flight project is designed to provide the flight experimentation and verification of the interaction of electromagnetic radiation with the ionized plasma generated by reentering spacecraft, and the evaluation of means whereby the effects of the plasma on radio waves may be minimized or eliminated. Flight experiments are essential to our understanding of the interaction of radio waves with plasma, as it is not possible to simulate the varying conditions encountered during reentry. Data obtained from flights conducted will supply the technological base upon which solutions to the communication black-out problem will be made for both manned and unmanned reentry at speeds of 25,000 feet per second and above.

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. A secondary objective is to develop a flight-proven technique for gathering statistical data, possibly in earth satellite spacecraft. The project is an extension of the current research on horizon characteristics. Two flight experiments are planned with an additional set of payload backup equipment and instrumentation provided. Technical advances in Scanner over previous experiments will be the use of star-mapping techniques to correlate sensor pointing directions with observed data, and the acquisition of extremely high resolution gradient data. Recent measurements at 14-16 microns indicate an independence from clouds and seasonal effects for this frequency band. Further study is necessary to verify the optimum frequency for horizon sensor development and application and to assess the spacecraft orientation accuracy attainable with horizon scanner techniques.

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY — HUMAN FACTOR SYSTEMS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

Future aerospace project successes depend upon the effective utilization of man, both space and ground based. The Human Factor Systems program is providing research supporting the successful consummation of these projects. Specific program objectives are (1) to obtain a better understanding of man's capabilities and limitation and to determine his utilization is advanced aerospace systems, (2) to obtain information which will be the basis for designs of systems for maintaining the high operating efficiency of crews during programmed and emergency phases of advanced aerospace missions, and (3) to determine overall human factor requirements and integrate them into the design of advanced aeronautical, astronautical and ground support systems.

The major program effort is located at Ames Research Center with participation by other NASA centers, other government agencies, universities and industry. The intra-NASA and Department of Defense-NASA review procedures for life sciences tasks avoid duplication of effort and provides a better balanced national life sciences program. Intra-agency coordination of supporting research and technology tasks is conducted through the Life Sciences Subpanel of the Supporting Research and Technology Panel, Aeronautics and Astronautics Coordinating Board. This across-the-board cooperative effort makes certain of a maximum utilization of current data and capabilities in the life sciences.

Future manned space missions depend on the effective, safe utilization of man for extended periods of time. Maximum reliability and safety, and minimum payload weight can be realized by utilizing man as a primary or backup component. Determination of the assignment of such tasks is dependent upon the physical condition of the crew, their performance and their ability to communicate. Throughout these missions, man will be subjected to a variety of natural and mission dependent environments such as vacuum, temperature, acceleration, weightlessness, radiation, and magnetic fields. We must know the physiological and psychological effects of each unique environmental factor, as well as the interaction of these factors to insure the effective integration of man as a part of the total system.

SUMMARY OF RESOURCES REQUIREMENTS:

Supporting Research and Technology

	1963	1964	1965
Supporting research and technology..................	$9,678,000	$13,200,000	$13,200,000
Flight program:			
Small biotechnology flight projects..................	112,000	---	3,000,000
Total costs..................	$9,790,000	$13,200,000	$16,200,000

BASIS OF FUND REQUIREMENTS:

	1963	1964	1965
Advanced concepts..............	$ 311,000	$1,053,000	$ 900,000
Human research and performance.	4,275,000	3,488,000	4,057,000
Life support and protective systems.....................	3,407,000	5,216,000	5,000,000
Man-systems integration	1,685,000	3,443,000	3,243,000
Total costs..................	$9,678,000	$13,200,000	$13,200,000

Advanced Concepts

Studies in advanced concepts analyze problems and their solutions in terms of concepts beyond the present state of scientific and technical art. Continuing fiscal year 1965 research in this area includes investigations in systems analysis, human analogs, and bionics. Bionics concerns the analysis of operating principles and of the construction of natural biological systems to determine what they may contribute to the science and technology of systems which include man. Other research includes investigations of cybernetic organisms (cyborgs) which involve the development of mechanisms which work like or may be combined with man. On the most elementary level, this science offers such devices as mechanical limbs which may be controlled as one controls his own limbs. Advanced concepts will offer auxiliary devices which will extend man's ability to perceive and act. For example, the electrical transmission of information to the auditory centers of the brain would bypass the ear entirely. Space suited astronauts would not need earphones; aircraft pilots could have unimpeded communications and yet be able to monitor the airborne sounds of their vehicle.

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Human Research and Performance

Space requires man to adapt to new environmental conditions such as zero gravity, zero or intense magnetic fields, variable degrees of ionizing radiation, various pressures and types of artificial atmospheres, relative social deprivation, and toxic effects resulting from contaminants. These environmental differences and their combinations are analyzed in terms of their effects on man's principal body systems; e.g., cardio-vascular, respiratory, central, nervous, gastro-intestinal, and endocrine. They are also analyzed in terms of effects on the whole man when living and working in the space environment. Research results will be used to establish design requirements for life support and protective systems and in determining the most effective utilization of man in future space missions.

In the hermetic space vehicle, many items not normally considered toxic or hazardous can create problems. For example, most plastic is characterized by a slow loss or evaporation of plasticizers or solvents. The closed air cycle of the space vehicle allows such air additives to concentrate, and reduced pressure in the vehicle accelerates such evaporations.

Toxic substances previously unknown are a potential hazard to ground personnel. New fuels are primarily the source of such exposures. An extensive toxicological program has been initiated.

Shielding systems using cryogenic super-conducting magnets offer protection from ionizing radiation with small weight penalty. Such systems, however, produce intense magnetic fields. Research is in progress to determine the effects of such fields on body chemistry and nerve conduction. Such fields have definite biological effects, but more intensive research is required.

Breathing systems using the conventional 5psi and 100% oxygen are unsatisfactory for long term exposure. Pure oxygen causes a number of toxic reactions to body tissue, and the combination of 100 % oxygen and low pressure causes lung deterioration. Further investigations are being conducted to determine the optimum gas pressure and mixture for long term use. Such data is a prerequisite for extended space flights.

Calcium loss from bones and reduction in vascular tone have been observed following brief periods of zero gravity exposure. An investigation is in progress to determine the extent of this problem and corrective measures to prevent or counteract its effects.

Life Support and Protective Systems

Life support and protective systems research has two major goals: (1) development of design concepts for life support equipment which can meet human requirements during long-term space flights, and (2) accumulation and validation of biotechnology data which can be used in the design of manned spacecraft and extra-vehicular systems. In equipment design, emphasis is on systems which require a minimum of auxiliary power, on regenerative systems which require a minimum of supplies, and on bio-instrumentation and associated data processing equipment for adaptive control systems. In design data studies, emphasis is on man's performance in a realistic space environment.

In fiscal year 1965 research in biotechnology will cover (1) work on advancing the state-of-the-art displays, specifically in analog types, which present man with unambiguous visual cues, (2) further surveys of existing psychological and environmental data to determine the validity of these data in the space environment, and, (3) bioinstrumentation and biodata processing equipment, including data display, to optimize man-machine integration and to minimize the work of the man in controlling his environment.

Some advanced display systems,to improve navigation and attitude control, will be flight tested. Ground based simulators using these advanced systems will be operated in conjunction with computers for solution of in flight visibility problems for all environments.

Work on protective systems will cover (1) preliminary designs of manned extravehicular locomotion and protective systems for both "zero-G" and lunar environments, (2) continuing studies on advanced space suits, and (3) preliminary studies on restraint equipment, radiation protection, support equipment, and escape systems applicable to earth orbital, lunar, and interplanetary missions.

Fiscal year 1965 effort will provide expanded laboratory testing of preliminary systems resulting from the advanced studies and feasibility experiments. Research center activity will be divided between Langley, Lewis and Ames.

Man-Systems Integration

Key activities in manned-system integration involve: (1) determining human engineering performance and engineering design criteria for use in design of future aerospace systems; (2) analyzing and simulating future possible aerospace missions to determine additional research requirements, design requirements, or possible experiments; and (3) implementing research experiments, through ground demonstrations and check out, which are intended to be flown in other flight programs.

Continuing efforts are aimed at improved safety in aircraft. Included are studies of pilots' ability and passenger comfort in flight through turbulent air, the abilities of pilots to react to sudden changes in control systems, or to abrupt changes in information input, such as transition between instrument and visual flight or from normal to emergency displays.

A contract effort, begun in fiscal year 1963, continues to investigate the ability of man to maintain space systems when wearing a space suit. The intent is to derive design criteria for space systems. Future investigations are planned to incorporate the zero-G environment. A specific investigation is being made as to the role man can play in maintaining or repairing nuclear power and propulsion systems. The role of man in reusable booster systems was investigated from a flight systems standpoint in fiscal year 1964; and continuation of this effort will be extended into the area of ground support, maintenance and turn-around.

Further investigation will determine design requirements for manned interplanetary and lunar base missions. These investigations will provide improved guidelines for research on subsystems. Mockups of potential payloads for advanced missions are being used in simulation studies of tasks and procedures.

Small Biotechnology Flight Projects

	1963	1964	1965
Small biotechnology flight projects........................	$112,000	---	$3,000,000

There is inadequate information concerning human reactions during, and supporting equipment needs for long duration manned flights. An orderly multi-phased approach utilizing fixed ground-based environmental and simulation facilities in conjunction with balloons, aircraft, ballistic rockets, satellites and manned space vehicles is necessary to provide the answers.

Small flight projects and experiments obtain data not possible through ground experimentation. Experiments will be included in ongoing flight projects as "piggy-back" payloads, where the flight characteristics and engineering design features are compatible.

Advances in sensing and data analysis techniques will be integrated in F104 and X-15 flights conducted at Flight Research Center to obtain improved psychological and physiological data. Biotechnology experiments, such as, heat transfer and fluid flow experiments will be integrated in biosatellite project flights to obtain data required for design of advanced space suits and life support systems. Experiments utilizing small mammals are being planned for integration with Saturn flights. These experiments demonstrate the effects of prolonged zero gravity (6 months or more) on the physiology and performance capacility of test subjects. The combined data from these small biotechnology flights will provide information on the effects of the space environment on humans, and will provide criteria for maximum utilization of man in future space systems.

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY — NUCLEAR ELECTRIC PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

Nuclear electric power generating systems offer the most practical sources of electric power in the kilowatt and megawatt levels for future spacecraft power. Nuclear electric propulsion systems have the highest performance potential of any system capable of development within the predictable future.

The nuclear electric program is intended to explore and evaluate the advantages and disadvantages, the limitations and problems of the various power and propulsion concepts and their subsystems, and develop the most promising concepts for mission use. The program covers: (1) technology development which includes gathering basic data for component design and component fabrication for evaluation in ground and flight facilities; and; (2) the development of selected systems.

SUMMARY OF RESOURCES REQUIREMENTS:

	1963	1964	1965
Supporting research and technology....................	$19,463,000	$24,600,000	$25,000,000
SNAP-8 development..............	15,994,000	15,500,000	18,000,000
Space electric rocket test (SERT)	3,188,000	4,000,000	5,100,000
Small nuclear electric propulsion and power flight projects.	1,248,000	600,000	---
Total costs..................	$39,893,000	$44,700,000	$48,100,000

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

	1963	1964	1965
Nuclear electric power	($9,084,000)	($12,600,000)	($13,000,000)
Space environment effects......	450,000	931,000	840,000
Liquid metal and metal vapor properties and technology....	2,640,000	3,517,000	3,900,000
Gaseous systems and components.	30,000	1,512,000	1,180,000

	1963	1964	1965
Dynamic systems and components.	$3,195,000	$3,336,000	$3,880,000
Direct conversion..............	1,700,000	1,694,000	1,700,000
Advanced concepts and mission analysis.....................	1,069,000	1,610,000	1,500,000
Electric propulsion	($10,379,000)	($12,000,000)	($12,000,000)
Electrostatic propulsion.......	6,997,000	5,662,000	5,700,000
Electrothermal propulsion......	1,298,000	1,623,000	1,700,000
Electromagnetic propulsion.....	1,092,000	2,330,000	2,500,000
Component technology...........	992,000	2,385,000	2,100,000
Total costs....................	$19,463,000	$24,600,000	$25,000,000

Nuclear Electric Power. The Nuclear Electric Power subprogram provides the technology needed for the design basis of the energy conversion equipment of advanced nuclear electric power generating systems. By "advanced" is meant systems which will be higher in power, lighter in weight, with longer operating lives than systems now being developed, such as SNAP-8. Advanced systems are required for both electric rocket propulsion and future auxiliary power applications.

Specific performance requirements will depend upon the specific applications; overall technology program goals are electrical power levels from hundreds of kilowatts to tens of megawatts, weights of less than twenty pounds per electrical kilowatt, and operating lives of years.

The Rankine cycle liquid metal turbogenerator systems, the Brayton cycle gas turbine type system, and the thermionic direct conversion type system are the principal approaches under investigation for conversion of thermal energy of electrical energy. Other concepts are being explored to a lesser extent for special applications, such as the Stirling piston engine concept for very low power use.

The technology program is being conducted for the most part under the technical direction of the Lewis Research Center, with a small supporting effort at the Jet Propulsion Laboratory.

Space Environment Effects. This technology area is concerned mainly with the space meteoroid problem as it effects radiator design. In the megawatt power range, armor needed for meteoroid protection has been estimated to be as much as 50 percent of the total radiator weight. Determinations of the mechanics of meteoroid penetration and the best approaches for protection are of first priority importance in providing long life, light weight electric power systems. The overall problem of space meteoroids, including all flight testing, is described in the Space Vehicle Systems program.

The environmental effects program consists of:

(1) Simulation of meteoroid impacts using hypervelocity particle accelerators. Simulated meteoroid impacts into targets of simple geometry have been conducted during fiscal year 1964. The results have established the damage mechanisms likely to occur in a real impact; such as dimpling, spalling, cratering, etc. Target configurations closely simulating space radiators are presently being studied. These include liquid-filled tubes, with varying thicknesses of armor and bumper configurations. In fiscal year 1965, additional radiator sections will be fabricated and extensive testing will be performed.

(2) Analytical studies to support the experimental meteoroid simulation program. Studies employing "blast wave" theory have demonstrated a capability of predicting the actual extent of damage using existing facilities as well as a method for predicting damage at actual meteoroid velocities which cannot be simulated in the laboratory. The work will continue in fiscal year 1965.

(3) Continuing examination of photographic and radar records of near-Earth meteoroids to improve the reliability of the meteoroid physical property and flux distribution data now available.

Radiators require ceramic coatings to improve the efficiency of the heat rejection (by radiation) process. Present programs have indicated a dozen promising coatings, some of which will be suitable for SNAP-8 and Surveyor flight radiator applications. Long term tests (up to 15,000 hours) have been conducted on four of these coatings. In fiscal year 1965, the performance of coatings at higher temperature levels will be established. Studies of techniques for applying beryllium armor to refractory metal alloy tubing and the development of diffusion barriers to prevent beryllium from altering the emissivity properties of the ceramic coatings discussed above will be started.

<u>Liquid Metal and Metal Vapor Properties and Technology</u>. This work deals with the materials problems associated with high temperature liquid metal systems and the accumulation of the thermophysical and transport properties of the alkali metal working fluids at the high temperature levels required for light weight systems.

The materials program includes:

(1) Accumulation of data on the physical properties of promising alloys.

(2) The development of suitable alloys of the refractory elements such as columbium and tantalum, for use as tubing and turbine materials as well as materials suitable for use in high temperature electrical generators.

(3) Welding and experimental fabrication studies of refractory alloys.

(4) Methods of improving chemical analysis techniques for determining the amounts of such impurities as oxygen in liquid metals, since corrosion rates and embrittlement are extremely sensitive to impurity levels.

(5) Corrosion testing with boiling alkali metal pumped loops and refluxing capsules.

Programs were started in all of the above areas in fiscal year 1963. Tests indicate that columbium base alloys are satisfactory for boiling potassium at 2,000 degrees Fahrenheit. By the end of fiscal year 1964 two columbium alloy pumped corrosion loops with liquid sodium will have been operated up to 2,000 degrees Fahrenheit for evaluating and endurance testing components such as valves, flow meters, pumps and heaters. A prototype corrosion test loop with boiling potassium is under construction and will be completed in fiscal year 1965. Alkali metal journal bearing materials are presently being evaluated and equipment is being constructed for measuring the friction and wear characteristics of candidate journal bearing materials in potassium at temperatures on the order of 1,600 degrees Fahrenheit. Similar friction and wear tests are planned for materials in high vacuum of 10^{-9} Torr over the same range of temperatures.

The dispersion hardened, tantalum-base alloy development program has resulted in initial alloy compositions which should exhibit high creep strengths up to 3,000 degrees Fahrenheit. All of these programs will continue in fiscal year 1965.

Prior to fiscal year 1963, little data was available concerning the thermodynamic, physical and transport properties of liquid metals at temperatures in the 1,500-2,000 degrees Fahrenheit range. A number of these properties for potassium are currently being obtained under contract. These are: liquid viscosity, liquid specific heat, vapor pressure, heat of vaporization and fusion, liquid thermal conductivity and pressure-volume-temperature relationships. An enthalpyentropy diagram and the vapor specific heat have been calculated from these data.

In fiscal year 1965 work will be completed on the vapor thermal conductivity and surface tension of potassium, plus most of the above properties for cesium.

Gaseous Systems and Components. The Brayton cycle gas turbine power system may be used with a space oriented fission reactor or isotope heat source. The inert gases, Neon, Argon and Krypton, are being studied for use as working fluids. The program consists of contracting for system components and subsystems with performance and endurance testing in-house. Three radial flow compressor-turbine packages were delivered in fiscal year 1964 and will be tested in fiscal year 1965. Additional axial flow equipment and electrical generator packages development has been started in mid-fiscal year 1964. The funds in fiscal year 1965 for the most part cover special test equipment plus construction of some higher temperature components.

Dynamic Systems and Components. Effort is concerned with the technology associated with the key components of turbogenerator systems of both the intermediate temperature (1,500 degrees Fahrenheit), superalloy and the high temperature (2,000 degrees Fahrenheit) refractory alloy types. These key components include alkali metal vapor turbines, pumps, liquid metal lubricated journal bearings, boilers, electrical generators, condensers and seals.

The first two full-scale potassium vapor turbine test facilities in this country were put in operation in fiscal year 1964 at General Electric, Cincinnati, and at Lewis. The contractor facility will provide performance tests with potassium and will be completed in fiscal year 1964 at the contractor facility. A one thousand hour endurance test to simulate erosive conditions will be started. The Lewis facility will be used to investigate design details of turbines.

Present programs have been concerned with obtaining the first data on the boiling and condensing of potassium in single tubes at temperatures up to 2,200 and 1,500 degrees Fahrenheit, respectively. Over 8,000 hours of boiling operations at temperatures above 1,500 degrees Fahrenheit have been accumulated. A multi-tube potassium boiler will be tested in fiscal year 1965.

Two facilities at Lewis are used to investigate liquid metal pump problems. Testing will continue in fiscal year 1965. The analytical phase of contract work on electromagnetic pumps was completed in fiscal year 1964, and construction of promising components and subsystems will begin in fiscal year 1965.

The first fully instrumented test rig for journal bearings utilizing water as the lubricant and operating in the flow region anticipated for space power conversion systems was completed in early fiscal year 1964. Adequate data to permit the evaluation of promising designs can be obtained in this rig. Six advanced journal bearing configurations have been evaluated experimentally. A liquid metal bearing test rig will be built in fiscal year 1965 for proof testing the bearings showing promise from the water test rig.

Work began in fiscal year 1964 to prove the endurance capabilities of a low power Stirling piston engine for use with either a radioisotope or solar energy source. This engine is theoretically more efficient than other energy conversion systems in the low power sizes. In fiscal year 1965, it is planned to initiate the design and construction of a radioisotope package for this engine and to design a power system with all its components, including pumps, radiator, and control elements.

Direct Conversion. The absence of rotating components, bearings, seals, etc., makes the direct conversion of heat to electricity potentially an attractive concept from the reliability standpoint. The major concept under investigation by NASA is the use of thermionic emitter systems. The

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major technological obstacle is the development of a satisfactory fuel element which can operate for a long time at a temperature level of 3,500 degrees Fahrenheit, a level far beyond the present state of the art. The work to date under contract has been concentrating on metallurgical studies of the compatibility of fuel and emitter materials. Compatibility, in terms of temperature limits for the refractory cladding materials, has been established for carbide and oxide fuels. In-pile tests have been conducted in the Vallecitos Test Reactor on a number of fuels. In fiscal year 1965, fueled diode testing will begin in the Plumbrook test reactor. In-pile tests of 5,000 hours equivalent operating life will be completed on the promising clad fuels. Work will continue on insulator and seals technology.

Advanced Concepts and Mission Analysis. Major effort deals with magnetohydrodynamic (MHD) approaches to electric power generation. Component investigations on a lithium-cesium liquid magnetohydrodynamic device are being done. Lewis is working in-house and under contract on single fluid Rankine magnetohydrodynamic systems. A program investigating an electrical generator concept using the direct conversion to electricity of the high energy particles emitted by radioisotopes is being supported.

To define the performance potential, technological problem areas, weights, and endurance, a number of power plant system studies have been performed which emphasize engineering detail rather than the parametric approach. Studies include work on systems for auxiliary power (100 kilowatt electric maximum) and propulsive power (1 to 5 megawatt electric). Analytical studies of this type will continue in fiscal year 1965.

Electrostatic Propulsion. This thrustor effort provides fundamental process and applied component research information necessary for the development of electrostatic thrustors in the range of a few tenth's of a pound to hundreds of pounds at specific impulses of 3,500 to 10,000 seconds or greater. Data is obtained on means of generating ions, on means of accelerating ions, on electrical theory relating to effects of building up a space charge, and on the composition and behavior of ion beams. Applied technology includes: the factors influencing fabrication of porous metal ion emitters; design considerations of electrical circuitry and components; design of propellant feed and storage components; selection of various materials for the construction of the different components; effects of scaling engine performance; size; clustering of low power engine modules into high power level engines; and instrumentation.

Investigations into the generation of ions by bringing cesium or mercury atoms in contact with a warm surface (surface contact ionization) will provide data and evaluation of the most suitable porous tungsten ion emitters. The condition of the ion emitters can limit the life of the ion engine. Two principal phenomena which influence the selection of the ion emitter material and design or fabrication techniques are: grain growth of the porous tungsten ionizer which can cause shrinkage and breakage of the ionizer or closure of the pores; and impurities, initially the cesium introduced by corrosion of that metal, in contact with hot cesium, which could affect the ionizer by means of a reduction in work function, oxidation or clogging of the feed system.

Preliminary results of recent studies indicate that tungsten made by sintering spherical particles may be an excellent ionizer. The program in fiscal year 1965 will provide more information to judge the qualities of spherical powder ionizers.

Work will continue to apply brazing and electron beam wielding techniques to the problem of attaining leak-free seals between the porous ion emitter and its support structure, particularly in larger ion engines.

A new type of surface contact ion source, one which operates at high current densities with simultaneous emission of ions and electrons, has demonstrated roughly an order magnitude increase in efficiency over other current sources. The present fiscal year 1964 and 1965 study is designed to improve the degree of ionization without undue power input increases, and to expand the resulting plasma to a density distribution from which the ions can be conveniently extracted and accelerated.

Several studies of means of generating ions through electron bombardment of targets are being continued to provide design information for the development of electron producing cathodes which will demonstrate high efficiency along with long life, and to examine the problem of extracting high intensity beams from the source. Other electron bombardment ion sources which produce high beam current densities with the promised long life are being investigated along with their associated accelerators.

Acceleration of ions without causing ion impact erosion of the accelerating electrodes is a problem area which is closely related to engine life. The research program in this area will be directed toward attaining long life by: studying means of improving the beam current density profile by developing improved electrode configurations, by analyzing and improving the ion optics, and finally by diverting ions toward noncritical areas. In addition a fundamental study on the sputtering erosion of accelerators is being conducted using electrode materials, propellants and voltage differences typical of ion engines.

One of the major questions regarding feasibility of ion engine operation in space is whether ion beams can be neutralized before leaving the engine thrust chamber exit. It is expected that final proof of this feasibility will be determined in the Space Electric Rocket Test I flight project. Studies are being continued in fiscal year 1965 of the fundamental phenomena involved and of the optimization of engine neutralizer systems.

Several colloid particle sources are being studied to obtain higher thrust per unit area than with conventional ion engines. The objective of these studies is to provide means of charging and accelerating previously prepared milli-micron size particles. Development of diagnostic instrumentation is being continued.

The objective of large ion engine experiments is to provide the information needed to develop engine systems (multi-kilowatt to 15 megawatts) capable of missions in cis-lunar and planetary space, and to explore and provide experimental confirmation of the problems involved in developing such large ion engines.

This effort includes development of contact ionization engines, and an electron bombardment ionization engine. The surface contact ion engine shows promise of yielding highest overall engine efficiency for values of specific impulse above about 7,000 seconds. Because of its high impulse capability, this type of engine is the most likely choice for ultimate use with lightweight electric power generating systems on interplanetary missions. The electron bombardment ion engine on the other hand offers the highest efficiency in the intermediate range of specific impulse from about 4,000 seconds up to 7,000 seconds, and is the most likely choice for use on early interplanetary missions.

To achieve reliable high power ion engines the building block technique is utilized, developing low power engine modules and scaling or clustering these modules into the high power (megawatt) level regime. This involves a four phase program: (1) the fabrication of small engine modules (approximately 1 kilowatt) for laboratory and flight evaluation (Space Electric Rocket Test I) of such basic problems as beam neutralization; (2) development of 3 kilowatt flight prototype modules for scaling or clustering to the 30 kilowatt size; (3) development and qualification of 30 kilowatt systems for determining scaling and system performance problems for reaching the next higher power level plateau (100 kilowatts to 1 megawatt); and (4) projecting the design criteria of the 30 kilowatt engine into the many megawatt power engine regime.

During Phase 1 and Phase 2, a circular strip surface contact ion engine was designed, fabricated and tested which provided 40 percent efficiency at a specific impulse of 4,500 seconds, impulse and 85% at 8,700 seconds impulse, and tested for more than 200 hours. This module was then scaled into a higher kilowatt power size. Studies have been conducted on other types of surface contact ion engines, such as the linear strip ion engine discussed last year, which present fewer engineering problems for scaling than the previously tested contact ion engines.

Also during Phase 2, a cesium electron bombardment engine was designed and developed which showed good performance between 4,500 and 7,000 seconds specific impulse. The most serious development problems of this engine type are: (1) ionization of a high percentage of propellant atoms with a minimum power utilization; (2) ion acceleration through the engine with a minimum of electrode erosion; (3) the requirement for 100 percent neutralization of the ion beam by injecting electrons from a cathode source into the beam at the accelerator exit so that the beam will leave the thrustor with a neutral charge; and (4) evelopment of materials for the ion emitter (ionizer) which will permit maximum propellant utilization efficiencies with minimum heat radiation losses.

The objective of small ion engine experiments is to develop thrustors with long life, with high reliability, and with the capability for a large number of restarts over a period of several months or years. Engine systems will be capable of being integrated in a three axis attitude control and station keeping system for various orbit missions. Thrustors will also be suitable for lifting or transfering small satellites from one orbit to another. The small ion engine will be initially designed for cyclic operation over a one year life span and ultimately for three to five years. Once these thrustors become available they will be placed on a flight simulator at the Goddard Space Flight Center to obtain system performance data over a range of station keeping attitude control missions requirements. These data will then be compared with other methods for station keeping attitude control to determine the most promising approach.

One small ion engine is scheduled for laboratory demonstration in September 1964. In fiscal year 1965, performance tests will be continued of the laboratory prototype system developed during fiscal year 1964. The development and engine test control and power elements will be performed and simulator facility tests will be conducted.

Electrothermal Propulsion. The objectives of this program are to advance the technology of electrothermal engines, so that efficient and reliable electric engine systems can be built in the specific impulse range of 700 to 2,500 seconds for a thrust range of tenths of a pound to possibly several hundreds of pounds, at power level range of a few kilowatts to possibly several megawatts. To achieve these objectives analytical and experimental studies are being conducted on components and basic processes, including electrode geometry required to generate the electric arc that heats the propellant; the process of converting electrical energy to thrust energy; the physical mechanisms which transfer heat from the propellant gases to the surrounding walls of the accelerator of electrodes; selection of propellants and methods for storing these propellants; and electrical circuitry (lightweight, efficient electronic components).

Electrothermal engines (including the arc jet and the resistojet) develop thrust by electrically heating a gaseous propellant, such as hydrogen, and expanding it through a nozzle. The difference between the arc jet and the resistojet concepts is the manner of propellant heating. In the arc jet the propellant is heated by passing it through an electric discharge, while in the resistojet the propellant is heated by passing it between electric resistance heated elements.

The objective of the small resistojet and arc jet engine experiments is to develop thrustors with long life and high reliability, and a capability for a large number of restarts over a period of several months or years. The engine systems will be capable of being integrated in a three axis attitude control and station keeping system for various orbit missions. The thrustors will also be able to lift or transfer small satellites from one orbit to another. Initial resistojet and arc jets will be capable of operating continuously for at least 90 days. Later resistojets and are jets will be designed for cyclic operation over one year and, ultimately, three to five year life spans.

The objective of large arc jet engine experiments is to develop experimental arc jet thrustors in the 30 kilowatt to 4 megawatts power range to provide the technology for scaling from small engines to sizes for future mission applications. The building block technique is being utilized, starting with the development of a 30 kilowatt engine capable of operating continuously for 90 days to several months. A 30 kilowatt DC engine has been designed and fabricated. This engine has been successfully demonstrated for 700 hours continuous running in a vacuum tank without any apparent electrode erosion, component deterioration or significant malfunctions. Engine efficiency was 45 percent at a specific impulse between 1,000 and 1,350 seconds. During fiscal year 1965 emphasis will be placed on performance improvement in an effort to attain high efficiency in the high specific impulse range (2,200 seconds) for the 250 kilowatt direct current arc jet engine.

Electromagnetic Propulsion Research. The program objective is to conduct feasibility studies of promising types of electromagnetic (MHD) engine system concepts for propulsion application, placing considerable effort on such areas as the physics of plasma production and acceleration processes. Included are analytical and experimental studies to determine the mechanisms which influence the conversion of electrical to dynamic energy, the transfer of heat to surrounding media, the coupling of ionized gases with its associated electric and magnetic fields to produce thrust, the selection of propellants, and the devising of methods for producing plasmas.

This engine concept develops thrust by accelerating a gaseous propellant plasma such as argon or hydrogen by coupled electric and magnetic field forces. The two general types of magnetohydrodynamic accelerators are pulsed and steady flow plasma accelerators which differ by the manner in which the electromagnetic forces that accelerate the plasma are created, and the manner in which the plasma is generated. These concepts show promise for covering the range of specific impulses from 700 to greater than 10,000 seconds.

Feasibility studies are being conducted on five different magnetohydrodynamic plasma accelerator concepts as follows: two different coaxial pulse type accelerators, a steady state Hall current accelerator, a microwave cyclotron resonance accelerator, and a traveling wave accelerator. Study of the fundamentals of electrical discharge in plasmas and the generation and acceleration of a plasma in a converging thrustor chamber is continuing; specifically, this study will cover the mechanisms of the initial breakdown of the propellant gas, electrical current intensification and localization within the gas, stability of the electrical discharge and current carry media through the plasma, and the coupling of the plasma with the electric and magnetic fields to produce magnetogasdynamic acceleration of the plasma. The intrinsic accelerator efficiency will then be determined.

The pulsed device now in operation shows potentialities of conversion to a high repetition rate continuous wave acceleration which should function like a steady flow machine. This would have considerable significance to space engine design, since the thrust levels attendant on steady flow acceleration would be considerably higher than for ion engines.

Laboratory data on the small (10 kilowatt) General Electric repetitively pulsed coaxial accelerator indicate power efficiencies of 40 to 45 percent at 6,000 seconds specific impulse. This concept shows promise for early electric propulsion application. The traveling wave magnetohydrodynamic accelerators also show potential for propulsion application.

Component Technology. Studies in this area provide parametric data which are required to make design trade-offs between the electric thrustors the power conditioning, switching equipment and the power supply system, to obtain optimum electric propulsion system capability. Analysis will define design requirements for components as influenced by potential mission requirements. Tests will be performed on electric propulsion system components, such as electronic components in their operating modes, and propellant storage and feed system components for long time periods in a zero G environment.

Investigations will be continued on mission applications for electric propulsion, in order to orient propulsion and vehicle requirements to research work and objectives. These studies must be continued and updated since experimental design and performance data continually change, thereby affecting the nature and results of the analysis.

SNAP-8 Development

	1963	1964	1965
Development and flight proj.	$15,994,000	$15,500,000	$18,000,000

SNAP-8

The objective of this project is to develop a 35 electrical kilowatt nuclear electric generating system suitable for space applications in the 1970's. The system must be capable of starting and operating continuously and without maintenance for 10,000 hours in the space environment. Future missions requiring electrical powers within single or multiple SNAP-8 design capability range from large orbiting space stations and lunar bases to manned and unmanned planetary probes and satellites. SNAP-8 is the only space power system under development in this power range.

SNAP-8 development is a joint National Aeronautics and Space Administration-Atomic Energy Commission program. NASA is responsible for development of the power conversion subsystem and its integration with the nuclear subsystem into a reliable electrical generating system. The nuclear subsystem, which includes the reactor, its control system and shielding, is the responsibility of the Atomic Energy Commission.

SNAP-8 utilizes a boiling mercury, turbogenerator cycle to convert thermal power developed by a compact space nuclear reactor into electrical power. The design approach places a major priority on reliability and ease of development rather than on light weight, and also considers flexibility to adapt with a minimum of change to a range of potential space missions. The program is presently planned through the ground development phase and includes in excess of 60,000 hours of non-nuclear and nuclear testing to develop the required reliability. Development of the space radiator required to reject waste heat from the power conversion process is deferred, pending assignment of a specific space mission.

During fiscal year 1964 the redesign of all major power conversion components to reflect the more conservative system concept has been completed. The fabrication of most components is well advanced, and the preliminary testing of some major components is underway. Supporting laboratory programs in materials and corrosion have been expanded to include long-term tests simulating both the reactor and power conversion loops. The SNAP-8 experimental reactor, the first major step in the Atomic Energy Commission reactor development program, after undergoing extensive nuclear physics tests at very low power, was brought to design power and temperature to obtain data necessary for the design of a flight-worthy reactor.

Accomplishments in the remainder of fiscal year 1964 will include the first testing of a fully-assembled turbine with hot mercury vapor, followed by initial testing of a complete SNAP-8 prototype power conversion subsystem at rated power conditions. The Atomic Energy Commission will complete power operation of the SNAP-8 experimental reactor. Design of the first prototype reactor will be nearing completion.

During fiscal year 1965 the project will concentrate on obtaining system performance of both the nuclear and non-nuclear subsystems in preparation for combined overall system operations. Test operations will commence on two complete SNAP-8 prototype power conversion subsystems for design verification, calibration, and evaluation work. Power conversion subsystem performance and start-up will be demonstrated and the first of four 10,000 hour endurance tests will be initiated. The Atomic Energy Commission will initiate power testing of the first prototype SNAP-8 space reactor. Preparations for the first nuclear testing of a complete prototype system in the Atomic Energy Commission Ground Prototype Facility at Santa Susana will be nearing completion.

Subsequent major project milestones as planned in joint National Aeronautics and Space Administration-Atomic Energy Commission coordination meetings are as follows:

(1) Complete 90 days of power conversion subsystem endurance testing utilizing prototype components in early calendar year 1965.

(2) The first integration of a complete electrical generation system and the first generation of nuclear electric power by a ground prototype SNAP-8 system at Atomic Energy Commission's Ground Prototype Test Facility in calendar year 1966.

(3) Complete first 10,000 hour endurance test of prototype SNAP-8 power conversion subsystem in calendar year 1967.

(4) Delivery of a flight prototype SNAP-8 system to NASA Plumbrook Space Propulsion Facility in calendar year 1967 for space simulation test.

Space Electric Rocket Test (SERT)

	1963	1964	1965
Spacecraft design, development and support............	$2,588,000	$4,000,000	$5,100,000
Launch vehicles...............	600,000	---	---
Total costs.................	$3,188,000	$4,000,000	$5,100,000

The purpose of the space electric rocket test flights is to provide required basic information on electric engines and electric engine systems not obtainable from experiments conducted in ground facilities.

All electric propulsion experimental investigations to date have taken place in ground vacuum chambers. During the initial experiments on ion engines, the problem of neutralizing the ion beam by the injection of electrons could not be fully investigated since electrons omitted from the vacuum chamber walls tended to automatically neutralize the beam. In later tests, the tank effects were eliminated and successful neutralization was limited to microseconds. Therefore, study of the neutralization problem over a longer period of time and demonstration that neutralization will occur in space is still required. In addition, such space environment factors as magnetic fields, cosmic and solar radiation, and absence of gas molecules may significantly alter the ionization and neutralization mechanisms of the engine.

Solving the neutralization question and correlation of tank data with flight data are the primary objectives of the Space Electric Rocket Test I ballistic flights now under active development. Space Electric Rocket Test I will be launched by the Scout vehicle for a ballistic flight time of approximately 50 minutes at altitudes above 250 miles. The capsule will be

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spin-stabilized. Changes in capsule spin rate caused by engine operation will be used to determine engine performance. The test time will be divided equally between a cesium contact-ionization engine and a mercury electron bombardment engine of different basic designs and utilizing different methods of beam neutralization.

The first complete capsule vibration survey was completed in April 1962. In fiscal year 1963 flight simulation tests of an integrated test capsule, with ion engines operating, were conducted utilizing the identical mobile launch instrumentation and equipment which is to be used during the flight. During these tests both engine power converters failed. Solution of this problem required a lengthy research and development ground test program, including repeated testing of the engines and redesigned converters in vacuum tanks. During fiscal year 1964 successful tests were conducted on the test capsule using the redesigned power converters through the complete flight sequence, including engines operating during capsule spin.

The results of the above tests will be factored into the final capsule and subsystem designs. The prototype and flight capsules will be assembled and ground tested under simulated flight conditions prior to launch.

Because Space Electric Rocket Test I indicated a greater need for data in the area of power converters, a research program was started in fiscal year 1964 to provide the technology for the design of reliable long-life converters. In addition, a ground test program will evaluate the performance capability of electric engine systems for use in station-keeping and attitude control systems before flight of the system.

In fiscal year 1965, Space Electric Rocket Test I launches will be completed. The ground test programs on power converters and evaluation of electric engines for station-keeping and attitude control systems will be well underway. The results from this work and from the electric propulsion effort will determine the necessity for further space electric rocket test flights.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1965 ESTIMATES

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY NUCLEAR ROCKETS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

This program provides the research, design and engineering data, test hardware, and general technology required to assure that nuclear rocket systems can be developed at the power levels, operating times, restart conditions, and specific impulse values needed in advanced space exploration missions.

It is generally accepted that nuclear rocket propulsion will be required in advanced missions beyond Apollo, such as a lunar logistics ferry, very heavy deep space instrumented probes, and manned exploration of the planets. This area of manned planetary expeditions is considered among the major applications for nuclear rockets; a nuclear rocket propelled Mars spacecraft can be 1/3 to 1/10 the weight of a chemically propelled spacecraft.

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

Nuclear reactor research and engineering work is of major importance, since this area constitutes the major new technology part of the program. In addition, emphasis is placed on non-reactor components whose operating requirements tax the available technology and on the study of the fundamental heat transfer, fluid flow, stress, and nuclear phenomena involved. An essential part of this program is work on experimental ground test engine systems to develop a full understanding of the interaction of components in nuclear rocket engines and of the system performance characteristics. These data form a basis for flight system development and provide information required by mission planners to incorporate nuclear capabilities in advanced missions. The effort is, therefore, directed to ultimate use in flight systems.

This is a joint Atomic Energy Commission-National Aeronautics and Space Administration program wherein the Atomic Energy Commission has primary responsibility for the nuclear reactor research and engineering work, and the National Aeronautics and Space Administration is responsible for the non-reactor components of the system, for combining the reactor and other components into engine systems, for vehicle development, and for providing propellants that are used throughout the program. The Space Nuclear Propulsion Office has been established by the Atomic Energy Commission and National Aeronautics and Space Administration agreement to manage all aspects of the nuclear rocket propulsion effort. The RIFT (Reactor-In-Flight-Test) vehicle system has been directed by National Aeronautics and Space Administration's Marshall Space Flight Center. Research and technology work in the nuclear rocket program is conducted both in Atomic Energy Commission and National Aeronautics and Space Administration laboratories, such as the Los Alamos Scientific Laboratory, Argonne National Laboratory, the Lewis Research Center, the Marshall Space Flight Center and also is conducted in industry and universities under contract.

SUMMARY OF RESOURCES REQUIREMENTS:

	1963	1964	1965
Supporting research and technology	$12,878,000	$21,200,000	$23,000,000
Kiwi	3,856,000	1,500,000	---
NERVA	41,884,000	52,000,000	34,500,000
RIFT	10,847,000	7,500,000	---
NRDS	---	500,000	500,000
Total costs	$69,465,000	$82,700,000	$58,000,000

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

	1963	1964	1965
Rocket reactor research	$7,607,000	$12,265,000	$13,100,000
Nuclear rocket engine component research	4,826,000	7,635,000	8,300,000
Safety	200,000	500,000	500,000
Vehicle technology	245,000	800,000	1,100,000
Total costs	$12,878,000	$21,200,000	$23,000,000

The supporting research and technology 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 on the special safety problems of nuclear rockets.

The Kiwi and NERVA technology projects represent work starting at a nominal 1,000 megawatt thermal power to serve as stepping stones to higher power, as well as to provide design information, hardware, and systems that could ultimately be developed as flight systems for use in space. To provide basic support to these current projects and to supply the necessary broad technological basis for design and development of future systems, a supporting research and technology program has been established to cover all the major technical areas involved with nuclear rocket engines and vehicles. The emphasis is on component research under the proper environmental conditions for the purpose of supplying design data and for extending available technology.

Rocket Reactor Research. The reactor is the key, new component of a nuclear rocket propulsion system. Because its principal function is to heat hydrogen to an extremely high temperature, the uranium fuel-bearing materials (fuel elements) in the reactor must operate close to their melting points. The materials for this purpose are selected from the most available refractory materials, and are materials whose properties and fabrication processes are not well known. The reactor is also required to operate reliably and stably through start-up, steady-state, shut-down, and restart. A total operating time of an hour or more is desired in some space applications. Reactor research is the primary responsibility of the Atomic Energy Commission and consists principally of the advanced graphite reactor work at Los Alamos. It also includes fast-tungsten reactor work at Argonne, some support of the water-moderated tungsten reactor concept, and supporting research and advanced concept projects such as cavity reactors at various laboratories.

NASA funds three activities under the heading of reactor research: (1) applied research on a tungsten reactor concept, the major part of which is done in-house; (2) a research program in specific problem areas in support of the graphite reactor development project and various advanced concepts; and, (3) the development and purchase of nozzles and liquid hydrogen feed systems (turbopumps) to support reactor tests at the Nuclear Rocket Development Station. The program is principally devoted to the investigation of the feasibility of a thermal, water-moderated, tungsten fuel element reactor concept proposed by the Lewis Research Center. Important continuing tasks include fabrication research to produce tungsten-uranium dioxide fuel elements of satisfactory strength and uniformity, prevention of fuel loss at the required operating conditions, development of a fuel element assembly with' acceptable thermal and neutronic behavior, and verification of properties through high-temperature testing in flowing hydrogen and nuclear radiation environments.

Some of the goals for fiscal year 1965 are: (1) complete definition of a reactor control system for the water-moderated tungsten reactor concept; (2) completion of the inital basic critical experiments; (3) in-reactor tests and electrically heated tests of promising fuel element configurations; and, (4) preparation for water and hydrogen flow systems tests in a cold flow engine simulator. The Lewis Research Center in-house effort is augmented by outside contracts, principally in the areas of fuel element fabrication, control analysis, and physics experiments.

The graphite reactor program is supported by National Aeronautics and Space Administration grants to Rensselaer Polytechnic Institute and the University of Arizona for studies in reactor control theory.

Advanced concept work is concentrated on various types of cavity reactors, in which the fissionable materials are in gaseous, liquid or dust form. NASA has a grant with Princeton University to investigate the fundamental problems of a liquid core rocket reactor. Gas core research is being conducted at Lewis Research Center and by industry contract. Smaller efforts in this area are also underway at Jet Propulsion Laboratory, Catholic University, and Case Institute of Technology. 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.

It is also NASA's responsibility to provide turbopumps and nozzles for reactor tests. NASA has been funding the development of a liquid hydrogen turbopump feed system to be used in the testing of high-power reactors at the Nuclear Rocket Development Station. This system is based on the liquid hydrogen pumps and turbines developed for Kiwi tests. System development tests on the operation of two feed systems in parallel are underway. Funds will be expanded in fiscal year 1965 to increase the flow capacity of this feed system to satisfy the pumping requirements for the high-power Phoebus reactor tests to be conducted at the Nuclear Rocket Development Station by Los Alamos.

Lewis Research Center has initiated a study of nozzles to support the Los Alamos Phoebus reactor program and to develop the technology of this essential area. One of the objectives of this study is to advise on the selection of a proper nozzle, in terms of performance, cost, reliability, and delivery date, that will meet the proposed schedule for Phoebus reactor tests at the Nuclear Rocket Development Station. Following the definition of the proper nozzle for the Phoebus reactor experiments, in fiscal year 1964, a contract will be let for the design and development of nozzles to support the high-power Phoebus reactor experiments.

<u>Nuclear Rocket Engine Component Research</u>. This research provides the necessary advanced component technology for nuclear rocket engines. This research coupled with rocket reactor research will provide information for specifying characteristics of future generations of nuclear rocket engines as well as establish 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.

Research is being conducted in the following areas: flow components and systems, turbomachinery, controls and instrumentation, design and analysis, radiation effects, nozzles, bearings and seals, and fluid property research. The activities in these areas, while aimed at certain engine types, are essentially oriented toward establishing and improving technology prior to incorporation into any engine project.

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. The means for pumping boiling cryogenic fluids is the goal of much general research on turbomachinery for both nuclear and chemical rockets. Nuclear radiation heats the hydrogen flow passages at the inlet to the hydrogen pump and causes increased boiling. During fiscal year 1964 a pump test rig at Lewis is being modified to simulate various inlet duct geometries with the capability for adding heat to the walls of these pipes. Tests commenced in fiscal year 1964 will continue during fiscal year 1965, with research and development costs incurred through the purchase of additional test hardware to cover a range of desirable operating conditions extending beyond NERVA requirements to higher pressure and flow conditions. In addition to in-house design studies of turbomachinery, some contract studies will be let in fiscal year 1965 to define further research and development problems and their solutions for advanced nuclear rockets.

Advances in nuclear rocket controls and instrumentation technology are required to provide reliable techniques for sensing operating conditions in order to permit reliable control of nuclear rocket engines. The requirements for startup of an entire reactor engine system in a very short time pose many unsolved control problems (complicated by intense radiation) such as adequate temperature sensing, chilldown control to prevent serious two-phase flow problems during startup, pump control to prevent cavitation, thrust control, restart programs, and control for economical and safe operation during cool-down after operation. Research is directed at means for engine control, and at providing control components such as sensors, actuators, and measurement signal conditioning devices. Promising approaches will be continued and expanded during fiscal year 1965 in this area of research, since it governs the progress that can be made in developing improved and reliable control systems. The experimental program on control systems is augmented by extensive analytical study of the startup sequence utilizing analog and digital computer systems acquired during prior fiscal years.

Engine design studies will be performed to establish power levels, engine cycles, chamber pressures, and other engine parameters required for high-power systems. Studies of mission and vehicle aspects will be supported to assist in establishing important features that should be incorporated into engine designs. In fiscal year 1965 design study of clustered engines will be conducted to define problem areas, development approaches, and facility requirements. This information is vital to proper planning of future nuclear rocket developments and mission capabilities.

The radiation effects effort conducted as part of the engine component research work is directed toward defining 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 design work. Work in this area was started in calendar year 1959 and is continuing in the Plum Brook reactor.

The combined environments of radiation, vacuum, extreme temperatures and very high bearing speeds create difficult development problems in regard to bearings, seals and lubrication. By the beginning of calendar year 1965 an in-pile bearing test loop will be in operation for research on bearing configurations in a combined radiation and cryogenic environment. Fiscal year 1965 funding will support completion of the in-pile bearing tester, the operation of the tests, and the acquisition of test hardware.

Research on nozzles for nuclear rocket engines is essential because current technology is extended close to the limit to provide a nozzle for the NERVA engine conditions. The next step is to explore novel designs and materials for fabrication of higher performance nozzles. Analysis and research have been undertaken in areas of refractory metals and coatings, fluid mechanics and heat transfer, stress analysis and thermal fatigue. These technology efforts will continue in fiscal year 1965. By the middle of fiscal year 1965 a hydrogen heat transfer facility will be in operation which will permit testing nozzle concepts in a hot hydrogen stream. Appropriate nozzle hardware must be procured for these tests to provide pertinent data for design of advanced engines.

Fluid property research is needed to provide basic data on propellants and fluids used in nuclear rockets and to supply a basic technology and consulting capability in cryogenic engineering. For several years, NASA has supported 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. This program will be continued in fiscal year 1965.

Safety. Safety work is an integral part of the overall Nuclear Rocket Program. It includes effort on hydrogen safety by the Bureau of Mines. This work is aimed at unique safety problems associated with handling large quantitites of liquid hydrogen in the nuclear radiation environment. Also included is work on evaluation of destruct systems in a radiation field to assure safe disposal of nuclear engines.

Vehicle Technology. Studies completed during fiscal year 1964 indicate that a nuclear rocket powered stage on a Saturn V vehicle could perform logistics support missions in the post-Apollo time period with significantly increased payload capabilities. Thus, the nuclear stage provides logical advances to extend the capabilities and usefulness of chemical systems. Additional mission studies are planned to provide definition of concepts for nuclear powered vehicles suitable for planetary scientific probes and manned vehicles for advanced mission applications. These studies would include stage requirements based on clustered nuclear rocket engines, as well as other concepts.

Investigation of stage problems peculiar to nuclear propulsion require continuing effort to provide design criteria and information not available from chemical systems technology programs. Specifically, this involves experimental investigations of heating of the hydrogen propellant by nuclear radiation. This type of work should lead to analytical approaches for solution of problems of reactor radiation heating on propellants, vehicle components, and tankage.

An additional stage problem peculiar to nuclear rockets is the effect of nuclear radiation on critical stage materials. Specifically, it is planned to conduct environmental testing (combined nuclear radiation and cryogenic temperatures) on stage insulation, vapor barrier, and bonding materials. Radiolytic off-gassing in particular will be checked because of its deleterious effect on insulation properties, adhesive properties, and strength.

Since nuclear rocket stages use considerable amounts of hydrogen propellants both during ground tests and flights, propellant loss due to "boil-off" from solar or nuclear heating, pressure build-up from liquid hydrogen evaporation, and tankage weight to withstand such pressure build-up can be significant. Preliminary analyses have shown that boil-off losses and tankage weights could be reduced markedly by use of "slush hydrogen". It is planned to investigate possible benefits and trade-offs resulting from use of "slush hydrogen" systems.

Kiwi

	1963	1964	1965
Reactor test support components....................	$2,556,000	---	$ ---
Propellants....................	1,300,000	$1,500,000	---
Total costs..................	$3,856,000	$1,500,000	$ ---

This project provided reactor test support components, such as nozzles and turbomachinery--and propellant support for the Kiwi test series of reactors designed by the Atomic Energy Commission's Los Alamos Scientific Laboratory. With the completion of Kiwi testing in fiscal year 1964, support of this project is terminated.

NERVA

	1963	1964	1965
Engine systems development.....	$5,829,000	$7,900,000	$3,500,000
Component and subsystems development..................	18,718,000	20,300,000	18,500,000
Propellants....................	1,984,000	3,000,000	3,000,000
Ground test and operations support.....................	15,353,000	20,800,000	9,500,000
Total costs..................	$41,884,000	$52,000,000	$34,500,000

The project objectives have been revised to constitute a NERVA technology development project as part of the Nuclear Rocket Program. This revised project maintains a continuing effort including emphasis on reactor engineering and sufficient engine testing to permit the United States at

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some future time to undertake with assurance, the development of nuclear rocket propulsion systems that will be needed for heavy payload, deep space missions.

This work is conducted as a joint Atomic Energy Commission-National Aeronautics and Space Administration effort by the Aerojet-General Corporation and the Westinghouse Electric Corporation under the direction and management of the AEC-NASA Space Nuclear Propulsion Office.

The program contains a reactor research and engineering program to provide reactor technology for the power levels, temperatures, operating times and operating cycles required for various nuclear rocket missions. It will allow assembly and testing of reactors with turbopumps, nozzles and suitable control systems into experimental ground test engine configurations to establish a base of information on the system design and operating characteristics. The experimental data from the reactor and engine system testing will permit advanced mission planning to consider the use of nuclear rockets, and the initiation of development, with assurance, of a nuclear rocket propulsion system at any required power level. It will lay the foundation from which the United States can proceed rapidly to develop the capabilities required for advanced missions.

Specific technical objectives for the NERVA technology project will be in the areas of reactor, engine systems, facilities and component technologies.

Reactor technology development will be based initially on full-scale reactor testing at the nominal 1,000 megawatt power level to determine the suitability of the reactor design both for continuing technology advancement, for use in obtaining engine system data, and for ultimate application to a flight system. Other objectives will include investigation of the overall performance capability of fuel elements and core structure, to include investigation of the trade-offs of such parameters as operating temperature, lifetime, and restart characteristics.

Engine system technology work will include transient investigations of engine system start-up characteristics, demonstration of typical operating cycles, the system dynamics of engine throttling, and an investigation of engine restart characteristics.

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

Selected engine components technology will be developed to support the engine systems technology efforts of system integration and evaluation. However, component development will be limited. Valves and lines will be facility "boiler plate" types wherever possible. Components will not have to be qualified to the high degree of reliability necessary for flight operation. Components such as turbopumps, nozzles with hot bleed ports, and actuators for engine reactor control will be developed to allow satisfactory operation when exposed to such extreme environments as nuclear rocket reactor radiation levels, liquid hydrogen cryogenic temperature, and high temperature hydrogen exhaust gas. The radiation environment will require a radiation effects program to prove component and instrumentation performance at high radiation levels before use in the more complex reactor and engine systems experiments.

Progress made to date has resulted in demonstration of the ability of a reactor to start up rapidly and operate stably using liquid hydrogen as the coolant; in redesign of the reactor support to avoid the flow induced vibrations that were previously encountered; in cold flow tests demonstrating that the general design approach does avoid such vibrations; in demonstration of the suitability of the reactor control approach used; in fabrication of good quality fuel elements which in laboratory testing meet required operating conditions; in development toward the achievement of a radiation resistant actuator for operation during reactor and engine tests; in advances in high speed bearing technology for application in hydrogen turbopumps; and in many other areas related to reactor, engine, and vehicle technology.

Engine System Development. The objective of this part of the NERVA effort is to perform the necessary system engineering, fabrication and testing leading to experimental engine configuration testing. This effort provides the data necessary for engine system integration and evaluation. In addition, this task includes the efforts necessary to coordinate and integrate the component and sub-system development as well as ground test and operations support efforts.

Cold flow tests with a non-nuclear engine simulator will be conducted prior to and concurrent with full-scale experimental nuclear engine system testing. This simulator will utilize the NERVA components planned for the experimental power engine system tests. Some of the major problems which will be investigated include the initial portion of engine start-up with liquid hydrogen, flow stability, flow leakage, system pressure losses, and control response times. In fiscal year 1965, the fabrication assembly, and thorough system checkout of the cold flow development test system will be completed and the test program initiated. Test data from the reactor test will be correlated with results from the engine simulator testing.

Component and Subsystem Development. This effort, supports the experimental reactor and ground test engine system testing. The task includes efforts on propellant feed system, thrust chamber assembly and controls. Feed system efforts will be directed towards obtaining a suitable centrifugal turbopump capable of providing propellant at required flow rate and pressure to the nozzle inlet. This turbopump will be designed to withstand the radiation levels caused by the reactor. Efforts will be minimal on other components in the feed system such as a tank shutoff valve, reactor cooldown valve and lines and disconnect assemblies. A radiation-resistant turbine power control valve will be developed. Efforts during fiscal year 1965 will include test programs to obtain performance characteristics of the turbopumps throughout its operating range. Additional radiation testing of turbopump bearings operated at design conditions will be undertaken and closely coordinated with work to be done at Lewis.

Efforts during fiscal year 1965 will include provision for pressure vessels, propellant inlet lines and nozzles necessary to support reactor experiments. Dynamic testing and structural testing of the thrust chamber assembly will be conducted. The nozzle will be subjected to long-duration chemical firings to evaluate performance and mechanical integrity.

The controls components being developed are the turbine power control valve, its actuator, and an engine system controller which controls turbo-pump and reactor operation. Development work during fiscal year 1965 will include irradiation testing of the actuator at its expected design conditions, analytical evaluation of the control system, and testing of control system hardware, both in the non-nuclear engine simulators and in the reactor experiments at the Nuclear Rocket Development Station.

A radiation effects effort will be conducted as part of the component development effort. The objective of this effort will be to evaluate the effect of the combined nuclear and cryogenic environment on the performance characteristics of engine components and systems. Irradiation tests of mechanical and electrical components will be conducted during fiscal year 1965.

Ground Test and Operations Support. This effort provides remote handling equipment, checkout and test equipment and handling and maintenance equipment for reactor and engine system test operations. Other subtasks of this effort include development, proof testing and provision of instrumentation for diagnostic and control purposes, reliability and quality assurance, and operational safety efforts. During fiscal year 1965, equipment necessary for engine support will be delivered to the Nuclear Rocket Development Station and proof testing and procurement of diagnostic instrumentation for engine system testing will be undertaken. Technical guidance on ground test safety will be continued and safeguard reports and procedures will be issued. Activation and checkout of Engine Test Stand No. 1 (ETS-1) and Engine Maintenance, Assembly and Disassembly Building (E-MAD) will be undertaken in fiscal year 1965. Reactor assembly and disassembly operations in E-MAD are planned for fiscal year 1965.

Propellants. This task area covers propellant procurement based on test schedules for the NERVA technology project required for reactor tests, non-nuclear component tests, engine simulator tests, etc. Over 90 per cent of the propellants procured will be liquid hydrogen.

RIFT

	1963	1964	1965
Stage development...........	$6,557,000	$3,700,000	$ ---
Development support.........	1,890,000	1,800,000	---
Program support.............	2,400,000	2,000,000	---
Total costs...............	$10,847,000	$7,500,000	$ ---

The RIFT Project was initiated to provide a vehicle for evaluating the operating characteristics of the NERVA engine and associated stage and engine sub-systems in the space flight environment. The vehicle was to be designed as a third stage for the Saturn V permitting the evaluation of stage operating characteristics in the physical, dynamic, radiation, and space environment required for deep space missions. This contract was terminated in December 1963. Vehicle technology work in fiscal year 1965 will be conducted only under Supporting Research and Technology programs.

The RIFT Project was paced by the reactor development work with no major full-scale hardware commitments permitted. The fiscal year 1963 effort was aimed at the definition of technical problem areas and the fiscal year 1964 effort is concentrated on establishing an integrated test program leading to solutions of the major identifiable technological problems. Initial testing has been conducted in the fields of structures, insulation, radiation effects, welding, and fabrication techniques. In addition to the preliminary design and testing work accomplished during fiscal year 1963 and in process during fiscal year 1964, design refinement was continued with an extensive effort in handling and transportation techniques. Almost all of the work performed in this project provides useful information for the chemical rockets now under development and will be available for use in eventual nuclear rocket flight applications.

Nuclear Rocket Development Station Operations

	1963	1964	1965
General site support...........	$ ---	$100,000	$100,000
Facility checkout and maintenance......................	---	350,000	350,000
Capital equipment.............	---	50,000	50,000
Total costs..................	$ ---	$500,000	$500,000

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 Los Alamos Scientifc Laboratory.

Technical support, maintenance, housekeeping, services, and management functions must be provided at this site. These funds provide for NASA's share of the general site operations; the major part is now an Atomic Energy Commission obligation.

General Site Support. These costs represent the NASA share of the support services for 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. In includes NASA's share of the cost for a support service contractor to maintain and operate various shops such as the plumbing, electrical, carpenter, welding and machine shops. Also included are the costs of activation of all facilities, maintenance and operation of support facilities and equipment. There are routine or recurring services. Cost specifically for test operation services requested by individual test contractors on a work order basis are not included. These test operation costs are budgeted through the respective NASA project manager's office.

Facility Checkout and Maintenance. All major facilities making up the reactor test facility complex are under construction. Modifications and additions to some facilities are under design or construction. Engine test facilities consisting of the Engine Test Stand #1 and the Engine-Maintenance and Disassembly Building will be activated during fiscal years 1965 and fiscal year 1966. Other facilities will be added as the program requires.

Capital Equipment. This represents the cost of equipment purchased by the Government for the use of Government and contractor personnel in carrying out station support activities, such as shop equipment and warehousing equipment.

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY — CHEMICAL PROPULSION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objectives of the chemical propulsion research and technology programs are to conduct research to increase knowledge of chemical propulsion processes, to investigate new concepts and techniques to advance the technology of chemical propulsion to meet the requirements for space exploration, and to support the mission office role in applying these technologies to the achievement of NASA's mission objectives.

The supporting research and technology objectives in chemical propulsion are to provide and to extend the knowledge that will increase the national capability to explore space. Although a principal part of this effort is directed toward future advances, an equally important part is to develop the engineering data that will apply to and aid in solving problems arising from projects under development.

Chemical propulsion is the prime mover in transporting payloads from Earth into space and in the space environment. It appears certain that chemical propulsion methods will continue to be used as prime movers for at least the next decade and as auxiliary propulsion devices when nuclear propulsion systems become operational.

The full potential of chemical rockets has not yet been exploited. Continued research and development will make possible the accomplishment of difficult missions not now programmed, as well as increasing the effectiveness of accomplishing missions such as flights to the Moon and operations in Earth orbit. Increases in performance by use of better propellants, more efficient engine cycles, and better integration of the engine with the total vehicle system have the potential not only of increasing the payload-carrying capability of our space vehicle systems but also of lowering the overall operational cost of fabricating and operating these systems.

In current NASA development programs, problems of inadequate engineering data or experience on which to judge the most appropriate solution have often been encountered. An example of this is the combustion instability problem in F-1 engine development, a matter which is now substantially in hand. Part of the research and technology program is to provide a sound engineering basis for the solution of such problems so that costly delays to development programs can be avoided.

The chemical propulsion supporting research and technology program is presented in five categories. These are: chemical propulsion research, high impulse propellant investigations, liquid rocket engine technologies, solid and hybrid rocket motor technologies, and experimental feasibility demonstrations of advanced systems. Chemical propulsion research includes analytical studies of propulsion systems, conceptual designs and cycle analysis, combustion phenomena including ignition and combustion oscillations, fluid mechanics, gas dynamics, heat transfer phenomena, and applicability of materials. High impulse propellant investigations cover examination of new propellants, determination of properties, theoretical calculation and experimental verification of performance, as well as actual engineering experience in dealing with such new materials. From this work will come the sound design criteria and engineering data for use in major engine development programs. This technology effort can be further subdivided in terms of its application, such as booster propulsion, upper stage propulsion, spacecraft propulsion, attitude control systems, retrothrust engines and the like. Experimental engine work is to demonstrate advanced concepts in a complete engine system prior to their application to specific mission objectives. This early development work will prevent the delays in mission accomplishment which result when the propulsion system development, a long-lead item, must wait for mission selection and approval. Included herein are the continuation of the M-1 engine project and the demonstration of large solid propellants motor feasibility.

SUMMARY OF RESOURCES REQUIREMENTS:

	1963	1964	1965
Supporting research and technology....................	$14,392,000	$21,800,000	$21,800,000
Experimental engines............	35,000,000	24,000,000	38,000,000
Small chemical propulsion flight projects...............	330,000	---	---
Total costs..................	$49,722,000	$45,800,000	$59,800,000

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

	1963	1964	1965
Analysis, aerothermochemistry...) Heat transfer and materials.....)	$3,095,000	$5,892,000	$5,933,000
High energy propellants.........	3,710,000	7,225,000	7,413,000
Liquid rocket engines...........	6,790,000	6,640,000	6,000,000
Solid rocket motors.............	797,000	2,043,000	2,404,000
Total costs....................	$14,392,000	$21,800,000	$21,800,000

Analysis, Aerothermochemistry, Heat Transfer and Materials

Analysis and conceptual design studies are conducted to identify problem areas, to compare competitive systems, and to guide future work.

For example, recent interest in an old idea - air thrust augmentation - has led to an analytical study of its advantages and some experimental work. A cooperative investigation between NASA and the Air Force has been established to examine the advantages of the air augmentation schemes as applied to the booster propulsion system in a practical flight.

In aerothermochemistry, a number of research projects are now underway in converting chemical energy to kinetic energy. In combustion, studies of combustion oscillations will be continued to provide design criteria for future engine development. Other work of a fundamental nature is the study of the kinetics of detonation waves and their relationship to combustion oscillations, and the examination of non-equilibrium flow processes in nozzles.

In solid rockets, research on burning rate and combustion processes includes ignition characteristics, the effect of rate of change of pressure on extinguishing combustion on surface burning rates, and other combustion phenomena.

More information will be sought on film cooling techniques used in conjunction with high temperature and ablative materials, with partial cooling by radiation in some cases.

High Energy Propellants

The program in high energy propellants was broadened last year to investigate three combinations: (1) addition of fluorine in oxygen to boost the performance of launch vehicles using oxygen-kerosene, (2) hydrogen-fluorine, and (3) oxygen difluoride and diborane. Investigations on fluorine additions to oxygen-kerosene show that performance gains up to 30 percent could be realized in vehicles such as Atlas. Investigations of compatibility of materials and the feasibility of using this additive in existing oxygen-kerosene engines is underway.

Hydrogen-fluorine work is underway on an experimental engine to be described on subsequent pages.

Performance of an oxygen difluoride-diborane engine of 2,000 pounds thrust is being investigated. Plans for additional work are underway to assess more completely the performance of this promising combination.

Work on other combinations is planned. These include propellant property studies, oxygen-fluorine or oxygen difluoride with light hydrocarbons, and metal additions.

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During the past year work was started on experiments with a turbo-pumped hydrogen-fluorine engine. The RL-10 engine already developed for use with hydrogen and oxygen was selected for the experiments. Some problems with material compatibility in rotating seals in the turbo pump have been encountered and work is underway to obtain improved seal materials. High energy fuel performance in the present engine will be limited by the oxidizer to fuel ratio that can be run. After pushing the limit operation of the present engine, additional work will be undertaken on new thrust chamber materials and pump modifications to reach higher mixture ratios which favor the high performance characteristics of the fluroine propellant.

A program to develop a gas generator for a hydrogen-fluorine engine has been started to provide a second possible approach to an advanced hydrogen-fluorine engine. This work will be continued and preliminary design studies of an advanced hydrogen-fluorine engine will be made based on the knowledge gained from this experimental engine work.

Liquid Rocket Engines

Work in this area is concerned with engineering studies of components, subsystems and systems for launch vehicles and spacecraft.

In launch vehicle propulsion, work has continued on high pressure engine technology as a promising approach to very large engines for first-stage propulsion. The increase of pressure to the order of 2,500 psi and higher introduces new engineering problems in, for example, bearings, and thrust chamber cooling. New combustion chamber concepts, such as the toroidal chamber - expansion nozzle skirt are being investigated. It is planned to scale model a toroidal chamber and gas-confined nozzle to test the performance of this combination. Another concept is a self-contained, high-pressure engine module designed to be used in multiple with a single nozzle. Work is planned on components of this type engine.

Spacecraft propulsion work is continuing on positive expulsion techniques for providing propellant to the engine during zero-g conditions. Combinations of positive expulsion of a portion of the propellant and simple pressurization of the tank under positive acceleration will be investigated. Gas pressurization generated by in-tank reaction processes will be studied. Effort will continue on the application of high temperature and ablative materials for chambers and nozzles and on techniques for varying thrust.

Solid Rocket Motors

Solid rocket motor technology is concerned with components, subsystems, and complete systems for both launch vehicles and spacecraft. Effort in this category is primarily directed towards research in propellant characteristics. Other work includes a continuation of studies of an internal support for very large grains. Also being continued are studies of improved methods of thrust vector control by use of hot gases which are supplied either by a gas generator or by a tap directly from the combustion chamber. A key component in this technique is a gas valve capable of operating at high temperature.

In the coming year more emphasis will be placed on research and technology applicable to very large boosters and problems associated with their use. This would include, for example, improving techniques of inspection and qualification of loaded motors, better understanding of instability and ignition problems, improved physical properties, clustering studies, and handling and transportation problems.

Spacecraft engine technology effort is concentrated in four areas. These are: (1) high propellant mass loading, (2) stop-restart capability, (3) hybrid system, and (4) packaged propulsion units for attitude control.

The goal of the program is the design of motors with a high percentage of propellant. Another part of this work is obtaining longer nozzle life through partially submerging or recessing, or through establishment of a cool boundary layer.

A significant achievement during the past year has been the demonstration of accurate thrust termination control by two techniques: rapid venting, and control of chamber volume. These and other techniques are being investigated to achieve stop/start control and recycling capabilities.

Hybrid motor systems offer promise in both launch vehicle and spacecraft applications. These are systems where the fuel is a solid and the oxidizer is introduced as a liquid. Conceptual design studies for space applications are completed and experimental work to demonstrate the feasibility of hybrid propulsion for a spacecraft engine will be initiated.

Ideas for using solids for small propulsion units for attitude control have been examined. One is the use of a series of miniature and expendable solid rocket units to generate small increments of impulse as needed. This work will be extended to flight experiments aboard a TIROS satellite. The second idea is the use of a subliming solid wherein the solid is transformed into gas for propulsion thru the application of heat. These units hold the promise of high reliability as well as long storage time and life.

Experimental Engines

	1963	1964	1965
Large solid motor demonstration.	---*	---*	$13,000,000
M-1 engine......................	$35,000,000	$24,000,000	25,000,000
Total costs...................	$35,000,000	$24,000,000	$38,000,000

* Previously an Air Force program.

Large Solid Motor Demonstration

The large solid propellant rocket motor feasibility demonstration was initiated by NASA and the Air Force in June 1963; it includes both 260" diameter and 156" diameter solid propellant motors.

In November 1963, the Department of Defense requested that NASA fund the 260" class motor program in fiscal year 1965 and thereafter, with the Department of Defense continuing to fund the 156" portion.

In fiscal year 1963 and 1964, the Department of Defense obligated almost $30,000,000 to the 260" motor program. The fiscal year 1965 NASA request is based on a Department of Defense estimate of the amount required to complete the current phase of the 260" motor program. Transfer of the direct management and funding responsibilities for this program to the NASA will allow closer coordination between the demonstration firing program and the solid motor launch vehicle studies currently in progress, to evaluate such vehicles as:

1. Solid stage plus an S-IVB stage.
2. Solid boost assist for the Saturn IB vehicle.
3. Solid boost assist for a Saturn V vehicle.
4. First stage for post Saturn vehicle.

Efforts on this project through fiscal year 1964 will include completing engineering, propellant tailoring, 44" and 65" motor tests, and fabrication and checkout of full scale hardware.

In fiscal year 1965 a two-part effort to complete the current phase of the 260" motor program will be accomplished. The first part is for two parallel projects to design, fabricate, and static test two 260" diameter motors each weighing about 1,800,000 pounds and generating 3,000,000 pounds of thrust for about 110 seconds. The second part covers design, fabrication, and static test of a 900,000 pound 156" diameter motor, to prove a 3,000,000 pound thrust nozzle (same as used on the 260" diameter motor) for a 50-second burning time, plus proof of the fabrication procedure applicable to the 260" diameter motor utilizing a grain configuration and igniter similar to the 260" size. In addition, a 120" motor for component evaluation of the Aerojet program will be completed in fiscal year 1965.

M-I Engine

The M-1 turbopump fed rocket engine is being developed for single or multiple use in upper stages of large launch vehicles. This engine will develop 1,500,000 pounds of thrust, using liquid hydrogen-liquid oxygen propellants.

Development of the prototype engine began in 1962, and is under the technical direction of the Lewis Research Center. The components of the M-1 engine are of a new magnitude in size for hydrogen engines, and will be tested as a system to verify their design and to develop criteria for the design, test and retest cycle.

During fiscal year 1965, the program will emphasize component testing, with a limited effort in engine systems. Most design effort will be completed, and the testing of many major components begun. The majority of sub-scale tests will be near completion. Versions of the liquid oxygen pump and fuel pump, both at 3/8 scale, will be tested.

At Lewis, cold-air tests of fuel and liquid oxygen (LOX) turbines will be performed to determine the aerodynamic performance, range of operation, and flow distortions. Full-scale testing of the fuel and LOX pumps as separate components, and as a system connected in series will be started.

Other test programs to be initiated involve vibration tests of thrust chamber components, and general testing of the thrust chamber and gas generator igniters.

Several testing programs will be continued in fiscal year 1965. These include tests of full-scale injectors, gas generators, and interconnect lines.

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY — **SPACE POWER PROGRAM**

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Space Power program provides research and technology to advance our knowledge, by providing new and improved methods of chemical and solar power generation for space exploration. The program includes all elements of complete systems such as: (1) the energy collection equipment (solar collector) or reactant supply; (2) the prime converter (i.e., solar cells, thermionic generators, thermoelectric converter, fuel cell, etc.); (3) the energy storage system (battery or thermal energy storage material); and (4) power conditioning equipment devices and switch-gear. In addition to the more basic work, part of the effort is directed at development of improved devices and demonstration of the feasibility of advanced systems, including, when necessary, flight demonstration.

All space vehicles use electrical energy for the operation of their equipment, such as communications, telemetry, life support, and instrumentation. Thus, this multi-disciplined program makes a direct contribution to a broad cross-section of the national space program. The energy source for space power systems may be chemical, solar, or nuclear; this program deals with methods of obtaining energy from the first two sources. Work on power generation using nuclear energy sources is covered under Nuclear Electric Systems.

The electrical power for space vehicles and the total time this power is needed varies widely. The power levels vary from a few watts to many kilowatts and durations from a few minutes for a launch vehicle to goals of several years for space vehicles. This wide range of applications requires a number of power generation techniques, each with its own capabilities and limitations.

As launch vehicle capabilities increase, making possible more complex spacecraft, it is essential that the technology in the power generation field not become a limiting factor. All systems experience to date has been at rather low power levels.

Many problems also remain to be solved in the types of systems presently being used to improve reliability and life as well as to reduce weight and volume requirements. This work is needed to develop equipment and the knowledge needed to avoid failures such as those in the past associated with the adverse effects of the space environment (i.e., the Van Allen belt, solar flare radiation, ultraviolet degration, and high and low temperature effects).

SUMMARY OF RESOURCES REQUIREMENTS:

	1963	1964	1965
Supporting research and technology	$8,335,000	$13,000,000	$13,000,000
Total costs	$8,335,000	$13,000,000	$13,000,000

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

	1963	1964	1965
Photovoltaics	$2,141,000	$2,750,000	$2,750,000
Thermionics and thermoelectric	1,872,000	1,750,000	1,750,000
Solar dynamic systems	1,660,000	4,850,000	4,850,000
Batteries, fuel cells and engines	2,662,000	3,650,000	3,650,000
Total costs	$8,335,000	$13,000,000	$13,000,000

Photovoltaics. Solar cells are the most common energy-conversion devices used in space. Significant progress has been made on cells which resist radiation damage and in obtaining a fundamental understanding of the mechanism of damage. Cells currently in production have benefited from the research program and have three times the useful life in the radiation belts compared to cells in use a year ago. During this year, experiments were conducted on special silicone cells which are 12 times more resistant to such damage as the reference cells. This work will continue so that the advantages can be fully exploited in flight programs.

Progress has also been made on thin film solar cells which are very light and flexible. A contractor production facility has been established to produce experimental quantities of 6" by 6" cadmium sulfide thin-film cells. A program has been initiated to evaluate the simulated environmental effects of space on these advanced devices, a necessary first step before practical application. Studies are also being conducted on techniques of deploying large arrays of these cells for multi-kilowatt systems. The anticipated results are considerably lower costs, improved mechanical characteristics, and better stability in the space environment.

Work will be continued to develop solar cells for high and low-temperature applications. More payload and greater reliability are anticipated.

Thermionics and Thermoelectrics. The direct conversion of heat energy to electricity by the thermionic process continues to show great promise. The development of a prototype, solar-heated, thermionic system with all of its elements shows significant progress. Efforts extend from basic research on materials and metallurgy, through physics and thermionic generation, to engineering development of thermionic devices.

Improvements in thermionic converter design have extended converter life from 1,000 hours or less to more than 3,000 hours in tests presently underway. Alternate designs have been explored, and multi-converter generators have been fabricated and tested with both electrical and solar heating. This effort will be continued in fiscal year 1965.

It is desirable to keep a thermionic system operating during dark periods in orbit, by supplying heat energy stored during sunlight to avoid thermal cycling. Fundamental information has been obtained on thermal storage materials, such as thermal conductivity and heat of fusion. The whole thermal storage area will receive increased attention in the coming year, because of its great promise for solar-thermionic and dynamic systems with long life and low weight.

Important progress has been made on the development of fabrication technique for solar collectors. Work on a 9.5 foot diameter high precision mirror master by spin casting offers a solution to extending this technology to mirrors larger than 5 feet. A successful plastic submaster was produced and reproduced in nickel. A test mirror made from the nickel master is undergoing tests.

The feasibility of power systems based on thermoelectric conversion of heat is also under investigation. An example of work in this area is a flat sandwich panel with thermoelectric couples between the skins. One skin is treated with a coating to produce a high equilibrium temperature when exposed to sunlight, while the other surface runs at a much lower temperature as it faces black space. Progress has been made in this technique, and the work has been supported by research on improved thermoelectric materials. Effort in this area will continue.

Solar Dynamic Systems. A significant milestone was reached in the solar mercury Rankine cycle system (Sunflower) this year with the successful completion of a life test with an accumulated time of 4,300 hours. The test was terminated by test-rig problems rather than any basic fault in the machine. While many problems remain to be solved, the feasibility of this system concept has been demonstrated.

Work was also started on an alternate approach to dynamic power conversion, based on a gas (Brayton) cycle, which is expected to have higher efficiency and hence produce more power from a given size solar collector, if the expected component performance can be achieved. It is planned to continue development of this system to a point where a selection can be made between the alternate approaches. Solar dynamic systems are expected to be most useful in the range of power of a few kilowatts to tens of kilowatts. Applications may come late in this decade, and hence an aggressive program is required at this time.

Batteries, Fuel Cells, and Engines. Much progress has been made in this area. For example, a new type of sealed, rechargeable battery has been developed. This device includes a fuel-cell oxygen electrode which reduces pressure build-up to a safe level, and provides an external signal at the completion of charge, facilitating charge control. This advance is expected to improve the life and reliability of space batteries and significantly reduce their weight for many applications. Testing required to provide the engineering data needed by applications engineers is planned for next year.

To determine the basic limitations in fuel cell life and reliability and find ways of extending them are the goals of much of the work. Important development work has been accomplished this year on an improved H2/02 fuel cell of moderate temperature. The system is simplified and uses materials which should have longer life. Work needs to be done to verify these improvements. Effort to date has been on an open-cycle system (product water vented to space); work will be done on the application of the basic equipment in a closed cycle and tests of the endurance of the components.

Progress has been made on other fuel cell tasks, including the development of inorganic ion-exchange membranes (electrolyte and separator) which should have longer life than the organic type now being used. Studies of fuel cells as biochemical reactors for processing human wastes are also underway. Much work remains to be done in these areas, now at the basic research stage.

An experimental hydrogen-oxygen internal combustion engine designed for operation in space has been operating successfully. Potential applications include mechanical, hydraulic and emergency electric power generation. In fiscal year 1965, effort will be concentrated on improved engine efficiency.

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OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY AERONAUTICS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objective of the Aeronautics program is to conduct the research necessary to generate information for the design, construction, and operation of advanced aeronautical vehicles. This research program supports current and projected civil and military requirements and helps to maintain United States leadership in these fields.

Research is carried on in the technical disciplines of aerodynamics, loads and structures, propulsion, and operating problems. This research has provided the information and technology for such advanced vehicles as the F-111 (TFX), the tri-service XL-142, and the supersonic transport.

The detailed research program will continue at the Langley, Ames, Lewis and Flight Research Centers, in support of the supersonic transport program. It is the National Aeronautics and Space Administration's responsibility to provide the required research information and technical support to enable industry to build a reliable, economical, safe, and publicly acceptable commercial supersonic transport.

In advanced aeronautical research, manned hypersonic air-breathing vehicles are being investigated. Such vehicles have the potential of providing hypersonic reconnaissance capabilities, hypersonic transport, and recoverable hypersonic air-breathing space boosters.

Studies of vertical and short take-off and landing aircraft (V/STOL) will continue in fiscal year 1965, with particular emphasis on high-speed jet-powered types and those types nearing military operational status.

Research in basic areas includes studies of new materials for airframes requiring long duration, high temperature operations; studies of high temperature air-breathing engine components which will increase engine efficiency and economy; studies of noise to gain a better understanding of its origin and means of alleviating it; studies of the boundary layer and boundary-layer control to reduce drag; studies of structural concepts to provide reliable light-weight structures; and studies of air-breathing propulsion cycles and engine components to increase efficiency and permit the design of efficient light-weight engines for V/STOL aircraft, supersonic transport, and hypersonic aircraft.

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 cognizant government agencies.

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

SUMMARY OF RESOURCES REQUIREMENTS:

	1963	1964	1965
Supporting research and technology....................	$6,580,000	$8,900,000	$9,400,000
X-15A..........................	5,580,000	900,000	900,000
Supersonic transport............	2,513,000	10,200,000	24,700,000
V/STOL.........................	925,000	2,100,000	2,000,000
Total costs..................	$15,598,000	$22,100,000	$37,000,000

BASIS OF FUND REQUIREMENTS:

Supporting Research and Technology

	1963	1964	1965
Aircraft aerodynamics...........	$879,000	$1,500,000	$1,900,000
Aircraft loads and structures...	1,510,000	1,600,000	1,700,000
Air-breathing propulsion........	1,519,000	2,520,000	3,290,000
Aircraft operating problems.....	2,672,000	3,280,000	2,510,000
Total costs..................	$6,580,000	$8,900,000	$9,400,000

Aircraft Aerodynamics

Aircraft aerodynamics relates to the performance, stability, and control of manned vehicles during sustained atmospheric flight. This program is a continuing one directed toward improvements in subsonic, supersonic and hypersonic airplanes.

In fiscal year 1965 there will be an increased effort in hypersonic aerodynamics and aerodynamic configurations for hypersonic air-breathing vehicles now that their aerodynamic feasibility has been established.

Further increases in overall aerodynamic efficiency are needed to produce an economic, profitable United States supersonic transport. Research in this area will be increased by exploring all possible means of increasing lift and decreasing drag at supersonic-cruise speeds, and by investigating advanced configuration concepts to improve range and payload.

Recent wind tunnel and flight research on V/STOL aircraft has placed greater emphasis on the stability and control during hovering and transition of higher-performance jet-powered types. General as well as detailed configuration studies with models and man-carrying test-bed aircraft will be carried on in order to provide a better understanding of jet-interference flows and how to avoid undersirable effects on control during the V/STOL mode of operation.

In the helicopter area, the aerodynamics of high speed rotors is being studied by industry contract. Increased attention will be devoted to the compound helicopter which utilizes auxiliary wings, in addition to rotors, in order to increase limited range and endurance.

Included in these estimates, as in the past, are funds for wind tunnel and related studies in direct support of the development of military aircraft and missile systems.

Loads and Structures

The design of efficient and reliable aircraft structures is dependent upon the loads and heating which the structure must withstand, the physical properties of the material used, structural techniques, and improved methods of design analysis, including dynamic effects.

An important problem in aircraft design is fatigue, which has the characteristic of fracturing or weakening of structural materials under a relatively small load, if this load is applied a large number of times. For aircraft which will operate at supersonic speeds, aerodynamic heating introduces complicating factors into the fatigue problem. This heating degrades the properties of the commonly used aluminum alloys and places emphasis on heat-resistant materials such as stainless steels or titanium alloys. During fiscal year 1965 extensive research will evaluate the fatigue properties of structural specimens utilizing heat resistant alloys.

It is expected that by fiscal year 1965 the structural configuration and characteristics of the supersonic transport will be broadly established. Analytical and wind tunnel investigations will be conducted to evaluate structural designs. Additional studies will be required to establish flutter characteristics.

Those aircraft designs proposed for hypersonic aircraft which employ hydrogen as a fuel present formidable structural problems. A particularly severe problem is the design of that hydrogen tankage which is exposed to high temperatures on the outside and cryogenic temperatures on the inside. During fiscal years 1963 and 1964 studies of refractory metals and design concepts culminated in the construction of a sizeable specimen of tankage structure for testing under realistic temperature conditions. This structure will be studied experimentally during fiscal year 1965, with realistic heating and loading, in a high temperature hypersonic wind tunnel at the Langley Research Center.

Air-breathing Propulsion

The air-breathing propulsion program supplies the basic and applied research information required in the development and planning of both military and commercial aircraft. New and existing propulsion systems will be analyzed to determine potential improvements which can be realized, and engine component modifications will be studied to determine inter-related effects throughout the system. Air inlets and exhaust nozzles will be investigated experimentally to provide future design criteria for supersonic aircraft.

Research in the hypersonic propulsion regime will include basic boundary-layer and shock-wave-interaction studies to define the pressure and temperature fields existing in a hypersonic inlet. Studies will provide information on the operation of hypersonic inlets at off-design conditions. Necessary data on supersonic mixing and combustion will be obtained.

Aircraft Operating Problems

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

Spin entry mechanics will be studied to improve prediction of an airplane's tendency to enter spins. Dynamic model tests will be run on specific airplane models, such as the TFX and several executive types. These aircraft will be flight tested to evaluate their stability characteristics in the spiral mode.

A Lockheed Jetstar aircraft, purchased in fiscal year 1963, is being equipped to simulate in flight the stability, control, and performance characteristics of a variety of advanced airplanes. The flight test phase of this program will be initiated in fiscal year 1965.

Jet engine noise research continues to obtain information on the contribution of the exhaust jets and other components to the total noise level. On-going flight and wind tunnel tests and analytical work are directed toward minimizing sonic booms for projected supersonic transport configurations, and determining atmospheric effects on boom intensity and propagation.

A variety of aircraft are being tested to develop steep approach techniques to alleviate the airport noise problem. Helicopters, V/STOL, and conventional aircraft are being used under simulated IFR (Instrument Flight Rules) conditions to determine information requirements for landing under all weather conditions.

To improve ground directional stability during take offs and landings, experimental investigations will be made to determine tire corner force during high speed braked and unbraked rolling on wet and dry runway surfaces. Several runway additives will be investigated to ascertain their effectiveness.

X-15 Research Aircraft

	1963	1964	1965
Aerodynamics....................	$35,000	$32,000	$30,000
Loads and structures...........	60,000	1,000	95,000
Propulsion......................	10,000	10,000	25,000
Operating Problems..............	5,475,000	857,000	750,000
Total costs..................	$5,580,000	$900,000	$900,000

As the X-15 program has progressed, new problems have been defined in the areas of structures, stability, control, heating, and operation. The X-15 aircraft will continue to be used to obtain additional vitally needed research data in the areas of air-breathing propulsion, aerodynamics, and structures. The X-15 is the only vehicle available to obtain this information. The X-15A-2 airplane, which was damaged during an emergency landing, is being repaired and modified to increase its performance capability. This modification will provide a design mission of Mach eight, at an altitude of 100,000 feet. This will permit extension of basic investigations, especially aerodynamic heating. The first flight of the modified X-15 should be made near the end of fiscal year 1964.

Supersonic Transport

	1963	1964	1965
Aerodynamics....................	$392,000	$967,000	$1,810,000
Loads and structures...........	612,000	930,000	790,000
Propulsion......................	342,000	1,389,000	19,500,000
Operating problems..............	1,167,000	6,914,000	2,600,000
Total costs..................	$2,513,000	$10,200,000	$24,700,000

The National Aeronautics and Space Administration's role is to provide the research information necessary to meet the goals of the project. Work in various areas will be intensified in fiscal year 1965. Work in fiscal year 1965 will be concentrated mainly on improvements in the areas of propulsion, aerodynamic efficiency, dynamic stability, noise, sonic boom, and structural materials.

The increase in funds requested for fiscal year 1965 for supersonic transport research reflects the need for continued research on propulsion systems to provide the advanced power plants that will be needed for future operational supersonic transports and for follow-on vehicles. In prior years, fiscal years 1962 and 1963, funds were procured by the Federal Aviation Agency for a joint Federal Aviation Agency-National Aeronautics and Space Administration-Department of Defense research program for a supersonic transport. It is the responsibility of the National Aeronautics and Space Administration to provide the research information and technology in support of the program while the Federal Aviation Agency proceeds with the prototype development.

A major increase is required in fiscal year 1965 for work in the supersonic transport propulsion field. At present, the most advanced high-Mach number engine available in the United States is not suitable for the supersonic transport aircraft because its thrust level is too low for the supersonic transport mission and it has a high specific fuel consumption. A new, advanced engine will be required for an economically feasible supersonic transport airplane. The increased funds will be used to continue work at the level required to produce the supersonic transport engine that is required. Work will be done in-house and on contract in the areas of inlets, compressors, gas generators, turbines, and exits during fiscal year 1965 to support this development program.

V/STOL Aircraft

	1963	1964	1965
Aerodynamics	$520,000	$570,000	$740,000
Loads and structures	9,000	535,000	180,000
Propulsion	106,000	195,000	450,000
Operating problems	290,000	800,000	630,000
Total costs	$925,000	$2,100,000	$2,000,000

Increased emphasis will be given in fiscal year 1965 to National Aeronautics and Space Administration wind tunnel studies of configurations representative of high speed jet V/STOL types. Particular attention will be given to studies of the interference effects of direct-lift and vectored-thrust jet fighter types. This research will require relatively large, highly-instrumented models to obtain reliable simulation and measurement. Work will continue on propulsion system improvement.

Flight studies are planned utilizing the XH-15A helicopter in order to determine structural loads and dynamics of a nonarticulated (rigid) rotor system, and to study the apparent potential of this new concept for improving helicopter flying, handling and performance characterisitics.

Investigations with the variable stability X-14 deflected jet airplane and the YHC-1A helicopter will increase general information on handling requirements for V/STOL aircraft, particularly for steep approach and blind landing conditions. Other related work will be carried out, both with ground simulators and in flight, to determine optimum guidance and control systems and pilot instrument displays for all weather landing of V/STOL aircraft.

Flight studies of short-take-off-and-land type aircraft which have particular application as civil medium and short-range transport will continue. The recently modified C-130B boundary layer control airplane will be used.

OFFICE OF TRACKING AND DATA ACQUISITION

TRACKING AND DATA ACQUISITION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objective of the NASA tracking and data acquisition program is to provide operational ground instrumentation support required by all NASA flight projects.

Every space flight mission undertaken, whether launch vehicle development, scientific satellite, space probe, or manned spacecraft, is undertaken to further our knowledge of the space environment by means of the acquisition and analysis of scientific information recorded during these missions. The critical element in getting such information back to the managers of the mission is the world-wide network of tracking and data acquisition stations. These stations, linked together and to the NASA mission control and data centers by a communications net, receive and record telemetered scientific data, including voice and video data; track the spacecraft in order to determine its position; and transmit signals to the spacecraft as required. Each flight mission has its own specific requirements for tracking accuracy; amount and kind of spacecraft-gathered information to be transmitted; command signals to be received; and location of ground instrumentation to perform these functions. The NASA networks, supplemented as required by other than NASA stations, are a flexible and responsive tool used to fulfill the requirements of the flight missions.

SUMMARY OF RESOURCES REQUIREMENTS:

	1963	1964	1965
Supporting research and technology	$13,277,000	$12,000,000	$15,500,000
Network operations	55,943,000	81,500,000	99,800,000
Equipment and components	52,922,000	116,500,000	152,600,000
Total costs	$122,142,000	$210,000,000	$267,900,000

BASIS OF FUND REQUIREMENTS:

To be responsive and flexible in giving tracking and data acquisition support to varied flight projects, the NASA networks require a continuing program of component and system improvement and development, station network operations, and equipment additions and modifications.

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The program for supporting research and technology will be directed primarily toward the improvement of existing equipment systems and subsystems and, in addition, toward development of new equipment for ground instrumentation support. Greater capability than that which presently exists in ground instrumentation is necessary to support planned manned and unmanned flight projects.

The program for network operations reflects the increasingly complex support capability required by the NASA flight programs. To perform these functions, additional personnel, logistics and maintenance are required for operating the networks as new stations and equipment become operational.

To meet specific ground support requirements for the various types of flight projects, new equipment capability in the networks is necessary. Major equipment requirements for fiscal year 1965 are related to the observatory class satellite projects, the Apollo manned space flight missions, and the deep space flight projects. There are also increasing equipment requirements for the communications and data processing functions which are vital for an integrated tracking and data acquisition capability.

Supporting Research and Technology

	1963	1964	1965
New systems development.........	$3,088,000	$2,995,000	$3,100,000
Integrated systems analysis, development and test..........	826,000	1,361,000	2,090,000
Improvement to existing systems.	9,363,000	7,644,000	10,310,000
Total costs..................	$13,277,000	$12,000,000	$15,500,000

The purpose of the supporting research and development program is to provide for the developments necessary to assure the orderly augmentation of tracking and data acquisition support systems. From this program evolve the techniques and prototype hardware elements for improving existing systems and demonstrating the feasibility of new systems to meet the support requirements of future space flight missions.

New Systems Development

A major effort in fiscal year 1965 is the development of the Airborne Range and Orbit Determination (AROD) system which was initiated in fiscal year 1963. This project was initiated to provide a flexible tracking system to meet the upcoming requirements of the Saturn V project. The objective of the AROD development is to provide the necessary on-board and mating ground equipment so that the range and orbit of space vehicles can be accurately determined. A prototype of an AROD station will be built and the test phase started. The test phase will include aircraft flight tests to provide a preliminary performance evaluation of the integrated system.

Integrated Systems Analysis, Development and Test

This category provides for: (1) analysis, test and evaluation of prototype components and subsystems prior to integration into the networks; (2) development of more efficient mathematical techniques for determinging trajectories and orbits; and (3) development of mathematical techniques and equipment modifications to provide improved in-orbit checkout support for Saturn V class vehicles and spacecraft.

An example of the second area of effort is the development of better mathematical techniques to determine rapidly, more accurately, and efficiently the orbits and trajectories of spacecraft. With the increased number and complexity of space flight missions such as Apollo, Interplanetary Monitor Probe (IMP), Pioneer and Lunar Orbiter, improved computational techniques are required to rapidly and efficiently compute and predict spacecraft trajectories. Diverse missions such as these require optimized computer programs essentially unique to each project. As new missions are evolved, additional unique modifications to the computer routines or programs are required to meet the spacecraft and experimenter requirements for orbit determination.

For the Saturn V vehicle and Apollo spacecraft, the tracking and data acquisition network must provide means for checking out the entire system while in orbit. This checkout is quite similar to the prelaunch one but is somewhat more difficult since it must be accomplished remotely. Large amounts of data will be transmitted to the ground network, collected, edited, sorted and processed to arrive at command decisions in near real time. These decisions are then transmitted from the ground to the vehicle. In fiscal year 1965 further analytical effort and equipment modifications will be undertaken to meet the Saturn and Apollo requirements. The techniques and equipment resulting from this continued effort will be integrated into the In-orbit Checkout Equipment.

Improvement to Existing Systems

This category provides for the development of component and subsystem improvements for existing tracking and data acquisition systems. These improvements will be accomplished by analyzing, developing, and testing the latest techniques that show promise of providing the operational capabilities required by future flight projects. Affected subsystems are:

	1963	1964	1965
Spacecraft subsystems...........	$364,000	$590,000	$1,715,000
Antenna subsystems..............	2,248,000	1,771,000	1,797,000
Receiver and transmitter subsystems....................	4,360,000	4,326,000	4,650,000
Data handling and control subsystems....................	1,350,000	686,000	1,308,000
Central processing and reduction subsystems..........	1,041,000	271,000	840,000
Total costs..................	$9,363,000	$7,644,000	$10,310,000

Spacecraft Subsystems

In fiscal year 1964 an effort was initiated to develop a light weight, highly reliable and efficient on-board data processing and memory subsystem for future spacecraft requirements of the Advanced Orbiting Solar Observatory (AOSO) class. In addition to this developmental subsystem, an initial study effort of feasible telemetry system components (i.e., transmitters, modulators and signal conditioners) was started. The original effort had, as its primary aim, the development of flight proven subsystems which would be compatible with existing ground systems, and would be capable of meeting foreseen space flight projects. The original effort will be continued in fiscal year 1965 and will have as its primary objective the development of a family of standardized on-board transmitters, receivers, data handling modules, and memory units. By such standardization, economies and improved reliability can be realized in such future projects as AOSO and the advanced IMP.

Antenna Subsystems

In fiscal year 1965, the improvements underway on antenna feeds will be continued with the objective of being able to support several spacecraft, operating over a wide frequency range, with a single feed antenna. Prototype cassegrain feeds, currently in use in the Deep Space Network, will be adapted for use on the large data acquisition antennas for support of projects such as Relay B and Syncom III. Improvements in the servo system of these antennas will be required to support the more stringent tracking and accuracy requirements of these projects. The development of antenna surface accuracy measuring techniques originated in fiscal year 1963 will be completed in fiscal year 1965.

Receiver and Transmitter Subsystem

This subcategory of effort includes development and test of prototype hardware, and will provide each network with the receiving and transmitting subsystems that have the capability of meeting the constantly increasing spacecraft requirements for more accurate and reliable tracking and data acquisition support.

To increase the quantity of data that could be acquired by the network without spacecraft weight or other system parameter increases, a considerable effort has been underway for several years to improve the ground receiving subsystems. The results of these past developments are now being incorporated in the networks with such equipments as low noise parametric amplifiers and maser systems. These improvements will yield increases in receiver sensitivity by a factor of between six to ten over that previously available. In fiscal year 1965, effort will be directed toward development and evaluation of improved techniques, such as coherent phase modulation detectors and low threshold frequency modulated detectors, to further increase the sensitivity of the receivers.

During fiscal year 1965, efforts to improve transmitter subsystems for the Deep Space Network and the Satellite Network will be continued. There will also be an initial development of a 1,500 megacycle high power ground transmitter system capable of sending a more varied and greater volume of data to a spacecraft as required by future flight projects.

Data Handling and Control Subsystems

For the Eccentric Orbiting Geophysical Observatory (EGO), Polar Orbiting Geophysical Observatory (POGO), and Orbiting Astronomical Observatory (OAO), special purpose real-time satellite control and tracking systems were developed for each spacecraft. These control and tracking systems were intended to, among other functions, process spacecraft engineering telemetry data, formulate instructions based on such data, transmit these instructions to the spacecraft, supervise the execution of scientific experiments by the spacecraft and provide instructions to the spacecraft regarding future inquiries from other ground control stations. In fiscal year 1965, the development effort will be continued. This system is being developed to meet the requirements of the AOSO and the second generation of the EGO, POGO, and OAO spacecraft.

Central Processing and Reduction Substystems

Effort in this subcategory is directed towards improving the capability of existing telemetry data reduction and central processing systems. During the past several years, specialized telemetry reduction and processing systems have been used to convert the satellite data into the format desired by the experimenters. As the data rates increased with such projects as EGO, POGO, OAO, Surveyor, and Mariner, and in order to reduce the tremendous quantity of data so acquired, it has become necessary to build general purpose processing and reduction systems capable of handling a variety of spacecraft projects. Such general purpose systems will be more reliable and less expensive than present special purpose systems. In fiscal year 1965, the evaluation of several promising subsystems in this area will be made and the development of prototype hardware undertaken.

Network Operations

	1963	1964	1965
Satellite network...............	$12,252,000	$22,000,000	$25,600,000
Manned flight network...........	16,495,000	20,200,000	25,400,000
Deep space network..............	8,117,000	12,000,000	14,600,000
Wallops/Fort Churchill instrumentation...............	3,568,000	5,000,000	5,300,000
Aerodynamics test range.........	450,000	800,000	800,000
Network communications..........	10,821,000	15,000,000	18,700,000
Data processing and handling....	4,240,000	6,500,000	9,400,000
Total costs..................	$55,943,000	$81,500,000	$99,800,000

There are three basic networks used in NASA programs: the satellite, manned, and deep space networks. In addition, there are the aerodynamic test range at Flight Research Center, the Wallops/Fort Churchill instrumentation, network communications, and data processing systems.

Network Operations - Satellite Network

This network consists of 13 electronic stations operated by the Goddard Space Flight Center and 12 optical stations operated by the Smithsonian Astrophysical Observatory. The electronic stations provide the principal tracking and data acquisition support to the program while the optical stations, as described below, provide a more specialized service generally directed toward precision orbital tracking and determination. The stations in the network are operated under various arrangements. Those in the United States and in certain foreign countries are operated under commerical contracts. Other stations are operated by foreign government agencies in close liaison with NASA.

To prepare the network for support of the advanced satellite projects such as OAO and OGO, new facilities projects and equipment augmentation projects are underway. A new facility at Rosman, North Carolina is now operational and another at Fairbanks, Alaska will be operational by mid calendar year 1964. By mid calendar year 1965, a facility near Canberra, Australia and a second antenna system at Rosman, North Carolina will be operational. These facilities, using 85-foot diameter parabolic antennas, are being established to handle the increased bandwidth requirements of the satellite flight projects scheduled during calendar years 1964 and 1965.

In addition to these new facilities, 40-foot antennas are being installed at three existing stations and will be fully operational in fiscal year 1965. Equipment additions during fiscal years 1964 and 1965 include range and range rate tracking systems; automatic tracking, telemetry and command systems; installation of pulse code modulation equipment and a specially equipped mobile facility to support the more sophisticated flight projects.

The optical stations use Baker-Nunn satellite tracking cameras which provide certain optical tracking measurements of greater accuracy than those normally attainable by electronic means. Data obtained by these stations provide information concerning behavior of the Earth's atmosphere and factors affecting the shape of the Earth.

Network Operations - Manned Space Flight Network

The present network consists of 15 stations which collect and communicate real-time information concerning the location of the manned spacecraft, status of the equipment on board, and most important, the condition of the astronaut. All stations have radio voice communications with the astronaut, and can receive telemetry data relating the condition of the astronaut and the functioning of the systems in the capsule; selected stations also have command capability.

In order to support the Gemini and Apollo flight programs considerable augmentation to the network is required. Elements of the Gemini program such as long flight duration, rendezvous and maneuvering in space, demand an increased level of operations. To provide this capability, new equipment consisting of telemetry systems utilizing Pulse Code Modulation, digital command systems, radio frequency command systems, acquisition aids, consoles, displays and on-site data processing systems are being installed at ten primary stations. Additional personnel will be required to operate and maintain this more complex equipment and to man the stations during long duration flights scheduled in fiscal year 1965.

During fiscal year 1965, the Apollo program which is to follow Gemini will place a requirement for a cadre of personnel to train for the operation and maintenance of Apollo support stations.

NASA has overall responsibility for operation, standardization, calibration and operating procedures, and implementation. Of the 15 manned space flight stations, five are operated by a commercial contractor, seven stations and two ships by the Department of Defense, and one station under intergovernmental agreement by the Weapons Research Establishment of the Australian Department of Supply.

Network Operations - Deep Space Network

The Deep Space Network is comprised of stations that are used primarily to acquire, track, obtain telemetry data from, and send commands to spacecraft and probes in support of the NASA lunar and planetary programs. Because of the long distances over which communications must be maintained, these stations must have extremely high sensitivity. This high sensitivity is derived from large high-gain parabolic antennas, along with highly advanced transmitting, receiving and signal detection equipment.

During fiscal year 1965, two new stations with 85-foot parabolic antennas at Madrid, Spain and Canberra, Australia are scheduled for completion. These will handle the increased workload starting in calendar year 1965. By the end of fiscal year 1965, the total network will consist: of six operational stations with 85-foot antennas and one station with an 85-foot research and development antenna; of two mobile tracking stations; of a checkout station at the launch site; and of the network control center at the Jet Propulsion Laboratory.

The Deep Space Network supports the Ranger, Mariner, Surveyor, and Pioneer spacecraft missions. Examples of the workload demands of these missions are the flight times to the moon (66 days) and to Mars (270 days).

With the increased number of scheduled flights, stations and types of equipment, additional personnel are required to operate and maintain the network facilities.

Network Operations - Wallops/Fort Churchill Instrumentation

This instrumentation supports sounding rocket flights launched by Wallops Station and the Churchill Research Range at Fort Churchill, Canada. A wide variety of scientific research, vehicle testing, and flight hardware component testing programs are supported.

Most of the instrumentation is located at Wallops Island and consists of tracking, telemetry, data acquisition and data reduction equipment. In addition, an assortment of mobile equipment, including optical tracking and sound-ranging, is available for specific missions. Additional support is furnished by a range ship operating in the general area between Wallops Island and Bermuda.

Operations are accomplished under contract with industrial organizations or by reimbursable orders to other government agencies. The Churchill Research Range in Canada is on a cost sharing basis with the Department of Defense. The importance of this station is due to its geographic position in the high latitudes where probes can be launched into the aurora and other phenomena associated with the polar regions.

Network Operations - Aerodynamic Test Range

The Aerodynamic Test Range was established to provide support to aeronautical development and experimentation requiring coverage of extremely high velocity and high altitude aircraft flights. The range is located in the Nevada-Eastern California area, and is composed of three operating sites. The prime site is located at the Flight Research Center at Edwards Air Force Base in California, and serves as the southern terminus or recovery area for the range. The two up-range stations are located near Beatty and Ely, Nevada.

The principal activity of the range to date has been to support the X-15 research project. In this role, it has furnished the coverage for monitoring and controlling the X-15 research aircraft, the B-52 launch platform, and the "chase" aircraft during all mission phases. Thus, full coverage of the climb-to-launch, space-trajectory, and recovery portions of the test flights is provided.

In addition, the range stations serve as ground sites for mission communications and real time data telemetry. Communications, telemetry, data monitoring, recording, plotting, timing, and computing systems are provided at each station for full mission capability and coverage. The range facility located at the Flight Research Center is operated principally by NASA personnel, while those at Ely and Beatty are manned by contract personnel under the direction of a NASA station manager.

Network Operations - Network Communications

One of the most vital characteristics of an integrated network is a communications system which ties the various stations into the control center. Summarized data concerning the status of manned and unmanned space vehicles are sent from the stations to the control centers so that decisions can be made relative to future operations of the vehicles. Voice channels permit the manned space flight stations to provide critical "hand over" tracking instructions from station to station and to pass emergency instructions from the control center.

Presently, there are about 500,000 miles of leased voice and teletype circuits; it is estimated that about 1,000,000 miles of lines will be required during fiscal year 1965, due primarily to the Gemini and Apollo programs. Bandwidth requirements for transmission of data by land lines and microwave systems continue to increase in order to handle the large volumes of data for processing, reduction and analysis. In addition, wide-band data lines for scientific information will be required as new stations become operational in support of the larger satellite and deep space projects.

As examples, for the Gemini program an additional voice quality circuit to each station is required; for both Gemini and Apollo, control circuits between the Goddard Space Flight Center and the Integrated Mission Control Center at Houston will be installed; and, for the deep space flight operations, additional overseas communications are required to handle higher data rates and to interconnect the stations at Canberra, Australia and Madrid, Spain, with the Jet Proplulsion Laboratory.

Commercial common carriers, domestic and foreign, provide the majority of communications services; however, wherever these are unavailable, other government agency lines are utilized.

Network Operations - Data Processing and Handling

The utility of a space flight is realized only when data in a form usable by the experimenter is in hand. Although the tracking stations receive the radiated signals that carry the information transmitted by the spacecraft, this information is not in a readily usable form. It is only after the data is processed that usable data outputs from a space program are obtained. Such a capability has been established, and the service provided. In general, two tasks must be performed by the data processing facilities. These are the determination of the spacecraft's position in space as a function of time, and the conversion of the coded telemetered data into the experimenter's form. The determination of the position in space is accomplished by orbits and trajectory computing complexes.

The conversion of the coded telemetry data is performed by an assemblage of electronic equipment identified as a data processing line. Due to the

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unique nature of many space experiments, most data processing lines are designed to process characteristic data from a given satellite. Thus, a number of lines are necessary.

During fiscal year 1965, as the sophistication of new space missions increases, the quantity and complexity of the data to be processed require a further increase in the size and complexity of the data processing facilities. In addition, the more advanced satellites have a greater number of experiments and thus demand more total line operating time.

Equipment and Components

	1963	1964	1965
Satellite network...............	$9,390,000	$16,800,000	$15,900,000
Manned space flight network.....	28,100,000	69,630,000	106,900,000
Deep space network..............	7,636,000	11,570,000	12,000,000
Wallops and other instrumentation..........................	1,545,000	2,700,000	3,900,000
Aerodynamic test range..........	1,010,000	1,000,000	1,500,000
Communications..................	1,925,000	3,600,000	3,300,000
Data processing and handling....	3,316,000	11,200,000	9,100,000
Total costs..................	$52,922,000	$116,500,000	$152,600,000

Maintenance, improvements and augmentation of tracking and data acquisition equipment and components to meet the requirements of the flight missions are a continuing program requirement. Requirements of each category are discussed below. Estimates for the various equipment items include funds, where necessary, for minor alterations and additions to existing structures or new minor supplementary structures required to house, support and integrate the equipment with the existing network stations.

Equipment and Components - Satellite Network

	1963	1964	1965
Tracking systems................	$2,768,000	$1,696,000	$2,161,000
Telemetry systems...............	3,199,000	4,409,000	3,465,000
Command and control systems.....	509,000	1,242,000	1,912,000
Recording and display systems...	150,000	2,386,000	2,040,000
Test, calibration, and monitoring equipment..........	68,000	871,000	806,000

	1963	1964	1965
Spacecraft checkout equipment...	---	$1,269,000	$104,000
Timing systems..................	---	740,000	690,000
Real-time data handling systems.	$1,187,000	500,000	975,000
Special purpose equipment.......	151,000	510,000	1,175,000
Power systems...................	265,000	495,000	160,000
Maintenance, spares and replacement.........................	1,093,000	2,682,000	2,412,000
Total costs...................	$9,390,000	$16,800,000	$15,900,000

In response to the advanced requirements of the complex satellite programs, necessary additions and augmentation of the equipment and components of the network stations must continue. Implementation of these major new requirements began in fiscal year 1963 and is being continued in the remainder of fiscal year 1964 and in fiscal year 1965. The new equipment which will enlarge and update the network is required to provide for more precise tracking at greater distances, for an increased capacity for acquiring and handling high data output rates, and for the more complex command and control functions that must be performed by the stations.

Major items in the tracking category are the range and range rate system and the automatic tracking antenna and receiving system. To meet the requirements for more precise tracking coverage of polar orbits, and of satellites with high apogees (up to 250,000 miles), range and range rate systems are planned for selected stations in the network. These are high precision tracking systems needed to determine spacecraft velocity and location in space with extreme accuracy. Each system basically includes a transponder, antenna, transmitter, receiver, range measuring equipment and data recording equipment. The fiscal year 1965 program provides for one complete additional system plus component additions to the four which have been acquired, or are under contract. Additional automatic tracking and receiving system equipment will be installed at selected locations in the satellite network. The receiving system includes an antenna (136 Megacycles Yagi Array), with necessary hydraulic equipment to move and control the antenna, plus receiver equipment.

Additional telemetry systems and components are required in fiscal year 1965 to expand improved capabilities throughout the network, in order to meet high data output and complex experiment requirements. Improved detection efficiency, increased immunity to noise, automatic selection of bit-rates to accommodate preprogrammed or commanded data rates, qualitative and quantitative performance analysis and evaluation of ground receiving subsystems are included among those tasks necessary to reach this required level of capability. Additional telemetry receivers will be necessary to meet the increased capacity of the stations' telemetry links. Each telemetry antenna requires two dual channel telemetry receivers for reception from satellites with two frequencies. Thirteen receivers are scheduled to be provided in fiscal year 1964 and five more are to be obtained in fiscal year 1965 to meet the network requirements. The requirement to support the Polar Orbiting Geophysical Observatory class of satellites immediately after injection into orbit will be met by the use of equipment installed in trailers for ease in transportation from place to place. Present portable stations are not instrumented to receive the POGO telemetry frequencies and are not equipped with the necessary decommutation, or the command systems. Consequently, additional components are required at these stations.

To adequately perform the command and control functions for the distant satellites as well as for the near Earth spacecraft, additional variable and high-power transmitters are required at selected network sites. Dual systems are required at each site for redundancy and to enable rapid change of transmitting frequency and coding. These transmitters will be fed into suitable command antennas and will require related display, control and switching consoles.

Replacement of present equipment used for calibration and quality checks of the network stations is vital in assuring an adequate level of performance by the stations during spacecraft operations. Development of new calibration prototype equipment is nearly complete, and it is planned to replace the airborne units as well as the ground equipment.

Equipment for spacecraft checkout is required to determine compatibility between the spacecraft and ground systems. While the major portion of this work is performed at NASA centers, similar components are required also at the launch sites in order to enable experimenters to perform a final checkout prior to flight.

It is necessary to continue providing timing equipment for the Goddard Space Flight Center Time Standards Laboratory, and calibrated equipment for new and existing stations. All stations operate by synchronized time signals, and in order to perfect data acquisition in the required mode, improvement in equipment and engineering is necessary to meet the problems inherent in world-wide time synchronization of the network.

The major item in data handling is for real-time activities, a problem which still assumes significant proportions in all future planning for the network. Data control equipment is required to format operational control data for display at the station and for transmission to and from remote sites.

Equipment and components for special purposes, such as the simulation of unique spacecraft transmissions, non-standard data handling and on site processing, and components required to integrate new subsystems into the station complex, are included. Modifications and additions to station power plants are necessary to improve reliability and to increase capacity as dictated by additional equipment.

Included in the maintenance, spares, and replacement category for fiscal year 1965 are spare parts, emergency replacement equipment, and special maintenance items for the 40-foot antenna systems. Present station test equipment is becoming increasingly difficult to maintain because of its age, and much of it is technically inadequate to meet present requirements. A program to replace the existing equipment began in fiscal year 1964 and continues through fiscal year 1965. The equipment involved includes oscilloscopes, frequency counters, signal generators, simulators, audio oscillators, oscilloscope cameras, and assorted testers and checkers.

Equipment and Components - Manned Space Flight Network

	1963	1964	1965
Apollo			
Receiving systems................	---	$12,379,000	$15,472,000
Transmitting systems............	---	3,223,000	6,986,000
Ranging systems..................	---	980,000	2,156,000
Antenna systems..................	---	15,103,000	5,106,000
Command systems..................	---	1,600,000	3,000,000
Demodulation systems............	---	6,000,000	19,700,000
Data handling systems...........	---	8,406,000	12,284,000
Reentry ship modifications......	---	---	17,400,000
Aircraft modification and design	---	150,000	18,420,000
Maintenance, spares, and replacement.....................	---	1,252,000	3,905,000
Subtotal.....................	---	$49,093,000	$104,429,000
Gemini			
Data processing systems.........	$7,283,000	5,050,000	---
Data handling systems...........	4,428,000	6,040,000	---
Command systems..................	5,439,000	2,195,000	---
PCM telemetry systems...........	8,329,000	4,535,000	---
Maintenance, spares, and replacement.....................	---	2,717,000	2,471,000
Subtotal.....................	$25,479,000	$20,537,000	$2,471,000
Mercury			
Maintenance, spares, and replacement.....................	$2,489,000	---	---
Total costs..................	$28,100,000	$69,630,000	$106,900,000

The manned space flight network will provide the instrumentation support required by the Gemini and Apollo launch vehicles and spacecraft in the areas of tracking, telemetry, command and communications.

The Apollo Saturn IB and Saturn V programs impose more severe instrumentation requirements in these areas than encountered in the Gemini program. Continuous coverage is required for time periods and ranges not encountered with Gemini. The amount of information transmitted to or received from the Apollo spacecraft to enable the successful performance of its mission is greater than that for Gemini. To perform the tracking, telemetry, command and communications functions in support of Apollo in a manner encompassing these more severe requirements, the existing Gemini network will be expanded and augmented with unified S-Band systems and equipment.

Overall, the augmentation for Apollo will result in a network of nine stations with 30-foot antennas, three 85-foot antenna sites, one insertion ship, two ships for coverage of the early translunar coast period, two reentry ships, and aircraft for injection coverage. This implementation will allow the minimum level of ground instrumentation support of the Apollo program requirements.

The final configuration of all network stations to be used in support of the Apollo program, whether they are land stations, ships, or aircraft, will incorporate in the unified S-Band configuration the necessary receiving, transmitting, ranging, antenna, command, demodulation and data handling systems. A modular building-block approach will be used. This approach, which will make use of the same subsystems in all stations even though this number varies at some stations, will reduce maintenance, replacement and training costs.

Receiving systems, which are identical except for small changes in frequency and bandwidth to those of the deep space network, will provide the initial demodulation of voice and telemetry, provide doppler tracking, and emit signals for antenna directing. Transmitting systems will provide the transmitters and other ancillary equipment necessary for transmission of voice, command and ranging signals from the station to the spacecraft. Ranging systems provide the means for measuring the distance to the spacecraft and the spacecraft velocity.

Antenna systems range in diameter from 10 to 12 feet in the case of those used on the reentry ships to 30-foot diameter antennas for the land and ship stations used for orbital and post-injection tracking. These systems include servo mechanisms for precise pointing of the antennas.

The command systems and data handling systems are of the same design for Apollo as for Gemini and will be procured only for those stations not now augmented for Gemini. The command system provides digital data in suitable format for transmission to the spacecraft. Demodulation equipment prepares the data for storage and communication to the mission control centers and provides the input for the data handling equipment. Included in the data handling systems are teletype format equipment, recorders, displays, and operating consoles required for the routing and storing of data at the station.

Requirements for communications and tracking ships for Apollo program support are being coordinated with the Department of Defense, wherein the Department of Defense will be responsible for the implementation or modification of tracking ships required for Apollo. Three communications and tracking ships must be provided for insertion and post-injection coverage. Two existing ships must be augmented to provide reentry coverage. The necessary modifications of two reentry ships will be initiated in fiscal year 1965. The required operational date for these ships, in accordance with current flight schedules, is early 1967.

Studies have been made concerning the means for providing voice communications and telemetry reception and recording coverage of the S-IVB powered flight during the injection of the spacecraft into the translunar coast trajectory. If communications ships were used to meet the requirement for continuous coverage during this period, between six and twelve such ships would be required on station at the time of the injection burn. The specific number of ships between six and twelve is determined by a combination of factors including the date of launch, the desired launch window and the status of the S-IVB propulsion energy budget. It was concluded that the provision for this number of ships is prohibitively expensive and other methods of providing communications coverage were investigated. The most promising method was to provide the necessary coverage by means of instrumented aircraft.

Presently available aircraft are being assessed to determine their suitability for this use and preliminary design for the necessary modifications is planned during fiscal year 1964. The actual modifications will be initiated in fiscal year 1965 and will carry over into fiscal year 1966. Close coordination with the Department of Defense (DOD) will be maintained throughout the program since the DOD will be requested to supply and operate the aircraft.

Equipment and Components - Deep Space Network

	1963	1964	1965
S-band receiver, transmitter, and components................	$1,096,000	$2,936,000	$2,897,000
Atomichron and synchronization equipment................	300,000	115,000	115,000
Klystron and maser amplifiers...	358,000	1,045,000	815,000
Antenna and servo modifications.	1,126,000	1,264,000	1,985,000
S-band ranging and acquisition systems......................	1,079,000	1,155,000	1,297,000

	1963	1964	1965
Digital data and instrumentation systems..................	$460,000	$985,000	$1,175,000
Data transmission and processing equipment.................	1,026,000	570,000	495,000
Test transponders and calibration systems...........	1,001,000	745,000	1,225,000
Recording systems...............	130,000	980,000	---
Maintenance, spares, replacement, and documentation.......	1,060,000	1,775,000	1,996,000
Total costs..................	$7,636,000	$11,570,000	$12,000,000

In response to the increasing requirements for radio tracking, command, telemetry and data acquisition of unmanned lunar and planetary spacecraft and deep space probes, the existing network requires improvements and expansion to handle the specific upcoming spacecraft requirements. To reduce cost and maximize operational efficiency, all deep space network stations are standardized with compatible data acquisition, tracking, command recording and processing equipment. Any new equipment required is initially installed and tested at the Goldstone Station before it is integrated into the system. Once the new equipment has been accepted for general use within the deep space network, it is classed as Goldstone duplicate standard equipment, which standardizes the design and formalizes the documentation of like items throughout the network.

During fiscal year 1964 the L to S-band conversion of the network will continue. In the interim period, the stations will operate on both L-band and S-band frequencies, due to the prior commitments to the L-band spacecraft support. Some of the items that are being purchased and installed are recording equipment, feed systems for the antennas, higher power klystron transmitting tubes, improved operational maser amplifiers and modifications in the servo system and transmitter. One of the large antennas has been cleaned and thermocoated; the result of this has been a reduction in the thermal effects of the reflector.

During fiscal year 1965, the deep space network will consist of six 85-foot antenna stations, two mobile tracking stations and the network control center. The flight schedule for fiscal year 1965 shows an increase in the number of launches with onboard equipment operating in both L and S-band frequency spectrums. (The requirement for L-band coverage is anticipated to end in fiscal year 1965, and equipment directly related to this frequency spectrum is scheduled to be phased out by approximately the end of that fiscal year.) The primary effort in the fiscal year 1965 program continues to expand the S-band capability in the overall network and provides for additional major equipments and associated subsystems necessary for this task. This expansion will enable the network to support simultaneously more than one space probe operating in the S-band area, while retaining required capability for the L-band program. Both Mariner and Surveyor missions will overlap in time, and consequently, the ground antennas will require multiple S-band equipments to allow noninterfering command to and transmission from the spacecraft.

The stations which were not modified in fiscal year 1964 by the addition of the S-band traveling wave maser amplifier will be integrated into the network with these modifications. These changes provide the station with the capability to acquire data from and to track extremely weak radio frequency signals. This capability effectively extends the tracking and data acquisition function to cover greater distances of transmission with increased reliability in the quality of data recorded. To derive optimum performance from the S-band maser subsystem, it is planned to improve the closed cycle refrigerator system and the maser amplifier to be compatible for increased operating efficiency. In addition, servicing equipment of a special nature is required.

Modifications to the antennas will provide an auxiliary electric drive as a backup to the existing drive system. The drive system, including the servo subsystem, will be modified to permit operation by computer programming. To improve the thermal effects, the antennas will be cleaned and thermocoated.

S-band ranging systems and acquisition aid equipment will be added to those stations in the network that have not previously been modified. The ranging systems provide capability of measuring the range accurately to a spacecraft; and the acquisition aid equipment, with the wide beamwidth angle, permits the large antenna to acquire the spacecraft radio signals earlier. Additional work on a prototype planetary ranging system, including the interface between the transmitter and receiver, will be performed.

Digital data and instrumentation equipment will be added as standard equipment, and will be compatible with existing equipment at other stations in the network. This provides the capability to handle data in a timely and efficient manner by automatically putting the raw data in a format that is required for processing, prior to transmission to the network control center.

The data processing and transmission equipment improves the data handling and data processing capabilities that are required at the stations. On-site equipment is required to monitor, edit and transmit data over communication lines to the central computing center. This also includes intrasite communication equipment.

Accurate antenna alignment and calibration of the station's equipment is accomplished by test transponders installed at remote collimation sites. This equipment provides the station the capability to calibrate before, during (usually) and after a flight mission in order to determine the station's operating characteristics for each mission. This includes the microwave standards and special purpose equipment to operate the collimation sites.

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Maintenance, repair, test equipment, spares and replacement parts for equipment, including ground support items consisting of generators, cranes, pumps, etc, will be established at each station. These parts, supplies and equipment will reduce the operational down time at each station to a minimum. Normal real property maintenance, upkeep and minor alteration and site improvement is included.

Equipment and Components - Wallops and Other Instrumentation

	1963	1964	1965
Photographic processing equipment	$150,000	$220,000	$200,000
Range camera equipment	200,000	250,000	550,000
Aircraft calibration and test instrumentation	120,000	160,000	350,000
Antenna systems modifications	120,000	240,000	180,000
Timing equipment	---	75,000	---
Range ship instrumentation	---	80,000	---
Data systems	---	---	420,000
Telemetry system components	---	---	1,100,000
Radar system components	---	---	450,000
Maintenance, spares and replacement	955,000	1,675,000	650,000
Total costs	$1,545,000	$2,700,000	$3,900,000

This category provides for the procurement of equipments and components in two general areas: (a) expendable (non-recoverable) flight hardware and spare parts; and (b) state-of-the-art improvements to existing range instrumentation systems.

Non-recoverable flight hardware includes radar beacons, DOVAP transponders, antennas, and command-destruct receivers that are installed in the launch vehicles. Small meteorological rockets, to obtain last minute wind profiles so that elevation angles and launch azimuths can be corrected, are included in this category. These rockets constitute a safety measure to assure impact in pre-determined areas; they are ballistic and carry no guidance systems other than spin-stabilization.

The state-of-the-art improvements consist of various electronic components which are installed on existing antennas, or introduced into the circuitry of the range instrumentation systems (tracking, telemetry, data reduction, range safety, optics, etc.) that improve the range, accuracy, speed, and flexibility of these systems. The requirements for these improvements are generated by the number and types of rockets in the flight schedule, larger and improved rockets, and more complex payloads.

Equipment and Components - Aerodynamic Test Range

	1963	1964	1965
Tracking systems................	---	$750,000	$100,000
Telemetry systems...............	$800,000	---	600,000
Real time data handling systems.	---	---	250,000
Maintenance, spares, and replacement.....................	210,000	250,000	550,000
Total costs...................	$1,010,000	$1,000,000	$1,500,000

The aerodynamic test range operated by the Flight Research Center will require equipment modifications and additions to effectively support planned test programs. Such test programs include the hyper-velocity X-15 and the airborne simulator utilized for supersonic transport research.

The fiscal year 1965 program for the range will include radar ranging modification for longer range capability, a PCM ground telemetry system for installation at one of the uprange stations, equipment for the ground telemetry station and additions for real time data handling and display. With the initiation of the new flight research programs an increasing proportion of the estimated funds will be required for maintenance, spares, and replacements. Included in this category in fiscal year 1965 is replacement of the airborne tracking beacons required for use with the ground tracking radars.

Equipment and Components - Communication

	1963	1964	1965
Data terminal equipment.........	$80,000	$195,000	$555,000
Solid state switching units.....	---	2,735,000	1,662,000
Switching center equipment......	100,000	150,000	200,000
Teletype and voice equipment....	173,000	220,000	528,000
South American systems modification.......................	240,000	---	55,000
Test and evaluation equipment...	100,000	150,000	200,000
40 KW radio transmitters........	538,000	---	---
Mobile communication van........	250,000	---	---
Maintenance, spares, and replacement.....................	444,000	150,000	100,000
Total costs...................	$1,925,000	$3,600,000	$3,300,000

In order to support the more complex unmanned and manned space vehicles, it will be necessary to provide communication channels of higher data rates with minimum transmission errors. For example, the communication requirements from the deep space stations to support Surveyor will require over ten times the band width presently provided by the 60 word per minute teletype channel. Additional voice communication capabilities as well as additional automatic switching and monitoring facilities are required to ensure reliable communications.

Further, there will be a continuing emphasis toward better utilization of circuits and standardization of communications into a single system for common use by all programs, in order to keep the total circuit requirements to a minimum.

The requirement for higher data rates with very small error limits makes it necessary that additional error correction and detection equipment be used at the data terminals.

Solid state switching units must be installed in London, Hawaii, and Australia to work with the units being installed at Goddard Space Flight Center. These units will be used to meet the higher circuit speed requirement and to provide automatic checking and monitoring of the circuits.

Facility control and display equipments are required to bring mission network circuits to a central point where the capability exists to transfer these circuits back and forth between communications users, based on the type and priority of mission. This sharing process reduces the total number of circuits required.

A further step to reduce the total circuit requirements will be the use of compaction equipment to utilize the unused time on voice circuits. About 70 percent of the capacity of a four-wire voice circuit is unused due to normal speech pause between sentences, words and even syllables. This compaction equipment allows data to be passed during the unused time. It is estimated that by use of this equipment approximately twelve two-way teletype circuits can be carried simultaneously with a normal conversation over a voice circuit.

As the number and complexity of spacecraft in orbit increase, multiple station voice conferencing becomes necessary in order to provide smooth operational coordination between stations and to provide emergency instructions from the control center. When several voice circuits are conferenced together, they must all be working at the same levels if understandable conversations are to be realized. Because conditions can vary at the various stations, voice operated gain adjusting devices are required to maintain the proper levels.

Within the last two years in South America, such major changes as the provision of a mobile station van at Santiago, Chile as a communications backup for the satellite network, and the installation of three 40 kilowatt transmitters, with associated multiplexing equipment to replace obsolescent 10 kilowatt units, were made. During the coming year, data validity checking units will be installed to complete our planned program to bring these stations up to acceptable standards to handle the communication requirements.

Equipment and Components - Data Processing and Handling

	1963	1964	1965
Digital computing subsystems....	---	$4,950,000	$2,500,000
Off-line data processing systems	---	1,800,000	2,300,000
Peripheral equipment...........	---	720,000	1,250,000
Data processing subsystems......	$1,900,000	1,925,000	880,000
Signal conditioners.............	460,000	---	550,000
Special purpose data processing and display..................	540,000	715,000	450,000
Automatic analog data tape evaluation equipment..........	---	590,000	325,000
High density storage and record units.................	---	---	270,000
Test and evaluation equipment...	---	75,000	100,000
Maintenance, spares, and replacement...................	416,000	425,000	475,000
Total costs..................	$3,316,000	$11,200,000	$9,100,000

With the increasing use of onboard spacecraft digital systems, continuing expansion of the data handling facilities to manage the high output data rates is necessary. The equipment program to convert from analog to digital systems and to modify existing equipment, so as to be compatible with the digital systems onboard the spacecraft, will continue into fiscal year 1965.

Digital computing subsystems consist of computer mainframes and peripheral components which were previously leased.

In fiscal year 1965, a high speed central processor, with peripheral equipment to insure compatability with the digital systems in the spacecraft, will be procured.

Decisions on spacecraft performance and evaluation cannot be made by controllers and experimenters within the main computer complex itself. In order to provide the required information, peripheral equipment such as plotters, consoles, displays and computer links, must be located outside the immediate confines of the computer complex. This is a continuing program in fiscal year 1965.

Data processing subsystems consist of modifications to existing data processing lines in fiscal year 1965. Equipment items include a facility monitoring system, evaluators and analyzers to decrease the down time of present equipment and subsystem display devices for existing data processing lines.

Other hardware for data processing and handling include signal conditioning equipment to eliminate expensive multiple data reprocessing. The most significant experimental results are contained in the 20 percent of data lost during apogee due to limited capability of existing signal recovery equipment, resulting in expensive reprocessing and refining of data in order to retrieve the necessary information.

Special purpose data processing and display units are required for the particular satellite flight projects. Since data requirements vary considerably for each type of satellite, different types of data handling equipment will be required for the ground systems.

Automatic analog data tape evaluation units will provide for the automatic analog evaluations of tapes which are now made manually. The evaluation of analog telemetry tapes is required to sort out improperly recorded tapes and to monitor ground station recording capability.

High density storage and record units are included in the fiscal year 1965 program, and will provide the required recording and storage for the anticipated volumes of data that will have to be processed. These units will also provide greater accessibility to data.

Test and evaluation equipment includes data simulators necessary for checkout and maintenance of data processing lines and systems.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1965 ESTIMATES

ADMINISTRATIVE MANAGEMENT BUILDING

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

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

AUTHORIZATION LINE ITEM: Ames Research Center

LOCATION OF PROJECT: Moffett Field, Santa Clara County, California

COGNIZANT NASA INSTALLATION: Ames Research Center

TYPE OF CONSTRUCTION PROJECT: New

FUNDING:

FY 1963 and Prior Years	$71,000
FY 1964 Estimate	---
FY 1965 Estimate	$1,455,000
Total Funding Through FY 1965	$1,526,000

PROJECT COST ESTIMATES:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$1,353,000
Site development	LS	---	$14,500	14,500
Roads, walks, parking	LS	---	71,500	71,500
Utilities	LS	---	40,000	40,000
Building	Sq. Ft.	64,700	18.96	1,227,000
Equipment	---	---	---	---
Design	---	---	---	---

	Unit of Measure	Quantity	Unit Cost	Total Cost
		SUBTOTAL		$1,353,000
Fallout Shelter	---	---	---	102,000
		TOTAL		$1,455,000

PROJECT DESCRIPTION:

The proposed Administrative Management Building will consist of a central, two-story portion, 194 feet wide by 90 feet deep and two one-story wings each 110 feet wide by 35 feet deep. There will be a basement under the central portion only.

This building is needed to provide the minimum space required for approximately 280 persons comprising essentially all administrative-support personnel. The architectural and engineering design of the building is essentially complete. For economy and architectural compatibility, the reinforced concrete exterior and structure will be essentially identical with the existing Data Reduction Building. The location of the proposed building and a photograph of the existing Data Reduction Building are shown in figure 1.

PROJECT JUSTIFICATION:

Personnel in the Administrative divisions now have an average of only 67 square feet per person of office space including space occupied by files, etc. By fiscal year 1966 they will be crowded into an intolerable 52 square feet per person if more space is not provided. It is not feasible to usurp more space from research groups; on the contrary, research workers are already overcrowded by GSA standards and, in the near future, will be required to reclaim some of the offices now occupied by administrative personnel. As a temporary expedient to alleviate this overcrowding, it has become necessary to rent trailers.

Use of office space scattered about the Center has dispersed administrative functions to the further detriment of their efficiency. The plot plan shown in figure 2 illustrates this dispersion. Such dispersion separates many personnel from their supervisors and co-workers on common projects. All this breeds mistakes and inefficiency.

The proposed Administrative Management Building will provide space for Personnel, Procurement, Contract Negotiation and Administration, Administrative Services, Legal Matters, Public Affairs, Reproduction, and Management Analysis.

The space to be relinquished by administrative personnel now in the Administration Building will be used to provide space for the Assistant

Director for Life Sciences and his immediate staff, to provide adequate space for the Technical Planning Division, to alleviate overcrowding of the Director's immediate clerical staff, to provide space for visitor-control operations, and to provide space remote from restricted areas for discussions between visitors and Ames employees. The space vacated in the existing Administration Building Annex will be used to bring together the now-dispersed fiscal activities and to provide needed expansion of the Center's technical library.

<u>ESTIMATED FUTURE YEAR FUNDING</u>: None

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AMES RESEARCH CENTER
FISCAL YEAR 1965 ESTIMATES

ADMINISTRATIVE MANAGEMENT BUILDING

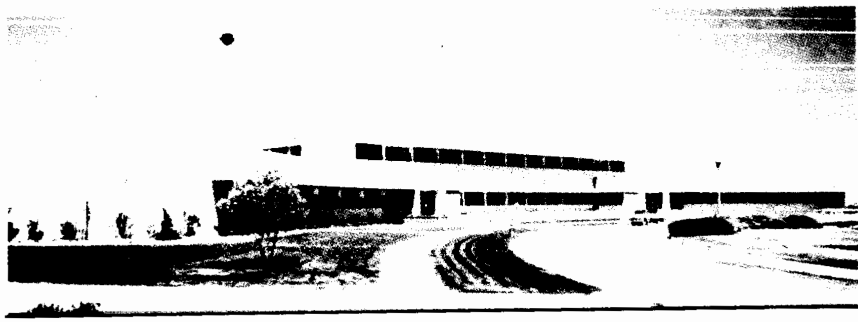
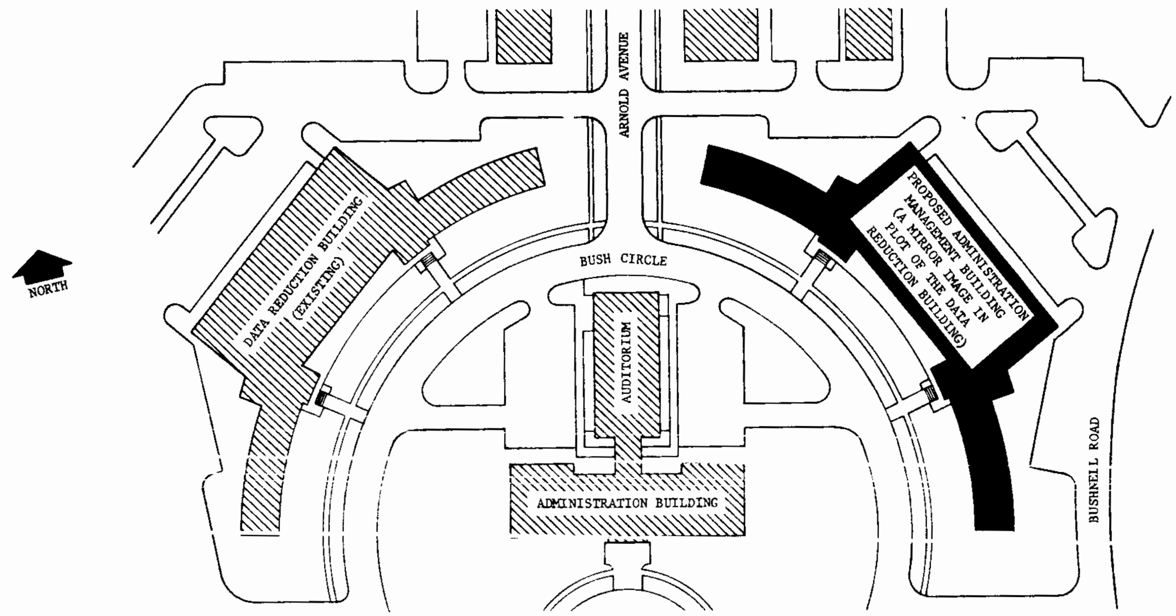


PHOTO OF DATA REDUCTION BUILDING
PROPOSED ADMINISTRATIVE MANAGEMENT
BUILDING TO BE SIMILAR IN APPEARANCE



GENERAL ARRANGEMENT

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1965 ESTIMATES

FLIGHT SIMULATOR FOR ADVANCED AIRCRAFT

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

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

AUTHORIZATION LINE ITEM: Ames Research Center

LOCATION OF PROJECT: Moffett Field, Santa Clara County, California

COGNIZANT NASA INSTALLATION: Ames Research Center

TYPE OF CONSTRUCTION PROJECT: New

FUNDING:

FY 1963 and Prior Years	---
FY 1964 Estimate	$20,000
FY 1965 Estimate	2,630,000
Total Funding Through FY 1965	$2,650,000

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$2,483,000
Utilities, parking	LS	---	$25,000	25,000
Electrical distribution	LS	---	40,000	40,000
Building	Sq. Ft.	9,000	18.00	162,000
Foundations for motion-generator equipment	LS	---	123,000	123,000
Cab struct. & Partial internal equipment	LS	---	165,000	165,000
Motion generator structure	LS	---	528,000	528,000
Motion generator drives	LS	---	560,000	560,000
Electrical and control equipment	LS	---	800,000	800,000
Visual projection equipment	LS	---	80,000	80,000

	Unit of Measure	Quantity	Unit Cost	Total Cost
Equipment				$147,000
Tie-in to existing analog computers	LS	---	$27,000	27,000
Computer control equipment	LS	---	120,000	120,000
Design	---	---	---	---
Fallout Shelter	---	---	---	---
		TOTAL		$2,630,000

PROJECT DESCRIPTION:

The flight simulator will provide simultaneously all of the essential sensory cues (visual and motion) associated with the manual control of advanced aircraft and spacecraft during critical phases of operation. The simulator will be housed in a 9,000 square foot, single-floor addition to the Ames Space Flight Guidance Research Facility (authorized in FY 1963 CoF budget) and will consist of three major elements: (1) a moving cab with associated motion-generating equipment, (2) a visual-projection system, and (3) analog computing equipment. Construction of Facilities funding is required for the building addition, the cab, and the motion-generating equipment. Other elements of the simulator will be supplied from equipment and components available at Ames.

The cab will carry three crewmen and will be furnished internally with instruments, controls, and equipment which can be arranged to simulate the cockpit interior of the vehicle under study. The cab will move, in three angular and three translational degrees of freedom, in response to pilot control. The visual projection system will simulate the external visual environment, as viewed through the cab windshield, and will be servo-controlled to maintain the proper relative orientation as the cab maneuvers. Analog computers will control the equipment to provide proper cab motion determined, in part, by programmed inertial and aerodynamic characteristics and, in part, by pilot control movements and simulated external disturbances (e.g., rough air).

The proposed facility will include, in addition to the simulator, a control room and supporting shop. No offices will be provided and no personnel will be permanently housed in the building.

PROJECT JUSTIFICATION:

Many advanced airplane and spacecraft designs now under development require additional crew members to aid the pilot in managing the complex systems necessary for the operation of the vehicle. New problems of aircrew coordination are introduced which must necessarily be considered in defining vehicle design limits that depend on the capabilities of the pilot and aircrew. The adequacy of existing one-man flight simulators to cope with these problems and provide meaningful solutions is severely limited.

Experience with modern subsonic jet and piston transports has shown that under some operating conditions airplanes designed to existing specifications tax the capabilities of the pilot to the limit. The workload reaches its peak as the airplane approaches the landing terminal under instrument flight conditions. The operation of supersonic transports will add to the complexity of all of the problems experienced in subsonic transport operations and, unless adequate solutions are found, will tax the capabilities of the already overburdened pilot and crew even further.

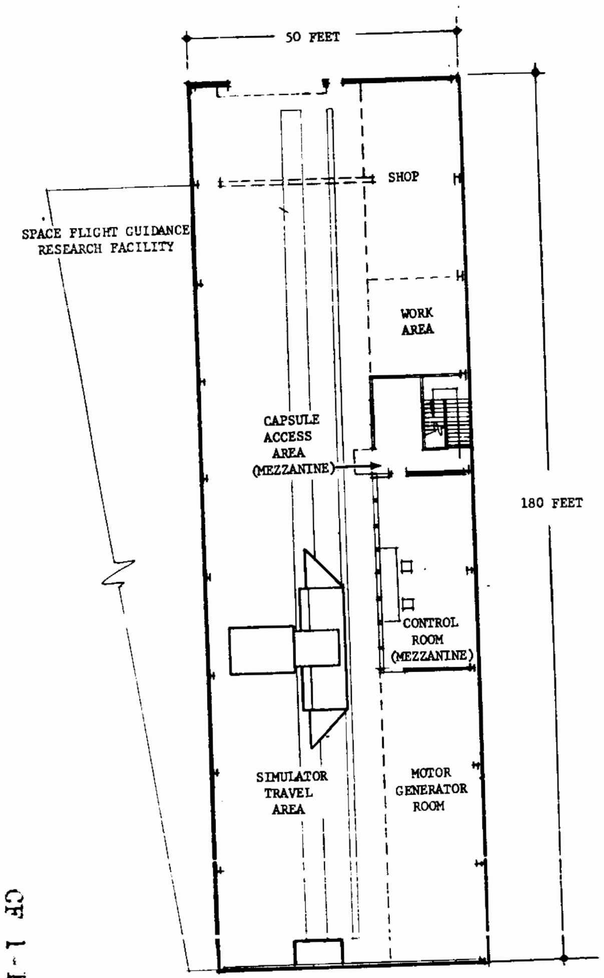
Problems generally have been met and overcome during the development of the subsonic air transport system. Two factors must be noted, however, which have played an extremely important part in this relatively successful development; first, the advances have come at a relatively slow rate, and second, military flight experience has been available with identical or similar aircraft prior to commercial use. In the case of the supersonic transport, neither of these beneficial factors will be present. The only feasible method of substituting for the technical guidance of real flight experience in an acceptable time period is through the use of the simulation technique.

The flight simulator described in this proposal will provide a unique research capability which, in addition to its general applicability to many advanced manned-vehicle control problems, will play an essential role in achieving early solutions to these critical supersonic transport problems. An entire operational flight can be simulated in real time, thus properly conditioning the pilot and crew for their critical let-down and landing tasks by subjecting them to all of the earlier stresses of the flight in proper time sequence.

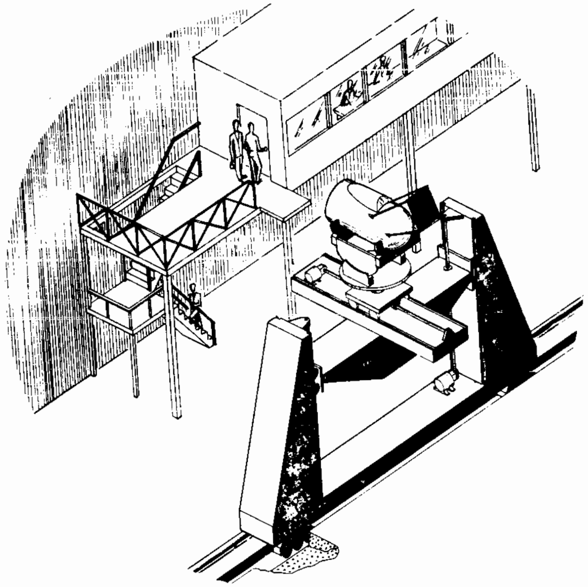
ESTIMATED FUTURE YEAR FUNDING: None

AMES RESEARCH CENTER
FISCAL YEAR 1965 ESTIMATES

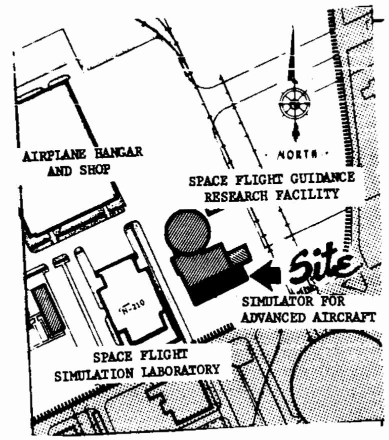
FLIGHT SIMULATOR FOR ADVANCED AIRCRAFT



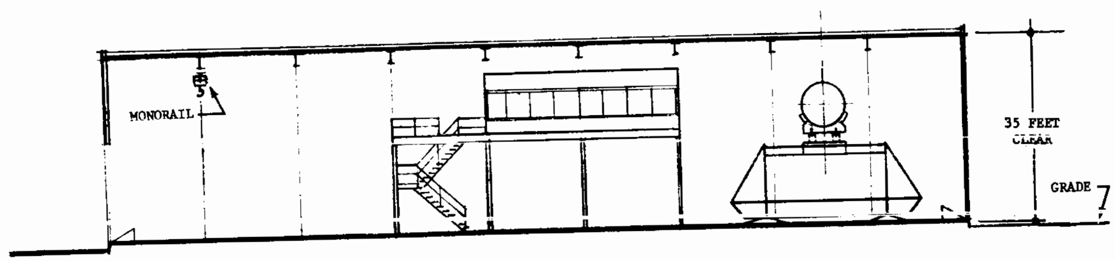
FLOOR PLAN



SCHEMATIC ISOMETRIC



PLOT PLAN



LONGITUDINAL SECTION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1965 ESTIMATES

INSTRUMENT BUILDING EXTENSION

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

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

AUTHORIZATION LINE ITEM: Ames Research Center

LOCATION OF PROJECT: Moffett Field, Santa Clara County, California

COGNIZANT NASA INSTALLATION: Ames Research Center

TYPE OF CONSTRUCTION PROJECT: Extension

FUNDING:

FY 1963 and Prior Years	---
FY 1964 Estimate	$75,000
FY 1965 Estimate	1,996,000
Total Funding Through FY 1965	$2,071,000

PROJECT COST ESTIMATES:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$1,286,000
Utilities	LS	---	$75,000	75,000
Electrical distribution	LS	---	45,000	45,000
Building	Sq. Ft.	46,000	21.00	966,000
Particular mech., plumbing and electrical	LS	---	200,000	200,000
Equipment				$630,000
Nuclear magnetic resonance equipment	LS	---	60,000	60,000
Microwave equipment	LS	---	97,000	97,000
Chemical analysis equipment	LS	---	60,000	60,000

	Unit of Measure	Quantity	Unit Cost	Total Cost
Clean room	LS	---	$40,000	40,000
Densitometric equipment	LS	---	35,000	35,000
Sensor materials processing equipment	LS	---	75,000	75,000
Shielded rooms	LS	---	25,000	25,000
Supporting instruments	LS	---	128,000	128,000
Instrument fabrication and assembly tools	LS	---	110,000	110,000
Design	---	---	---	---
		SUBTOTAL		$1,916,000
Fallout Shelter				$80,000
		TOTAL		$1,996,000

PROJECT DESCRIPTION:

This proposal covers an extension of the present Instrument Building as shown on the attached drawing. The extension will add a total of about 46,000 square feet of space, included in two floors and a partial basement, to the existing building. It will provide additional laboratories and shops for research and development on sensors, instrument systems, and measurement techniques especially needed to support the enlarged physical sciences and new life sciences activities at the Ames Research Center.

Included within the extension will be about 25,000 square feet of laboratory-office area and 6,000 square feet of shop area. The new wings will contain a diagnostics area primarily concerned with instrument problems as approached by spectroscopic measurement techniques; a sensors area in which transducers will be tailor-made for application to specific sensors problems; a life-sciences-systems area which will provide for development of complete instrument systems and for checkout and calibration of integrated sensor systems such as might be incorporated in a restraint couch for a centrifuge; and lastly, a shop area to be devoted to fabrication, assembly, and calibration of instruments and instrument systems.

PROJECT JUSTIFICATION:

The present instrumentation facilities were designed to meet the needs of Ames Research Center in 1950, when the research programs of the Center were primarily concerned with "conventional" aeronautics. In addition to the increased scope of the aeronautics programs, new research programs in the physical sciences and life sciences have generated a greatly increased requirement for instrumentation support. The initial expansion of this work has been accomplished within the existing instrumentation division facilities; however, the degree of congestion existing there will not permit further necessary growth. The quality of the present research is severely handicapped by inadequate instrumentation support.

One important area in which the Center must expand its program is that of long-range research on new measurement techniques. The instrumentation division at Ames has emphasized short-range solutions to instrumentation problems. The continuing trend toward higher speeds and operating altitudes for aircraft and higher entry velocities for spacecraft have focused attention on the field of rarefied gas dynamics, an understanding of which is dependent on data derived from pressure sensors. The instrumentation division has achieved a degree of success on this problem. One of the factors limiting performance of a present sensor is the energy loss due to the internal friction in the diaphragm material. Available theories describing energy dissipation in vibrating solids are unable to predict or explain the experimental results. A clear understanding of this phenomenon is fundamental not only to the improvement of the pressure sensor but also to the development of many devices important to space technology. The equipment and laboratories proposed will greatly facilitate future instrumentation research projects. Other examples of highly specialized measurement requirements associated with research on the aerothermodynamics of atmosphere entry pose an entirely new set of instrument problems requiring such specialized equipment as the microwave facilities and X-ray densitometers included in this proposal.

Additional facilities are also needed in order to develop the integrated circuits required in rugged instruments of small size and high reliability suitable for ground-based or space experiments. There exists a need for producing and processing sensors from semiconductor materials tailored to these particular instrumentation problems.

Research in solar phenomena, particularly remote measurements of the sun's magnetic field, requires that spectral measurements be made with high precision over a narrow portion of the spectrum. Special optical measuring techniques must be developed to meet these needs and the proposed facilities will provide this development capability.

Finally, the proposed addition will also provide the laboratory space and specialized equipment vitally needed to support biomedical and biophysical research at the Center, such as: development of a more absolute measure of blood pressure; development of practical means of continuous measurement of blood flow in the various parts of humans or animals without injury to the subjects. A major increase in instrumentation support is also required in connection with life sciences experiments sponsored by Ames for inclusion in space-vehicle payloads involving such techniques as microwave spectroscopy, or cellular resonance.

<u>ESTIMATED FUTURE YEAR FUNDING</u>: None

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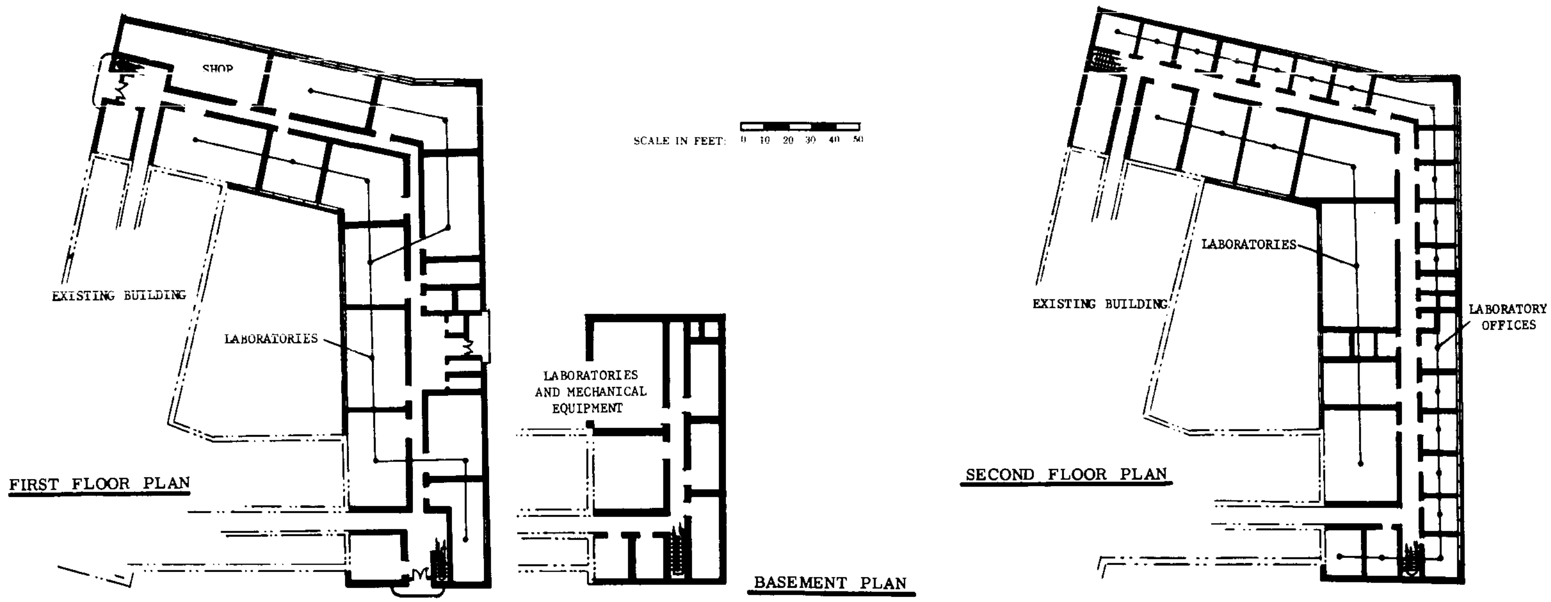
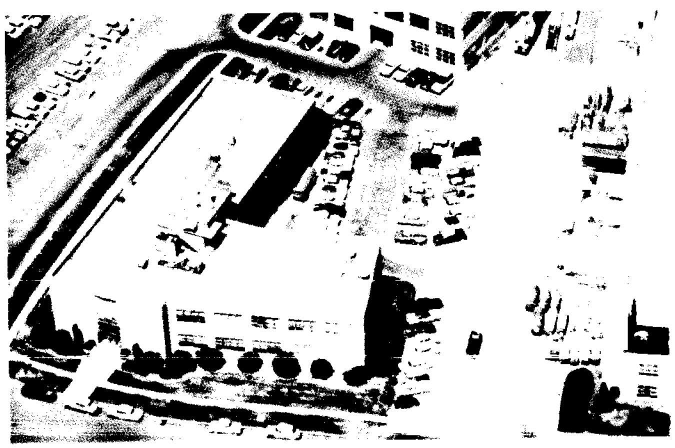
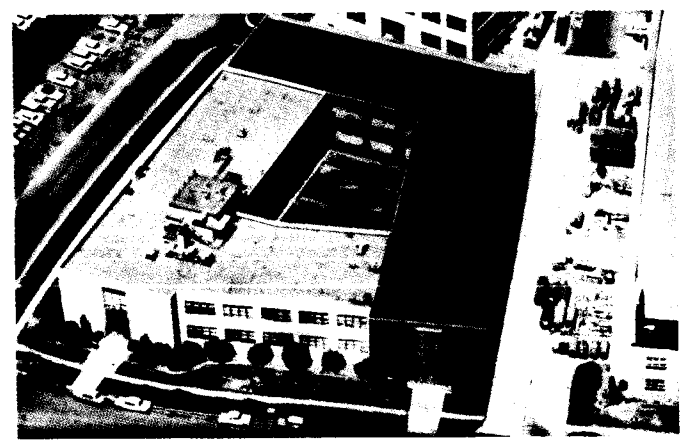
AMES RESEARCH CENTER
FISCAL YEAR 1965 ESTIMATES

INSTRUMENT BUILDING EXTENSION





EXISTING
INSTRUMENT LABORATORY



MODIFIED PHOTOGRAPH
PROPOSED WING IN PLACE

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1965 ESTIMATES

CENTER SUPPORT FACILITIES

PROGRAM OFFICE FOR THE INSTALLATION: Office of Advanced Research & Technology

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

AUTHORIZATION LINE ITEM: Electronics Research Center

LOCATION OF PROJECT: To be determined

COGNIZANT NASA INSTALLATION: Electronics Research Center

TYPE OF CONSTRUCTION PROJECT: New

FUNDING:

FY 1963 and Prior Years	---
FY 1964 Estimate	---
FY 1965 Estimate	$1,950,000
Total Funding Through FY 1965	$1,950,000

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$1,850,000
Heating and refrigeration plant	LS	---	$700,000	700,000
Sewage treatment plant	LS	---	50,000	50,000
Site preparation	LS	---	25,000	25,000
Roads	LS	---	65,000	65,000
Utilities	LS	---	1,010,000	1,010,000
Equipment	---	---	---	---
Design	---	---	---	100,000
For construction	LS	---	100,000	100,000

	Unit of Measure	Quantity	Unit Cost	Total Cost
Fallout Shelter	---	---	---	---
		TOTAL		$1,950,000

PROJECT DESCRIPTION:

The site development and support facilities for the Electronics Research Center located on a postulated 1,000-acre suburban site required up to the point of construction completion of the Center are included. Since a specific site has not been selected, these are the best available estimates based on advice and experience of other NASA Centers and the U. S. Army Corps of Engineers.

Site development includes site clearing and grading, topsoil and seeding, storm drainage system, utility tunnels, basic road network, walkways and street lighting.

Support facilities will comprise the heating and refrigeration plant and appropriate distribution systems, the sewage collection and treatment systems, the electrical transformer plant and distribution system, the communications system and the water supply system.

PROJECT JUSTIFICATION:

The Center Support Facilities are required to permit operation of and provide support for the individual laboratories and engineering and administration building of the Electronics Research Center.

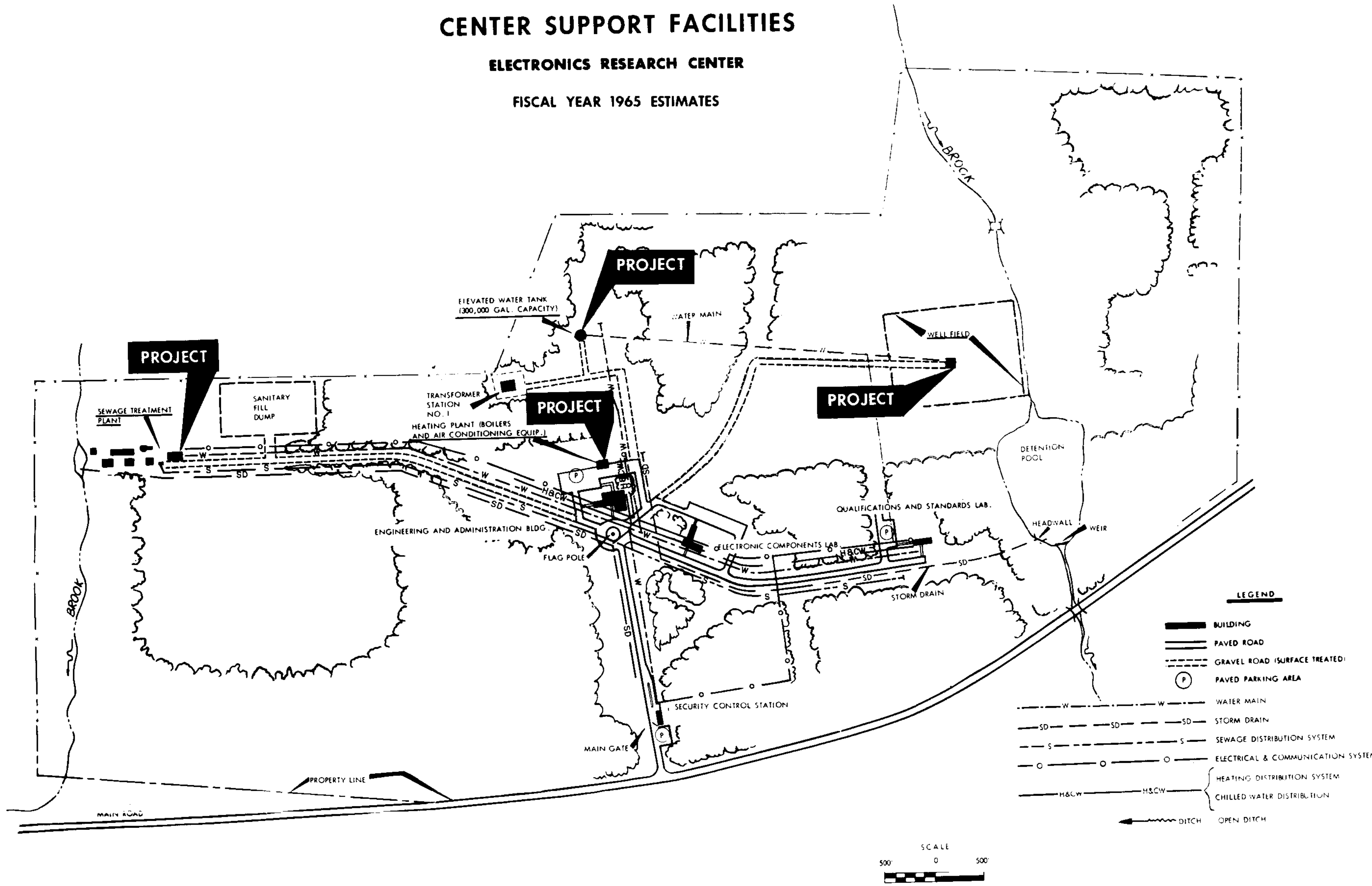
Without these basic road, clearing, and utilities the individual laboratories of the Center could not function.

ESTIMATED FUTURE YEAR FUNDING: $2,950,000

CENTER SUPPORT FACILITIES

ELECTRONICS RESEARCH CENTER

FISCAL YEAR 1965 ESTIMATES



CONSTRUCTION OF FACILITIES

FISCAL YEAR 1965 ESTIMATES

ELECTRONIC COMPONENTS LABORATORY

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

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

AUTHORIZATION LINE ITEM: Electronics Research Center

LOCATION OF PROJECT: To be determined

COGNIZANT NASA INSTALLATION: Electronic Research Center

TYPE OF CONSTRUCTION PROJECT: New

FUNDING:

FY 1963 and Prior Years	---
FY 1964 Estimate	---
FY 1965 Estimate	$3,200,000
Total Funding Through 1965	$3,200,000

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$1,192,000
Support building	Sq. Ft.	45,900	$24.77	1,137,000
Site preparation	LS	---	2,100	2,100
Roads & parking	LS	---	12,900	12,900
Utilities	LS	---	40,000	40,000
Equipment				$1,908,000
Component fabrication equipment	LS	---	734,000	734,000
Sample preparation equipment	LS	---	90,000	90,000

	Unit of Measure	Quantity	Unit Cost	Total Cost
Laboratory analytical equipment	LS	---	$319,000	319,000
Component test equipment	LS	---	461,000	461,000
Cryogenic equipment	LS	---	100,000	100,000
Glass technology equipment	LS	---	204,000	204,000
Design				$100,000
For construction	LS	---	86,000	86,000
For equipment	LS	---	14,000	14,000
Fallout Shelter	---	---	---	---
		TOTAL		$3,200,000

PROJECT DESCRIPTION:

This laboratory will be a three-story building containing laboratory and related equipment spaces, special laboratory areas, office adjuncts, utilities and equipment storage spaces housing 210 scientists and engineers, research assistants, and clerical aides. Approximately 45,900 total square feet will be divided into 15,000 square feet for laboratories on the first, second, and third floors; 3,000 square feet for special laboratories on the second floor; 1,400 square feet for a clean room on the third floor; 19,000 square feet for allied office space; and about 7,500 square feet for utilities and storage of laboratory equipment. Air conditioning and air filtering will be provided to maintain cleanliness and humidity control necessary for the precise investigations to be undertaken. The building will provide necessary isolation from noise, vibration, and radio frequency interference. A fire alarm system will be provided. Appropriate site development, parking for 168 cars (based on one space per 1.25 persons), immediate access roads, walkways, and utilities, including water, sewer, electric power, and communications will be included.

The facility laboratories will contain the following equipment: microcircuit research equipment, processing and testing equipment, precision servo system research and testing equipment, a glass technology laboratory, and thin film research and testing equipment; as well as specialized environmental facilities related to microcircuit and thin film work.

PROJECT JUSTIFICATION:

The Electronic Components Laboratory is required for the conduct of a research program pertaining to electronic components to be used in the space environment. The scope of the research will include studies and investigations in the theory, behavior, and design of electronic components in the following areas: solid state technology, materials, vacuum devices and electro-mechanical componentry. Analysis in depth of NASA flight and launch partial successes and failures has revealed in many instances electronic components failure or deficient performance. A major factor leading to failure or deficient component performance is found in the use in space of electronic components designed for the earth or near-earth environment. Although some improvements have been made in component design and development for space use, improvements of several orders of magnitude are required to meet the reliability and performance specifications of NASA's planned and future space flights.

The laboratory staff will conduct, supervise, and coordinate a balanced research program within and without the laboratory aimed at the creation and design of new and effective electronic components and circuits for space use. These research efforts will be directly related to the performance requirements of current and future space systems. The availability of tested component techniques and designs will materially aid NASA and industry project designers in their creation of new flight systems. A strong basic and applied research effort of this nature is necessary for success in the manned and unmanned space flight missions of the future.

ESTIMATED FUTURE YEAR FUNDING: None

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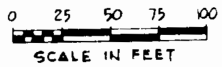
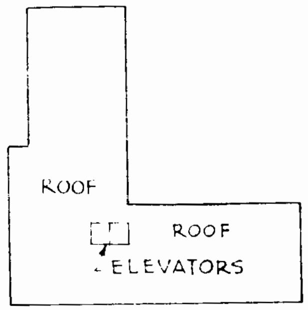
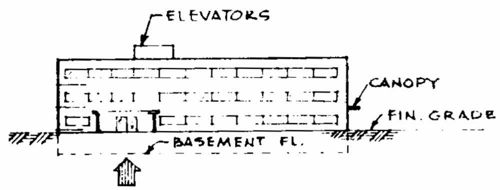
ELECTRONICS RESEARCH CENTER
FISCAL YEAR 1965 ESTIMATES
ELECTRONIC COMPONENTS LABORATORY

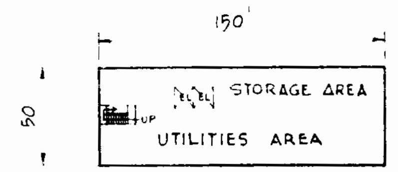




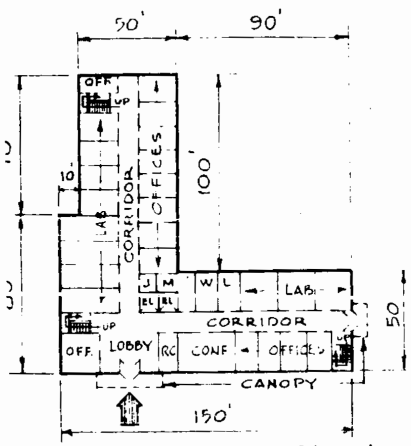
ROOF PLAN



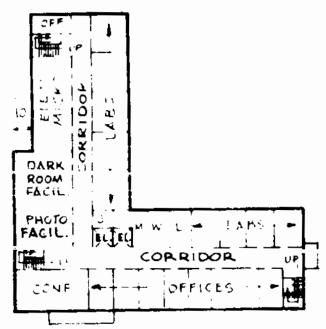
FRONT ELEVATION



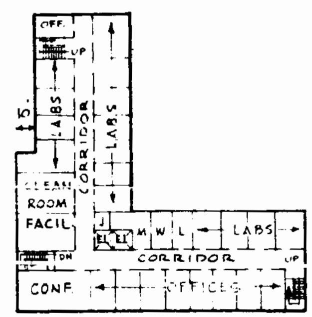
BASEMENT PLAN



FIRST FLOOR PLAN



SECOND FLOOR PLAN



THIRD FLOOR PLAN

CF 2-9

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1965 ESTIMATES

ENGINEERING AND ADMINISTRATION BUILDING

PROGRAM OFFICE FOR THE INSTALLATION: **Office of Advanced Research and Technology**

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

AUTHORIZATION LINE ITEM: Electronics Research Center

LOCATION OF PROJECT: To be determined

COGNIZANT NASA INSTALLATION: Electronics Research Center

TYPE OF CONSTRUCTION PROJECT: New

FUNDING:

FY 1963 and Prior Years	---
FY 1964 Estimate	---
FY 1965 Estimate	$1,850,000
Total Funding Through 1965	$1,850,000

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$1,632,000
Support building	Sq. Ft.	84,400	$18.67	1,576,000
Site Preparation	LS	---	5,000	5,000
Roads & parking	LS	---	25,000	25,000
Utilities	LS	---	26,000	26,000
Equipment				$122,000
Projection equipment, intercom, vaults and admin. equipment	LS	---	67,000	67,000
Library stacks and reproduction equipment	LS	---	35,000	35,000

	Unit of Measure	Quantity	Unit Cost	Total Cost
Infirmary equipment	LS	---	$15,000	$15,000
Security control station - identification equipment and guard alert services	LS	---	5,000	5,000
Design				$96,000
For construction	LS	---	91,000	91,000
For equipment	LS	---	5,000	5,000
Fallout shelter	---	---	---	---
		TOTAL		$1,850,000

PROJECT DESCRIPTION:

The Engineering and Administration Building will be a four-story building with a portion two stories high, irregularly shaped, approximately 82,000 total square feet in area. The facility will be divided into about 43,000 square feet of office and administrative space and about 7,000 square feet devoted to utilities, storage and equipment. In addition to providing administrative office, conference and engineering planning and drafting space for Electronics Research Center professional and engineering personnel, the building will contain: a kitchen and cafeteria with a seating capacity of 400, conference rooms, an auditorium accommodating 350 persons, the Center infirmary and a technical library. The building will be air conditioned; heating and air-conditioning will be supplied by the Center central heating plant. A fire alarm system will be provided. Site development, parking for 272 vehicles (supporting the Engineering and Administration Building and the security control station), access roads, and utilities such as water, sewer, electric power and communications will be included.

The security control station will be a one story structure with basement, containing 2,400 square feet of special guard facilities for Electronics Research Center security forces.

PROJECT JUSTIFICATION:

This building is required to house the first increment of administrative and technical staff of the Electronics Research Center. The building will provide for centralized location of center senior management, technical program planning, administrative planning and during the first years of Center operations, increments of the Center's research program staff.

NASA plans to be able to work out cooperative arrangements with educational institutions in the area whereby courses may be offered at the Electronics Research Center to advance the education of the Center professional staff. The auditorium and conference rooms will be used after normal working hours to provide classroom facilities at the Center.

The professional staff members involved in basic research and advanced development must have access to the latest scientific and technical manuscripts and professional journals in electronics and related disciplines. Hence a technical library will be included to serve as a repository for the required scientific publications and to provide a reading room and study area.

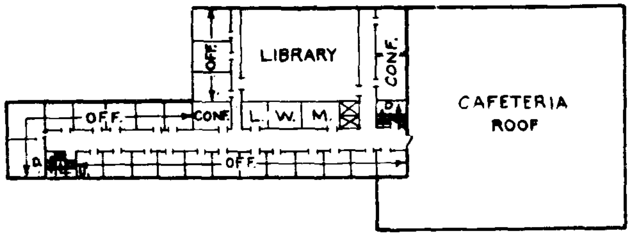
The security control station will serve as the administrative headquarters and initial visitor reception area for the Center and provides facilities for the security force engaged in the maintenance of NASA's security regulations and plant protection.

ESTIMATED FUTURE YEAR FUNDING: None

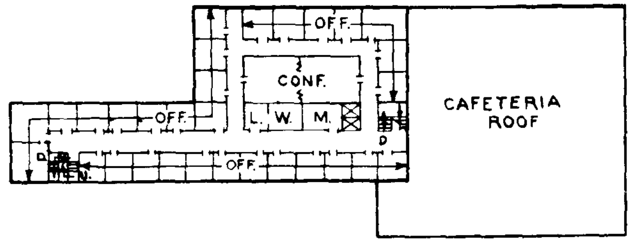
ELECTRONICS RESEARCH CENTER

FISCAL YEAR 1965 ESTIMATES

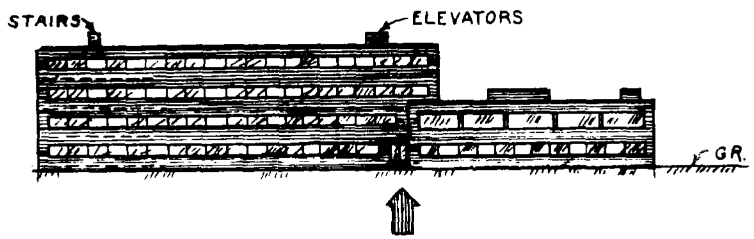
ENGINEERING & ADMINISTRATION BUILDING



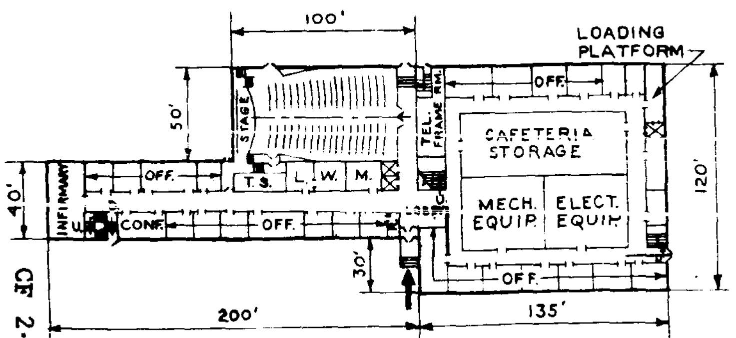
THIRD FLOOR PLAN



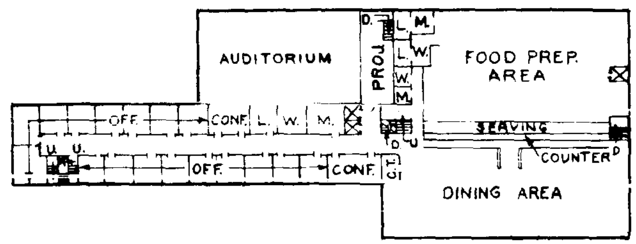
FOURTH FLOOR PLAN



FRONT ELEVATION



FIRST FLOOR PLAN



SECOND FLOOR PLAN

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1965 ESTIMATES

QUALIFICATION & STANDARDS LABORATORY

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

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

AUTHORIZATION LINE ITEM: Electronics Research Center

LOCATION OF PROJECT: To be determined

COGNIZANT NASA INSTALLATION: Electronics Research Center

TYPE OF CONSTRUCTION PROJECT: New

FUNDING:

FY 1963 and Prior Years	---
FY 1964 Estimate	---
FY 1965 Estimate	$3,000,000
Total Funding Through 1965	$3,000,000

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$746,000
Support building	Sq. Ft.	30,000	$23.58	707,400
Site preparation	LS	---	800	800
Roads and parking	LS	---	7,400	7,400
Utilities	LS	---	30,400	30,400
Equipment				$2,203,000
Test and environmental equipment	LS	---	1,425,000	1,425,000
Standards equipment	LS	---	415,000	415,000
Special laboratory equipment	LS	---	363,000	363,000

	Unit of Measure	Quantity	Unit Cost	Total Cost
Design				$51,000
For construction	LS	---	$38,000	38,000
For equipment	LS		13,000	13,000
Fallout Shelter	---	---	---	---
		TOTAL		$3,000,000

PROJECT DESCRIPTION:

The laboratory will be a two-story building, providing office space and laboratory facilities for 150 research personnel and clerical aides. Approximately 30,000 square feet total will be divided into 10,000 square feet devoted to laboratory areas (including 2,500 square feet reserved for a 100-inch centrifuge), 10,000 square feet of office space on the first and second floors, and 10,000 square feet of basement space for utilities and storage.

The building will be air-conditioned; heating and cooling will be supplied by the Center central heating plant. A fire alarm system will be provided. Appropriate site development, parking for 120 vehicles (based on 1 space per 1.25 persons), access roads, and utilities such as water, sewer, electric power and communications will be included.

PROJECT JUSTIFICATION:

This laboratory is required for the conduct of component qualification and testing and the establishment of electronic design and fabrication standards. Major difficulties have been experienced by NASA in obtaining electronic components, subsystems, and systems meeting the high standards of quality and reliability necessary for use in the space environment. The large number of developers and suppliers of electronic components and the rapid changes in technology have made the establishment of basic standards and reliability qualifications particularly difficult. The lack of a common set of qualification requirements and standards has led to unnecessarily high costs for component development and manufacture, and inability of NASA system and project engineers to specify appropriately qualified components in their designs. Costly redesign delays, flight failures, and confusion and waste in the space electronics industry are a result of the existing lack of a common set of space electronics components specifications and standards.

This laboratory will be the NASA focal point for the establishment and promulgation of space electronics qualifications and standards in the form of qualified parts lists, qualification specifications and standards, calibration methods and procedures and environmental testing criteria serving other groups within the Center, other NASA Centers, other government agencies and intereste industrial and university groups.

Component qualification testing; specifications for space qualified electronic sub-assemblies and subsystems preparation; design criteria preparation for electronics and guidance elements; and component reliability engineering including quality assurance, failure analyses, initial sample testing and test criteria will be carried out in this facility. The research effort in environmental testing, standards, design criteria and related areas of qualifications and standards must be increased significantly if NASA is to reduce the hazard of mission failures resulting from faulty electronic components and systems.

<u>ESTIMATED FUTURE YEAR FUNDING</u>: None

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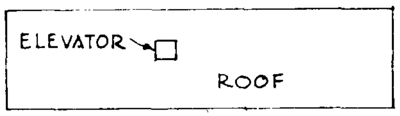
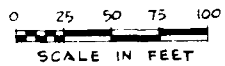
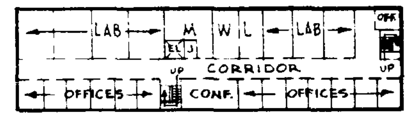
ELECTRONICS RESEARCH CENTER
FISCAL YEAR 1965 ESTIMATES
QUALIFICATION & STANDARDS LABORATORY

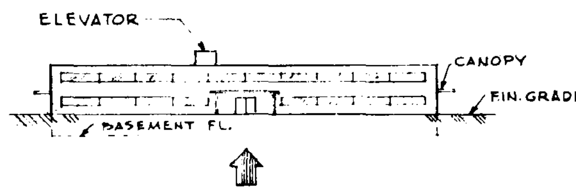


ROOF PLAN

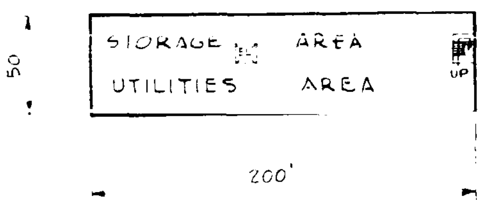




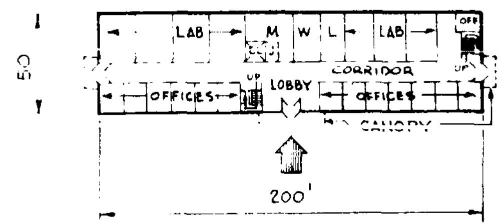
SECOND FLOOR PLAN



FRONT ELEVATION



BASEMENT PLAN



FIRST FLOOR PLAN

CF 2-17

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1965 ESTIMATES

STADAN ENGINEERING AND REAL TIME STATION

PROGRAM OFFICE FOR THE INSTALLATION: Office of Space Science and Applications

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

AUTHORIZATION LINE ITEM: Goddard Space Flight Center

LOCATION OF PROJECT: Greenbelt, Prince Georges County, Maryland

COGNIZANT NASA INSTALLATION: Goddard Space Flight Center

TYPE OF CONSTRUCTION PROJECT: New

FUNDING:

FY 1963 and Prior Years	---
FY 1964 Estimate	---
FY 1965 Estimate	$400,000
Total Funding Through FY 1965	$400,000

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$385,000
Operations building	Sq. Ft.	4,000	$ 18.00	72,000
Raised floor	Sq. Ft.	2,000	5.00	10,000
Generator building	Sq. Ft.	1,500	15.00	22,500
Restore facility to original condition	LS	---	150,000	150,000
Utilities	LS	---	85,500	85,500
Site preparation and fencing	LS	---	35,000	35,000
Roads and parking	LS	---	10,000	10,000
Equipment	---	---	---	---

	Unit of Measure	Quantity	Unit Cost	Total Cost
Design	---	---	---	$15,000
For construction	LS	---	$15,000	15,000
Fallout Shelter	---	---	---	---
		TOTAL		$400,000

PROJECT DESCRIPTION:

This project proposes the construction of a STADAN Engineering and Real Time Station at the vicinity of the Goddard Space Flight Center. The proposed location of the facility will be on a remote site of land obtained from the Department of Agriculture on a use permit, and will be readily accessible to Goddard personnel. The facility will be composed of an operations building and a generator building. The operations building will be of approximately 4,000 square feet area and will house electronic equipment and operating personnel. The building will be constructed of concrete and steel with movable partitions. A cavity in the raised floor will serve as an air-conditioning supply plenum for equipment cooling and cable raceway for intra-equipment cabling. A return air plenum will be provided in the ceiling arrangement. Foundations will be required for one pair of Minitrack, Telemetry, Array, Log Periodic, Command and Satan Antennas which will be transferred to this facility. Special switchgear, with dual buss, will be installed in order that the electronic equipment will not be subject to transient load pulsations. The voltage and frequency of the power will necessitate special regulation to permit proper operation of the electronic equipment. Communication connections will be made to the Goddard Space Flight Center Communications Center. The availability of real time data is a basic requirement. The construction will be such that enlargement of the facility may be accomplished should the need arise, without interfering with the operational capabilities of the station. The site will require that no high voltage transmission lines or other sources of RF interference be located in the immediate vicinity and no physical obstruction obscuring the horizon above ten degrees.

The generator building will be of approximately 1,500 square feet area. The construction will be of concrete and steel and will house diesel generators and associated switchgear equipment. The necessary electrical, chilled water, steam and drainage systems will be provided to adequately support the proposed facility including a parking area for approximately 45 personnel.

The facility will be capable of serving as a primary telemetry station in the NASA world wide network of satellite tracking and data acquisition stations and as a readily accessible facility to permit development, checkout and testing of new equipment and techniques as well as permitting engineering changes for network equipment to be verified and evaluated prior to modification of equipment at remote stations. Another use of the station will be spacecraft and ground equipment compatability testing prior to satellite launches.

PROJECT JUSTIFICATION:

As the unmanned space flight programs advance into a series of progressive and more complex flights the definite need for the design, development and evaluation of advanced equipment through the network is apparent. The advanced complex equipment required will have to be evaluated for determining operational performance prior to acceptability for field use. This project proposes the construction of a station to provide the Goddard Space Flight Center Engineering and Operations Division a means by which to perform this engineering function. At present, the development and evaluation capability is very limited and requires considerable enhancement. The complete telemetry system identical to the existing network system will provide spacecraft compatibility checks with the network and network equipment as well as the evaluation of any proposed engineering modifications.

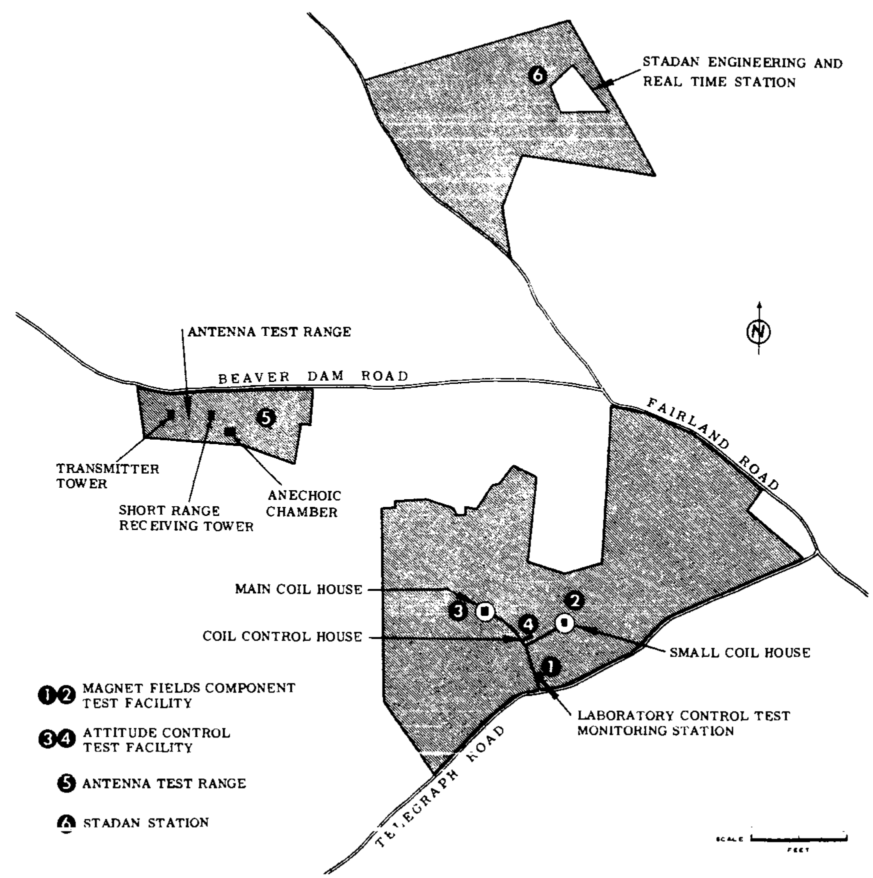
The existing "Real Time Telemetry Station" at College Park, Maryland will be integrated into this facility. The proposed station will have the capability to serve as a network link for gathering telemetry data. This data will be available for real time data processing because of the proximity to Goddard Space Flight Center. It will provide the project managers at Goddard Space Flight Center with real time data. The necessity of real time data has been demonstrated by past S-3, S-6 and S-49 satellite flights and future requirements.

The proposed facility will reduce total operating cost by closing the Blossom Point and College Park stations while enhancing project required capabilities. A savings of approximately $250,000 per year is expected from the elimination of overlap of operation as compared with a capital investment of $400,000. This savings results from elimination of contractor personnel required to operate Blossom Point and College Park, travel and duplication of logistics support. A recent detailed noise survey of the area adjacent to the Goddard Space Flight Center reflects an acceptable radio frequency noise level. The diesel generators will be used during critical tracking periods and as a standby in the event of commercial power failure.

ESTIMATED FUTURE YEAR FUNDING: None

GODDARD SPACE FLIGHT CENTER
FISCAL YEAR 1965 ESTIMATES

REMOTE SITE AREAS



CONSTRUCTION OF FACILITIES

FISCAL YEAR 1965 ESTIMATES

RELOCATION OF WALLOPS ISLAND TRAINING FACILITY

PROGRAM OFFICE FOR THE INSTALLATION: Office of Space Science and Applications

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

AUTHORIZATION LINE ITEM: Goddard Space Flight Center

LOCATION OF PROJECT: Greenbelt, Prince Georges County, Maryland

COGNIZANT NASA INSTALLATION: Goddard Space Flight Center

TYPE OF CONSTRUCTION PROJECT: New

FUNDING:

FY 1963 and Prior Years	---
FY 1964 Estimate	---
FY 1965 Estimate	$400,000
Total Funding Through FY 1965	$400,000

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$376,000
Operations and training building	Sq. Ft.	10,000	$22.50	225,000
Raised floor	Sq. Ft.	4,000	5.00	20,000
Utilities	LS	---	68,000	68,000
Site preparation and fencing	LS	---	50,000	50,000
Roads and parking	LS	---	13,000	13,000
Equipment	---	---	---	---

	Unit of Measure	Quantity	Unit Cost	Total Cost
Design				$24,000
For construction	LS	---	$24,000	24,000
Fallout Shelter	---	---	---	---
		TOTAL		$400,000

PROJECT DESCRIPTION:

This project proposes the relocation of the existing Manned Space Training Facility at Wallops Island, Va. to the Goddard Space Flight Center. The facility will be located north of the Multi-Purpose Building #19, near the northern boundary of the Center. The relocation will involve the construction of a combined operations and training building consisting of a ground floor and one additional floor, and will be of concrete and steel construction with masonry walls, and masonry and movable partitions. The operations area will be on the lower floor and will require approximately 4,000 square feet of raised flooring to accommodate cableways and air-conditioning ducts for electronic equipment. The relocated facility will continue to serve as a primary training center for personnel employed at the various tracking stations around the world. It will serve, in addition, as a readily accessible facility to permit the testing of new tracking and data techniques pertaining to the Manned Space Flight Program. The site for the facility will require that no high voltage transmission lines or other sources of RF interference be located in the immediate vicinity and no physical obstruction obscuring the horizon above ten (10) degrees. Offices, laboratories, classrooms, and parking areas will be provided for approximately 50 personnel. All necessary electrical, chilled water, steam and drainage systems will be provided to adequately support the facility.

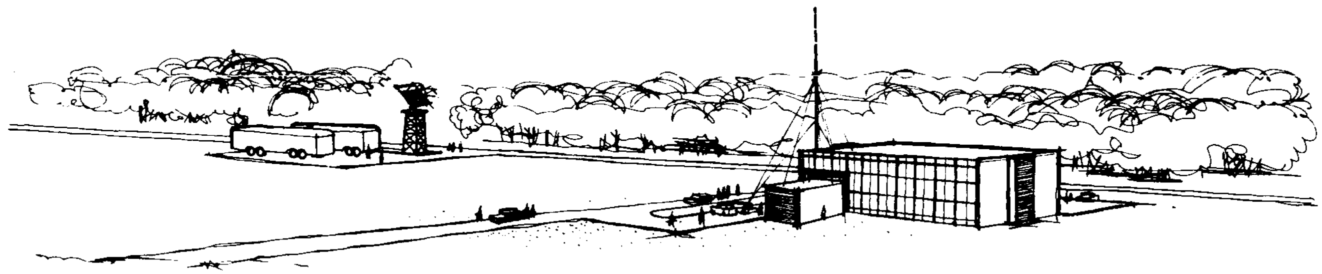
PROJECT JUSTIFICATION:

In order to make more effective use of the network training facilities by the personnel of the Manned Space Flight Operations Division located at the Goddard Space Flight Center, it is proposed that the Wallops Island Training Facility be relocated to the Center. The relocation is justified on the basis of operating economy since the training facility is presently staffed by contractor personnel whose jobs duplicate, to a degree, those performed by Goddard personnel. If the station is located at the Center, some of the contractor personnel could be eliminated and reductions could be made in travel, logistics, maintenance and operational costs. With the advent of the Apollo program it is apparent that the existing training area, established for the Mercury/Gemini programs, is unable to cope with the increased demand of the more advanced program. If the facility is not relocated, the present area must be greatly expanded due to the increased workload which will be necessary to meet the Apollo program.

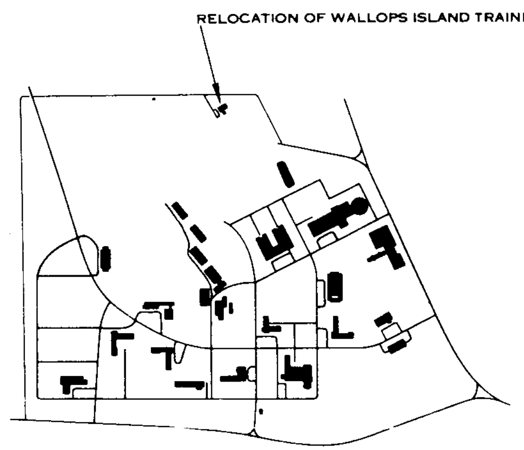
ESTIMATED FUTURE YEAR FUNDING: None

GODDARD SPACE FLIGHT CENTER
FISCAL YEAR 1965 ESTIMATES

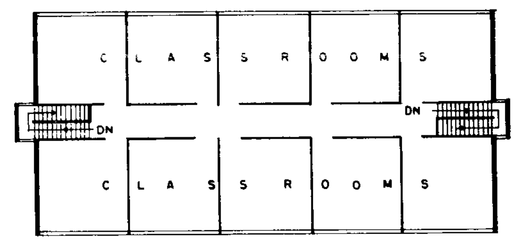
RELOCATION OF WALLOPS ISLAND TRAINING FACILITY



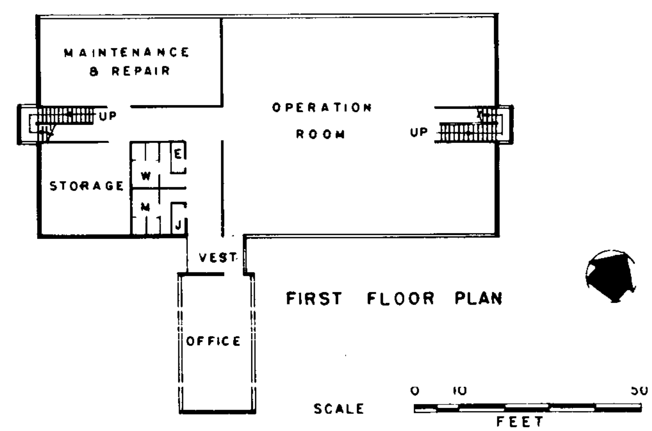
PERSPECTIVE



LOCATION PLAN



SECOND FLOOR PLAN



FIRST FLOOR PLAN

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1965 ESTIMATES

SUPPORTING SERVICES BUILDING

PROGRAM OFFICE FOR THE INSTALLATION: Office of Space Science and Applications

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

AUTHORIZATION LINE ITEM: Jet Propulsion Laboratory

LOCATION OF PROJECT: Edwards Test Station - Edwards Air Force Base
Kern County, California

COGNIZANT NASA INSTALLATION: Jet Propulsion Laboratory

TYPE OF CONSTRUCTION PROJECT: New

FUNDING:

FY 1963 and Prior Years	---
FY 1964 Estimate	---
FY 1965 Estimate	$400,000
Total Funding Thru FY 1965	$400,000

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$355,000
Support building	Sq. Ft.	14,000	$23.07	323,000
Site preparation	LS	---	2,500	2,500
Roads and parking	LS	---	1,000	1,000
Utilities	LS	---	28,500	28,500
Equipment				$25,000
Kitchen	LS	---	19,000	19,000
Photo laboratory	LS	---	6,000	6,000

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	Unit of Measure	Quantity	Unit Cost	Total Cost
Design				$20,000
For construction	LS	---	$20,000	20,000
Fallout Shelter	---	---	---	---
		TOTAL		$400,000

PROJECT DESCRIPTION:

This project provides for the completion of a 13,200 square foot combined engineering and support services building for Edwards Test Station. The proposed construction will provide a centralized supporting facility which will encompass almost all nonhazardous operations at the Test Station. The building will include support shops, photo laboratory, cafeteria, library and engineering offices.

The areas allocated for the various support functions housed in this building are of adequate size to support the present technical programs. The planned occupancy includes a total of thirty-six personnel.

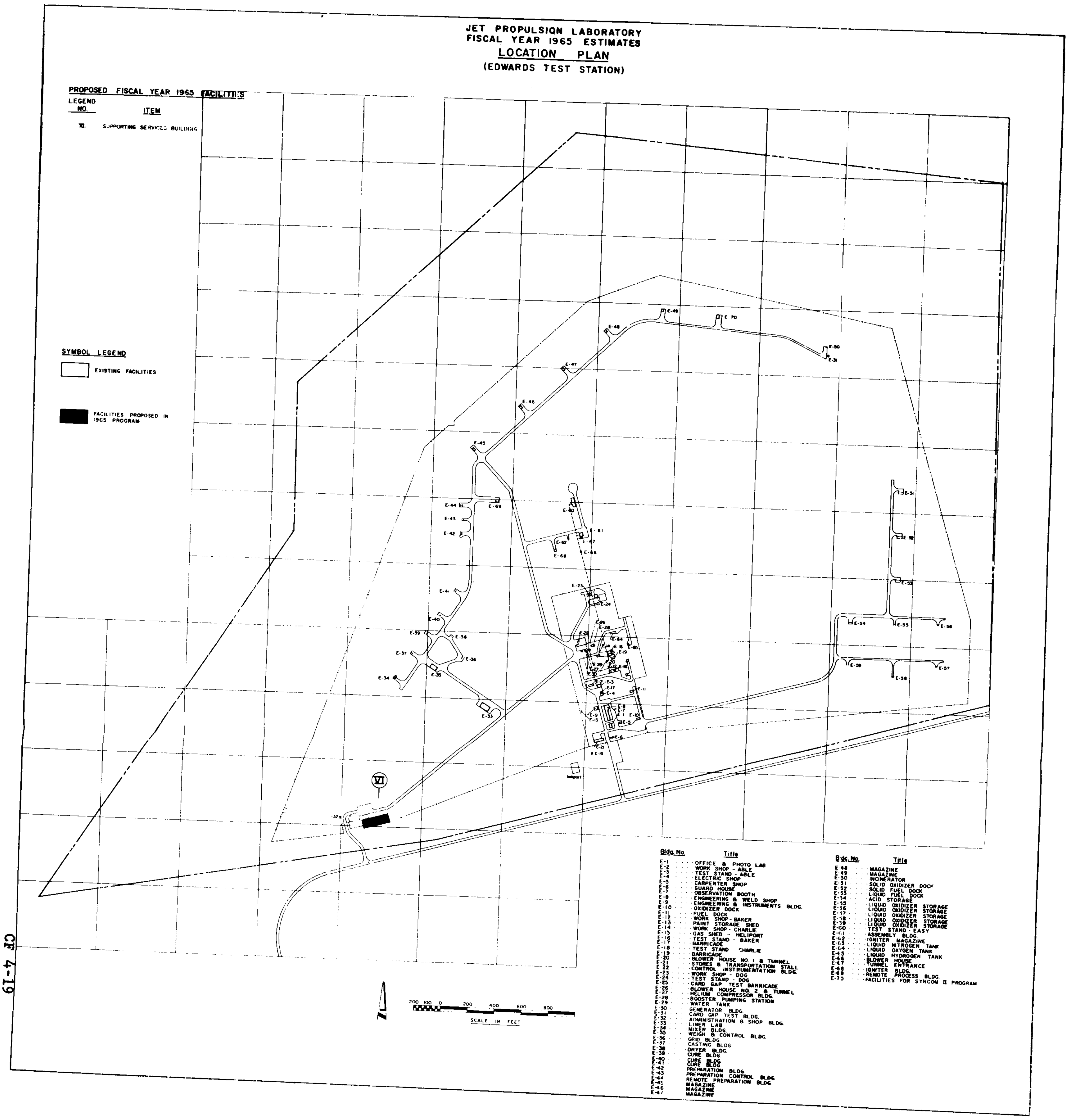
PROJECT JUSTIFICATION:

All of the old support services area is incorrectly sited from the safety standpoint as it lies within inhabited building distances of the test stands according to the Ordnance Safety Manual, ORDM 7-224. These safety deviations exist because ORDM 7-224, which is a part of JPL's contract, was not published until 1951, six years after the test station was activated. The new support service area is properly sited well away from explosive and toxic hazards yet close enough to provide a convenient, well integrated operation within one fenced area which provides maximum security and property control benefits with minimum manpower and transportation resources.

The proposed facility will provide support services for JPL technical operations which cannot be conducted in Pasadena because of the explosive and toxic hazards and the noise and atmospheric contamination which are often associated with test and development operations. The facility will be used to support such current JPL programs as Mariner, Syncom, and the liquid and solid propellant supporting research and advanced development programs. It will have the further capability to support propulsion testing of all spacecraft for which JPL is given responsibility.

In summary, the proposed facility is required to remove nonhazardous activities from the test stand areas to permit compliance with the Ordnance Safety Manual and to provide adequate facilities for operation of support functions.

ESTIMATED FUTURE YEAR FUNDING: None


JET PROPULSION LABORATORY
FISCAL YEAR 1965 ESTIMATES
LOCATION PLAN
(EDWARDS TEST STATION)
PROPOSED FISCAL YEAR 1965 FACILITIES
LEGEND NO.
ITEM
VI. SUPPORTING SERVICES BUILDING
SYMBOL LEGEND
EXISTING FACILITIES
FACILITIES PROPOSED IN 1965 PROGRAM
VI
SCALE IN FEET
200 100 0 200 400 600 800
Bldg. No. Title
E-1 OFFICE & PHOTO LAB
E-2 WORK SHOP - ABLE
E-3 TEST STAND - ABLE
E-4 ELECTRIC SHOP
E-5 CARPENTER SHOP
E-6 GUARD HOUSE
E-7 OBSERVATION BOOTH
E-8 ENGINEERING & WELD SHOP
E-9 ENGINEERING & INSTRUMENTS BLDG.
E-10 OXIDIZER DOCK
E-11 FUEL DOCK
E-12 WORK SHOP - BAKER
E-13 PAINT STORAGE SHED
E-14 WORK SHOP - CHARLIE
E-15 GAS SHED - HELIPORT
E-16 TEST STAND - BAKER
E-17 BARRICADE
E-18 TEST STAND CHARLIE
E-19 BARRICADE
E-20 BLOWER HOUSE NO. 1 & TUNNEL
E-21 STORES & TRANSPORTATION STALL
E-22 CONTROL INSTRUMENTATION BLDG.
E-23 WORK SHOP - DOG
E-24 TEST STAND - DOG
E-25 CARD GAP TEST BARRICADE
E-26 BLOWER HOUSE NO. 2 & TUNNEL
E-27 HELIUM COMPRESSOR BLDG.
E-28 BOOSTER PUMPING STATION
E-29 WATER TANK
E-30 GENERATOR BLDG.
E-31 CARD GAP TEST BLDG.
E-32 ADMINISTRATION & SHOP BLDG.
E-33 LINER LAB
E-34 MIXER BLDG.
E-35 WEIGH & CONTROL BLDG.
E-36 GRID BLDG.
E-37 CASTING BLDG
E-38 DRYER BLDG.
E-39 CURE BLDG.
E-40 CURE BLDG.
E-41 CURE BLDG.
E-42 PREPARATION BLDG.
E-43 PREPARATION CONTROL BLDG.
E-44 REMOTE PREPARATION BLDG.
E-45 MAGAZINE
E-46 MAGAZINE
E-47 MAGAZINE
Bldg. No. Title
E-48 MAGAZINE
E-49 MAGAZINE
E-50 INCINERATOR
E-51 SOLID OXIDIZER DOCK
E-52 SOLID FUEL DOCK
E-53 LIQUID FUEL DOCK
E-54 ACID STORAGE
E-55 LIQUID OXIDIZER STORAGE
E-56 LIQUID OXIDIZER STORAGE
E-57 LIQUID OXIDIZER STORAGE
E-58 LIQUID OXIDIZER STORAGE
E-59 LIQUID OXIDIZER STORAGE
E-60 TEST STAND - EASY
E-61 ASSEMBLY BLDG.
E-62 IGNITER MAGAZINE
E-63 LIQUID NITROGEN TANK
E-64 LIQUID OXYGEN TANK
E-65 LIQUID HYDROGEN TANK
E-66 BLOWER HOUSE
E-67 TUNNEL ENTRANCE
E-68 IGNITER BLDG.
E-69 REMOTE PROCESS BLDG.
E-70 FACILITIES FOR SYNCOM II PROGRAM

CF 4-19

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1965 ESTIMATES

THERMAL CONTROL HOUSING AND BUILDING ADDITION FOR DYNAMICS RESEARCH LABORATORY

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

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

AUTHORIZATION LINE ITEM: Langley Research Center

LOCATION OF PROJECT: Hampton, Virginia

COGNIZANT NASA INSTALLATION: Langley Research Center

TYPE OF CONSTRUCTION PROJECT: Alteration

FUNDING:

FY 1963 and Prior Years	---
FY 1964 Estimate	$60,000
FY 1965 Estimate	801,000
Total Funding Through FY 1965	$861,000

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$614,000
Laboratory	Sq. Ft.	7,425	$20.10	149,200
Sphere enclosure	Sq. Ft.	6,900	45.20	312,000
Additional ports	LS	---	10,100	10,100
Grading, paving, landscaping	LS	---	13,600	13,600
Utilities	LS	---	85,800	85,800
Catwalks, platforms and stairs in sphere enclosure	LS	---	43,300	43,300

	Unit of Measure	Quantity	Unit Cost	Total Cost
Equipment				$187,000
Crane	LS	---	$60,350	60,350
Special environmental controls	LS	---	126,650	126,650
Design	---	---	---	---
Fallout Shelter	---	---	---	---
		TOTAL		$801,000

PROJECT DESCRIPTION:

The proposed thermal control housing will enclose the 60-foot vacuum sphere of the dynamics research laboratory. Air conditioning equipment will be installed to maintain a uniform temperature around the sphere. Within the enclosure a bridge crane will be installed and observer's catwalk erected. The enclosure will be of steel frame and panel construction and will be approximately 80 by 90 by 80 feet high.

The project also includes a two-story and basement addition approximately 45 by 55 feet to the dynamics research laboratory building.

PROJECT JUSTIFICATION:

The 60-foot vacuum sphere to be enclosed, constitutes a free-body dynamics facility for research and development of spacecraft orientation and control systems in a simulated space environment. The requirement for temperature uniformity on the surface of the sphere is quite rigorous since spacecraft sensors are quite sensitive to temperature differentials. The sphere wall temperature differentials are caused by sunlight, wind, rain, and other weather conditions.

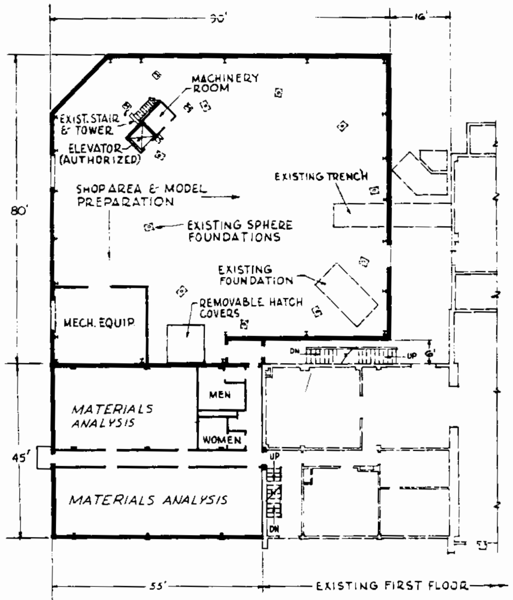
Without some means of stabilizing the wall temperatures, use of the sphere will be limited to a few hours beginning when temperatures stabilize after sunset, and ending at sunrise, on those nights when other weather factors are also constant. Uniform temperature of the sphere to about plus or minus 9°F is necessary in order not to introduce a false radiation which will interfere with evaluation of the sensor under test. A recent study indicated that the air-conditioned enclosure would be the most economical means to maintain an adequately uniform wall temperature for the necessary thermal differential between the planetary simulator and the walls.

The proposed bridge crane and catwalks are necessary to aid in meeting the programmed workload. This workload also imposes a need for a more extensive laboratory support area which will be met by the proposed laboratory addition. The addition will provide added facilities for evaluation and development of sensor and spacecraft elements relating to investigations to be carried on in the sphere.

ESTIMATED FUTURE YEAR FUNDING: None

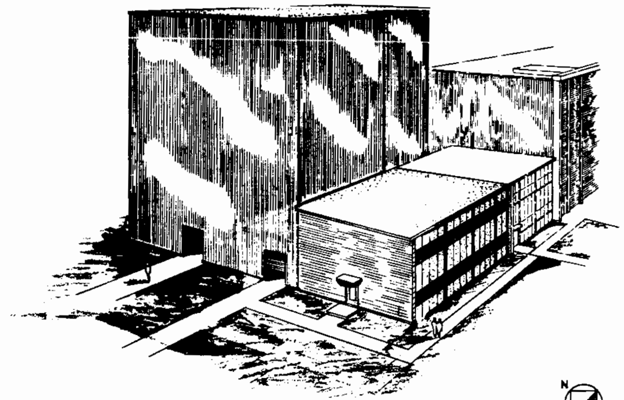
LANGLEY RESEARCH CENTER
FISCAL YEAR 1965 ESTIMATES

THERMAL CONTROL HOUSING AND BUILDING ADDITION FOR DYNAMICS RESEARCH LABORATORY

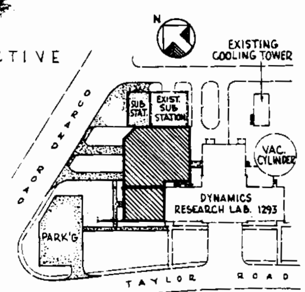


FIRST FLOOR PLAN

0 5 10 20 FT.

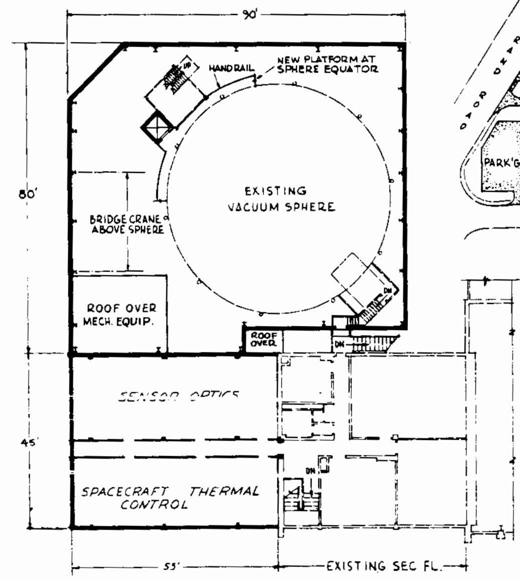


PERSPECTIVE



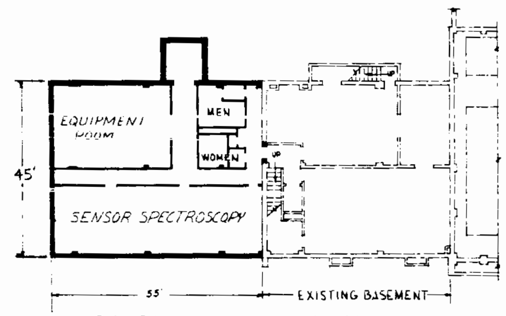
LOCATION PLAN

0 25 50 FT.



SECOND FLOOR PLAN

0 5 10 20 FT.



BASEMENT FLOOR PLAN

0 5 10 20 FT

LEGEND
EXISTING CONSTRUCTION
NEW CONSTRUCTION
NEW PAVEMENTS & WALKS

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1965 ESTIMATES

FATIGUE RESEARCH LABORATORY

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

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

AUTHORIZATION LINE ITEM: Langley Research Center

LOCATION OF PROJECT: Hampton, Virginia

COGNIZANT NASA INSTALLATION: Langley Research Center

TYPE OF CONSTRUCTION PROJECT: New

FUNDING:

FY 1963 and Prior Years	---
FY 1964 Estimate	$70,000
FY 1965 Estimate	1,221,000
Total Funding Through FY 1965	$1,291,000

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$873,500
Laboratory	Sq. Ft.	24,500	$24.20	592,900
Special foundations, fixtures and controls	LS	---	44,100	44,100
Site preparation	LS	---	21,600	21,600
Mechanical utilities	LS	---	12,000	12,000
Electrical utilities	LS	---	202,900	202,900
Equipment				$347,500
Cranes	LS	---	55,200	55,200
Fatigue research equipment	LS	---	112,000	112,000
Instrumentation	LS	---	170,700	170,700
Laboratory equipment	LS	---	9,600	9,600

	Unit of Measure	Quantity	Unit Cost	Total Cost
Design	---	---	---	---
Fallout Shelter	---	---	---	---
		TOTAL		$1,221,000

PROJECT DESCRIPTION:

This project will provide a laboratory with a floor area of approximately 24,500 square feet divided into three general areas:

(1) Hot structure test area, approximately 5,000 square feet provided to support large structural components during tests under cyclic heating and loading.

(2) General fatigue test area, approximately 15,500 square feet of air-conditioned space to house existing Langley fatigue test machines and associated equipment. Special cells will protect personnel from very high intensity noise associated with high-performance hydraulic test apparatus. A light-controlled room for photo-elastic stress analysis and special environmental control for tests in simulated space environments will be provided.

(3) General work space, approximately 4,000 square feet of space for working areas for scientific and supporting personnel.

This project will utilize the 10-megawatt power supply in an adjacent building.

PROJECT JUSTIFICATION:

Fatigue failures of materials and structures in operational aircraft continue to be very costly to the United States, both from a monetary standpoint and from loss in human lives.

Past efforts have been concerned primarily with aeronautical fatigue research, and NASA will continue to play a major role in this area. Extensive fatigue research is needed on high performance aircraft for which fatigue will be a major design consideration. As manned exploration of space is increased vehicles will be on longer missions and future space vehicles will be recovered and reused. Prevention of fatigue failure will become a major design consideration in this area also.

The need for fatigue research will continue so long as new materials, new structural configurations, and new environmental conditions occur.

Fatigue research at Langley is handicapped in meeting the program requirements because of the lack of adequate facilities. Tests require a more controlled environment operation and more space than is available in the present facilities.

This project was originally submitted in the Langley fiscal year 1964 budget estimates but was deferred by the authorization committee until a following year. The facility is considered urgent and is now being re-submitted.

ESTIMATED FUTURE YEAR FUNDING: None

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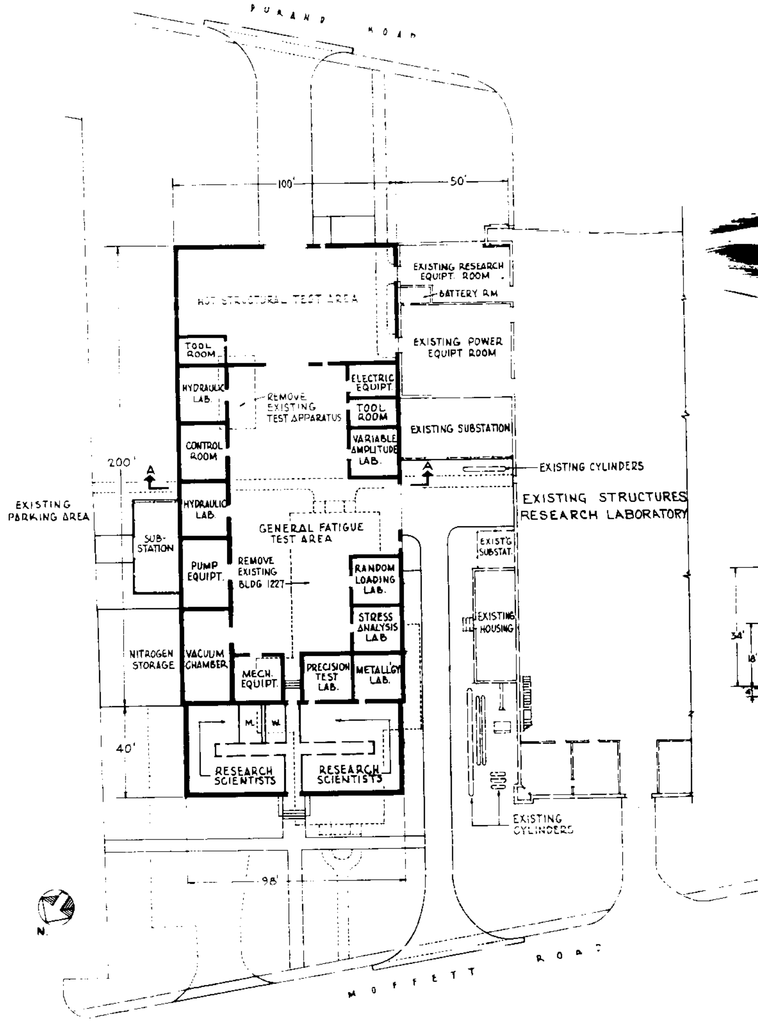
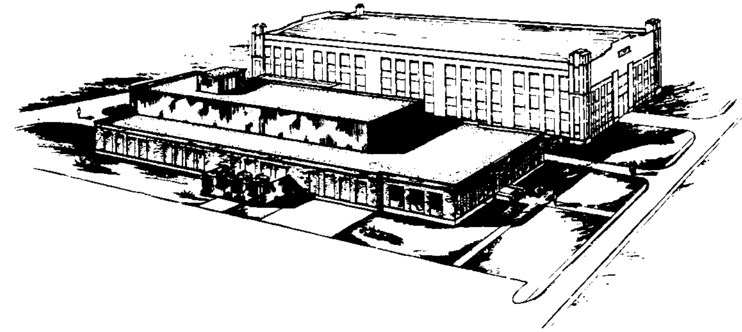
LANGLEY RESEARCH CENTER
FISCAL YEAR 1965 ESTIMATES

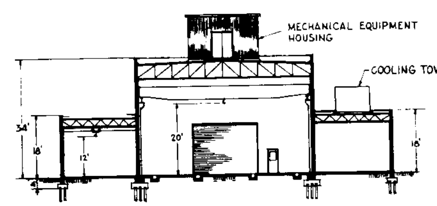
FATIGUE RESEARCH LABORATORY



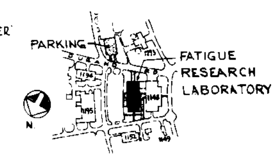
FLOOR PLAN



PERSPECTIVE



SECTION A-A



LOCATION PLAN

LEGEND
NEW CONSTRUCTION
EXISTING CONSTRUCTION
EXISTING TO BE REMOVED

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1965 ESTIMATES

CENTRAL HIGH PRESSURE AIR SUPPLY

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

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

AUTHORIZATION LINE ITEM: Langley Research Center

LOCATION OF PROJECT: Hampton, Virginia

COGNIZANT NASA INSTALLATION: Langley Research Center

TYPE OF CONSTRUCTION PROJECT: New

FUNDING:

FY 1963 and Prior Years	---
FY 1964 Estimate	$157,000
FY 1965 Estimate	2,077,000
Total Funding Through FY 1965	$ 2,234,000

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$753,100
Building (including equipment foundations)	Sq. Ft.	12,840	$27.32	350,800
Air storage field and manifold	LS	---	245,800	245,800
Electrical utilities	LS	---	150,400	150,400
Road extension	Sq. Yds.	790	7.72	6,100
Equipment				$1,323,900
Compressors	Each	3	301,200	903,600
Compressor auxiliary and connector piping	LS	---	420,300	420,300

	Unit of Measure	Quantity	Unit Cost	Total Cost
Design	---	---	---	---
Fallout Shelter	---	---	---	---
		TOTAL		$2,077,000

PROJECT DESCRIPTION:

This project will provide a central high-pressure air supply at the Langley Research Center capable of supplying 5,000 psi air at the rate of about 400,000 pounds per shift. An existing compressor station will be enlarged with the addition of three compressors, related electrical equipment, and cooling towers. The existing air storage will be increased by bottles providing about 73,000 pounds capacity.

PROJECT JUSTIFICATION:

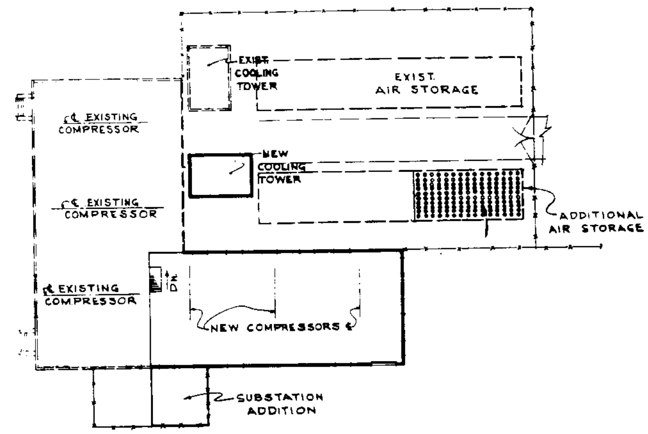
The original 5,000 psi air compressor station at Langley was designed in 1949 to generate hypersonic flows in a few adjacent blow-down wind tunnels with a maximum test section diameter of 10 inches. The practical applications of hypersonic flow phenomena have necessitated increased experimental effort at these speeds and have required new facilities which are now taxing the capacity of the present compressor station.

High pressure air to attain very high Mach numbers is presently used in 19 experimental facilities supplied by a 5,000 psi compressor station capable of producing nearly 200,000 pounds per 8-hour shift, and a storage field of about 500,000 pounds capacity. The average daily air requirement is presently about 320,000 pounds of air, so the compressors are operated on a two-shift basis. The storage field acts as a reservoir to supply the large, short-period demands for air. Imminent operation of the 8-foot high-temperature structures tunnel will double the daily air requirement. There will be delays in many vital programs to develop information having application to military and civilian aerospace vehicles if this facility is not obtained.

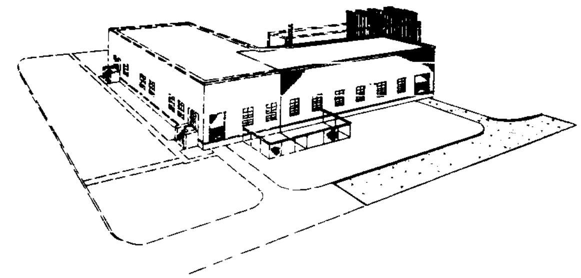
ESTIMATED FUTURE YEAR FUNDING: None

LANGLEY RESEARCH CENTER
FISCAL YEAR 1965 ESTIMATES

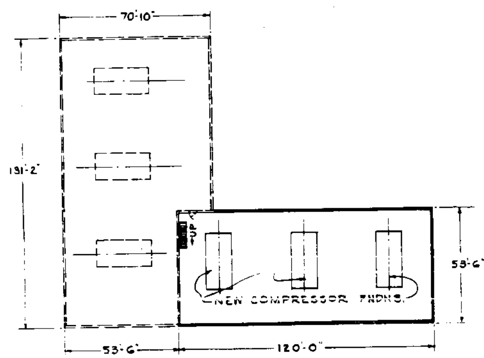
CENTRAL HIGH PRESSURE AIR SUPPLY



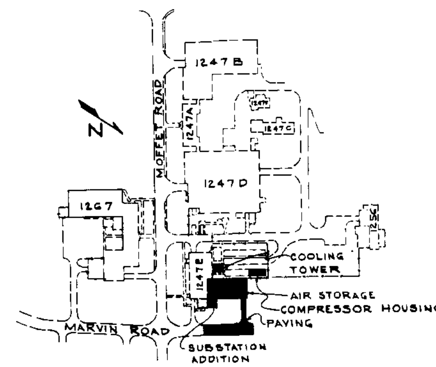
FIRST FLOOR PLAN



PERSPECTIVE
NO SCALE



BASEMENT PLAN
SCALE



LOCATION PLAN

LEGEND
▬▬ PROPOSED FACILITY
- - - EXISTING FACILITY

CF 6-13

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1965 ESTIMATES

UTILITY IMPROVEMENTS - ELECTRICAL SYSTEM

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

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

AUTHORIZATION LINE ITEM: Langley Research Center

LOCATION OF PROJECT: Hampton, Virginia

COGNIZANT NASA INSTALLATION: Langley Research Center

TYPE OF CONSTRUCTION PROJECT: New

FUNDING:

FY 1963 and Prior Years	---
FY 1964 Estimate	---
FY 1965 Estimate	$355,000
Total Funding Through FY 1965	$355,000

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$355,000
Transformers, circuit breakers	LS	---	$189,700	189,700
Bus install., cabling, switching	LS	---	165,300	165,300
Equipment	---	---	---	---
Design	---	---	---	---
Fallout Shelter	---	---	---	---
		TOTAL		$355,000

PROJECT DESCRIPTION:

This project will consist of increasing the available electrical distribution system capacity on the primary sub-station distribution bus at LRC. Transformers, circuit breakers, and other electrical gear will be added to provide the necessary isolation for circuits having high transient electrical loads. Provisions will also be included for updating and coordinating the balance of the distribution system at other secondary sub-stations to accommodate existing and programmed research facility requirements having transient power loads which affect the voltage regulation of the entire distribution system.

PROJECT JUSTIFICATION:

Expansion and modification of the Langley Research Center distribution system is needed to accommodate increases and changes in electrical load brought about by the addition of new research facilities.

Under present conditions, research facilities are being restricted in operation due to the limited capacity of the existing system. In addition, operation of the large (10,000 KW) electric arc air heaters operated in several new research facilities is imposing transient load disturbances on the distribution system. These disturbances affect the accuracy of data recorded on some research instrumentation with the resultant necessity for repeating test runs upon occasion.

The loads introduced by new facilities now under construction will increase the Center's base load by approximately 16,000 KW. These facilities involve new vacuum and helium pumping systems, power and auxiliaries for high heat rate environmental test systems and short time (10-minutes) high transient electric arc and heater power loads approximating 25,000 KW.

Isolation of the loads should be undertaken and the balance of the distribution system updated and coordinated in order to prevent possible breakdowns and eliminate undue interference with other research facility operations.

ESTIMATED FUTURE YEAR FUNDING: None

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1965 ESTIMATES

138-34.5KV ELECTRICAL POWER SUBSTATION
(Plum Brook Station)

PROGRAM OFFICE FOR THE INSTALLATION: Office of Advanced Research & Technology

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

AUTHORIZATION LINE ITEM: Lewis Research Center

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

COGNIZANT NASA INSTALLATION: Lewis Research Center

TYPE OF CONSTRUCTION PROJECT: New

FUNDING:

FY 1963 and Prior Years	---
FY 1964 Estimate	$40,000
FY 1965 Estimate	810,000
Total Funding Through FY 1965	$850,000

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$81,000
Site preparation - clearing, grading, and surfacing	LS	---	$13,000	13,000
Roads and utilities - water, gas, sewers, and communications	LS	---	18,000	18,000
Control, relay, and metering building	Sq. Ft.	1,540	12.99	20,000
Foundations, fence, cable, conduit and grounding	LS	---	30,000	30,000

	Unit of Measure	Quantity	Unit Cost	Total Cost
Equipment				$729,000
Power transformers	LS	---	$290,000	290,000
138 KV circuit breakers	LS	---	140,000	140,000
34.5 KV circuit breakers	LS	---	65,000	65,000
Control, metering, and relay equipment	LS	---	90,000	90,000
Substation structure, disconnect switches, insulators, bus bars, arresters, and instrument transformers	LS	---	144,000	144,000
Design	---	---	---	---
Fallout Shelter	---	---	---	---
		TOTAL		$810,000

PROJECT DESCRIPTION:

This project consists of modifications and additions to the existing electrical power system at the Plum Brook Station. A 138-34.5 KV substation will be installed on a loop of a 138 KV transmission line to be run into the station by the local utilities company. Two 40,000 KVA transformers will be installed, with capability of being converted to 50,000 KVA each by future modifications. The new substation will transform the power to the existing 34.5 KV transmission system level and will include all necessary circuit breakers, controls, metering, protective equipment, and automatic features required.

PROJECT JUSTIFICATION:

The present electrical service to the Plum Brook Station is provided by the local electrical power utility company by means of two 34.5 KV circuits emanating from a substation located in Sandusky, Ohio.

The estimated electric power requirements for the calendar year 1966 and beyond cannot be supplied by the existing 34.5 KV services.

On the basis of the estimated load development at Plum Brook Station, the expected load growth in the area, and facilities available to require additional service at the 34.5 KV level, it will be necessary to convert to 138 KV supply by the second quarter of calendar year 1966.

The nature of several of the research testing facilities at the Plum Brook Station requires a high degree of reliability of electrical power over

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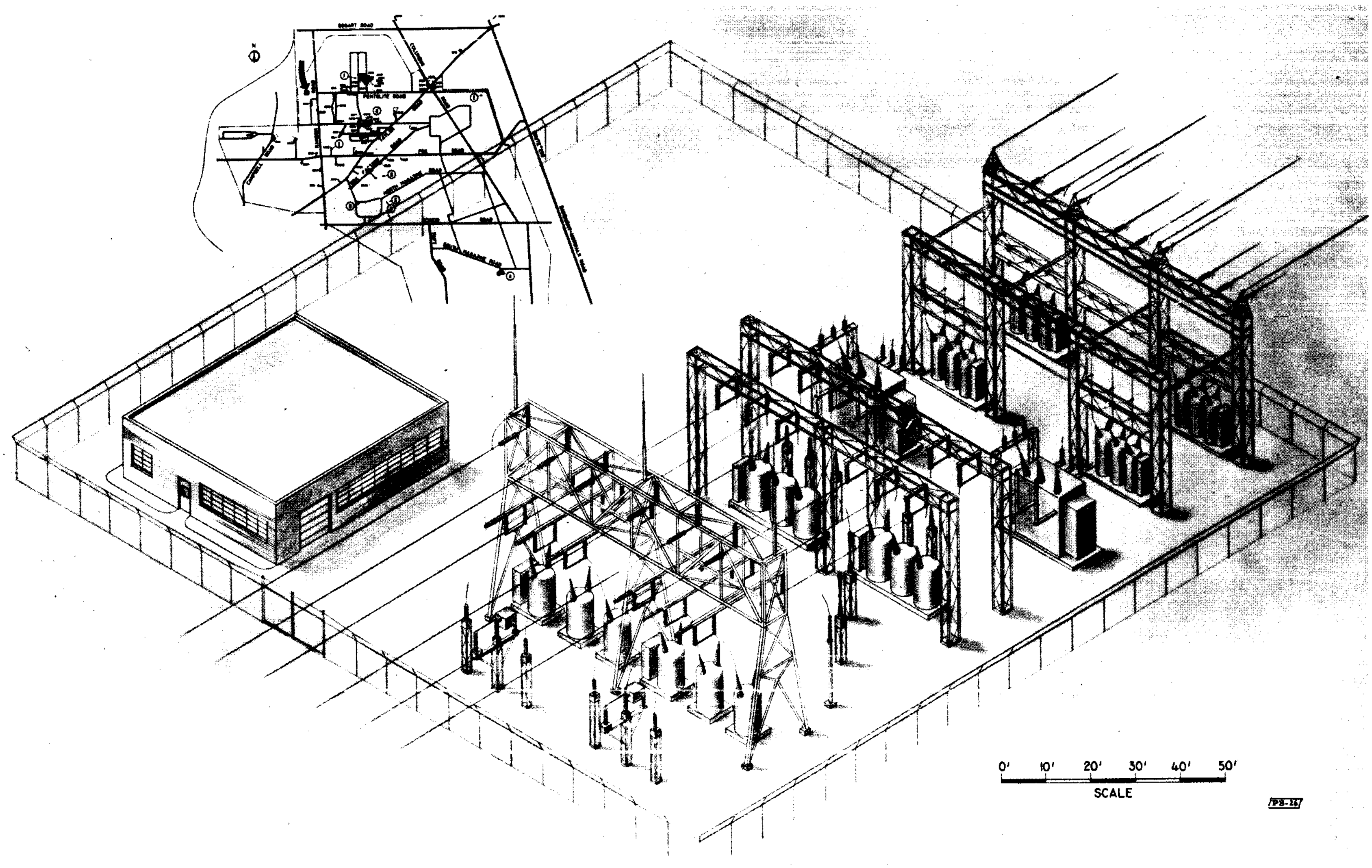
prolonged periods of time. Interruption of electrical power to these research facilities during testing operations may result in loss of experimental test data, set-up and operational time, and in some cases may lead to damage to research and facility components.

ESTIMATED FUTURE YEAR FUNDING: None

LEWIS RESEARCH CENTER
FISCAL YEAR 1965 ESTIMATES

138–34.5 KV. ELECTRICAL POWER SUB-STATION

PLUM BROOK STATION



CONSTRUCTION OF FACILITIES

FISCAL YEAR 1965 ESTIMATES

FACILITIES FOR M-1 ENGINE PROGRAM

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

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

AUTHORIZATION LINE ITEM: Various Locations

LOCATION OF PROJECT: Sacramento County, California

COGNIZANT NASA INSTALLATION: Lewis Research Center

TYPE OF CONSTRUCTION PROJECT: New

FUNDING:

FY 1963 and Prior Years	$13,166,000
FY 1964 Estimate	10,030,000
FY 1965 Estimate	3,970,000
Total Funding Through FY 1965	$27,166,000

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$240,000
Test stand modulars	LS	---	$200,000	200,000
K-1 stand	LS	---	40,000	40,000
Equipment				$3,730,000
Controls	LS	---	327,500	327,500
Propellant systems	LS	---	2,315,200	2,315,200
Other	LS	---	176,500	176,500
Instrumentation	LS	---	882,500	882,500
Fabrication	LS	---	28,300	28,300
Design	---	---	---	---

	Unit of Measure	Quantity	Unit Cost	Total Cost
Fallout Shelter	---	---	---	---
		TOTAL		$3,970,000

PROJECT DESCRIPTION:

This project provides for the following items of construction:

(1) Additional propellant unloading, distribution, and storage systems for liquid hydrogen, liquid oxygen, liquid nitrogen, gaseous hydrogen, gaseous nitrogen, and gaseous helium to complete the test area support necessary for test stand K-1.

(2) Additional deflector cooling water storage and pumping facilities for the K-1 test stand.

(3) Additional control room equipment for test stand K-1.

(4) Test equipment and industrial equipment to provide for equipment wear and replacement necessitated by damage, technical improvements, and/or design revisions.

PROJECT JUSTIFICATION:

This project is required to provide the additional facilities necessary to support the development of the M-1 engine. Prior year construction programs provided component test stands C, E, G, and H for thrust chamber, gas generator and turbopump testing; initiation of the Engine System Test Complex and partial construction of the limited firing duration K-1 engine test stand. This year's construction funds will complete construction of Engine Test Stand K-1.

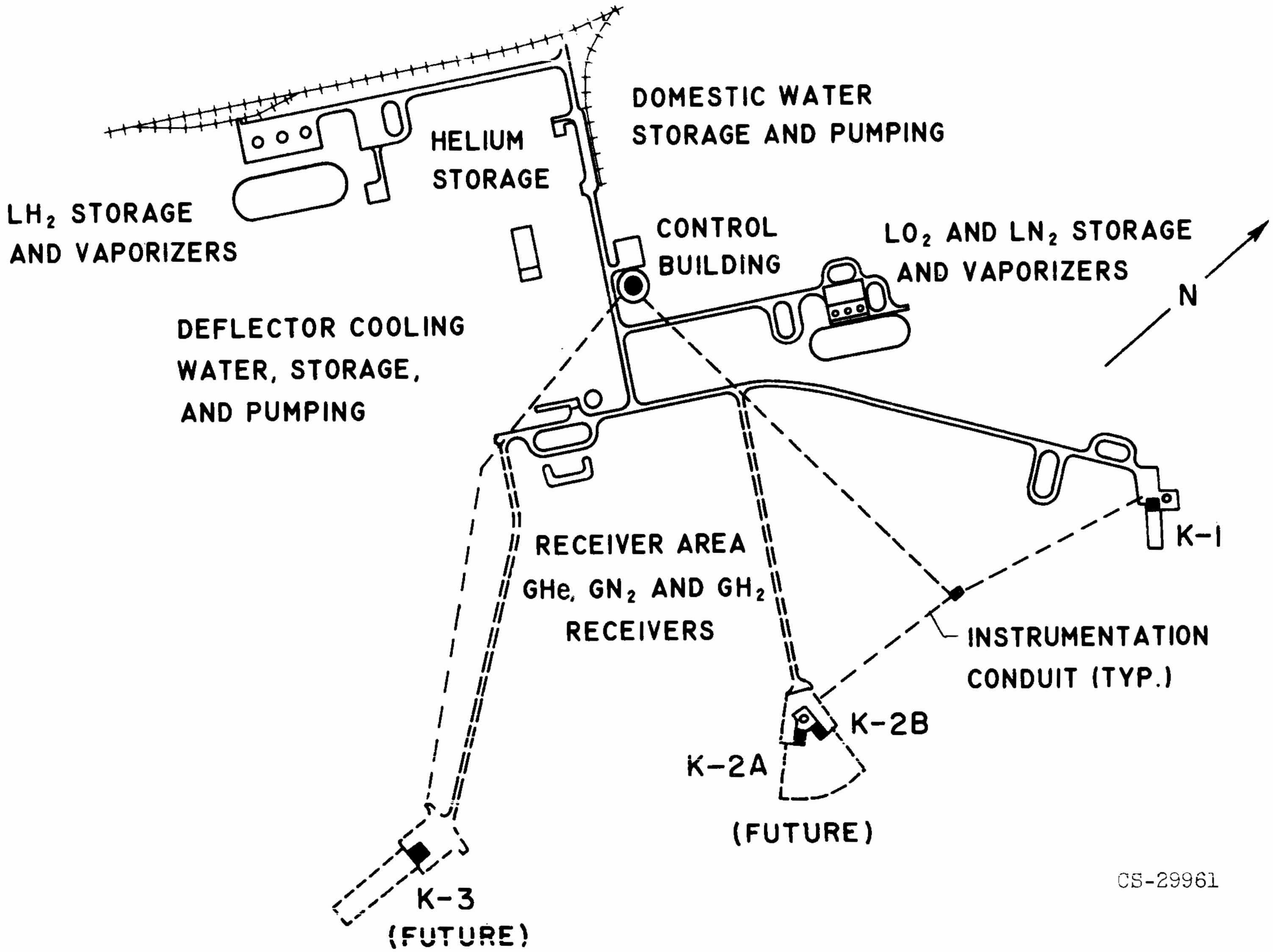
The K-1 stand will provide a capability for evaluation of the interaction of engine components, each operating at design conditions in an engine system. Such evaluation cannot be obtained on the existing component test stands. With the completed K-1 engine stand, the coupling of system components with the possibilities of complex vibrations or oscillations can be evaluated for the first time; components can also be evaluated in an engine system with respect to start and stop transients; and total system performance can be obtained with a realistic propellant flow configuration. In addition, this project allows for replacement of damaged test equipment, changes in test requirements and design revisions.

The K-1 engine test stand is planned to be used for engine tests in early 1966. Because of the funding exigencies of other programs, construction of this stand has been deferred. However, further delay in providing these engine test facilities and equipment will prohibit obtaining of information on component interaction in the environment of the engine system. Such information is vital to system integration and may require some component modification and redevelopment. Thus, these facilities are now crucial in the development of the 1,500,000 pound thrust liquid hydrogen/liquid oxygen, M-1 engine.

ESTIMATED FUTURE YEAR FUNDING: $33,000,000

M-1 ROCKET ENGINE PROJECT

ENGINE-SYSTEM TESTING K ZONE



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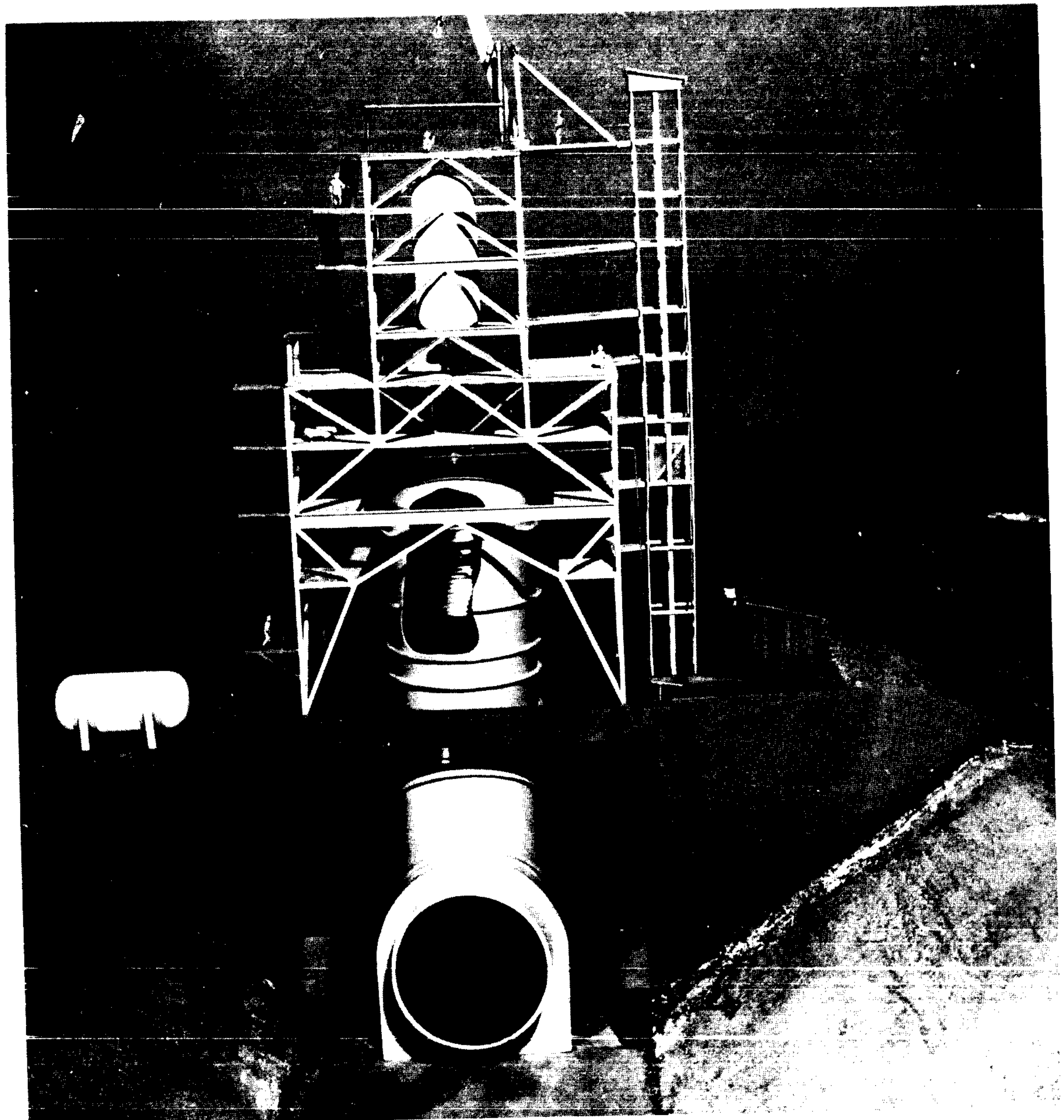

M-1 Rocket Engine Project - Test Stand K-1 Concept.

CF 12-28

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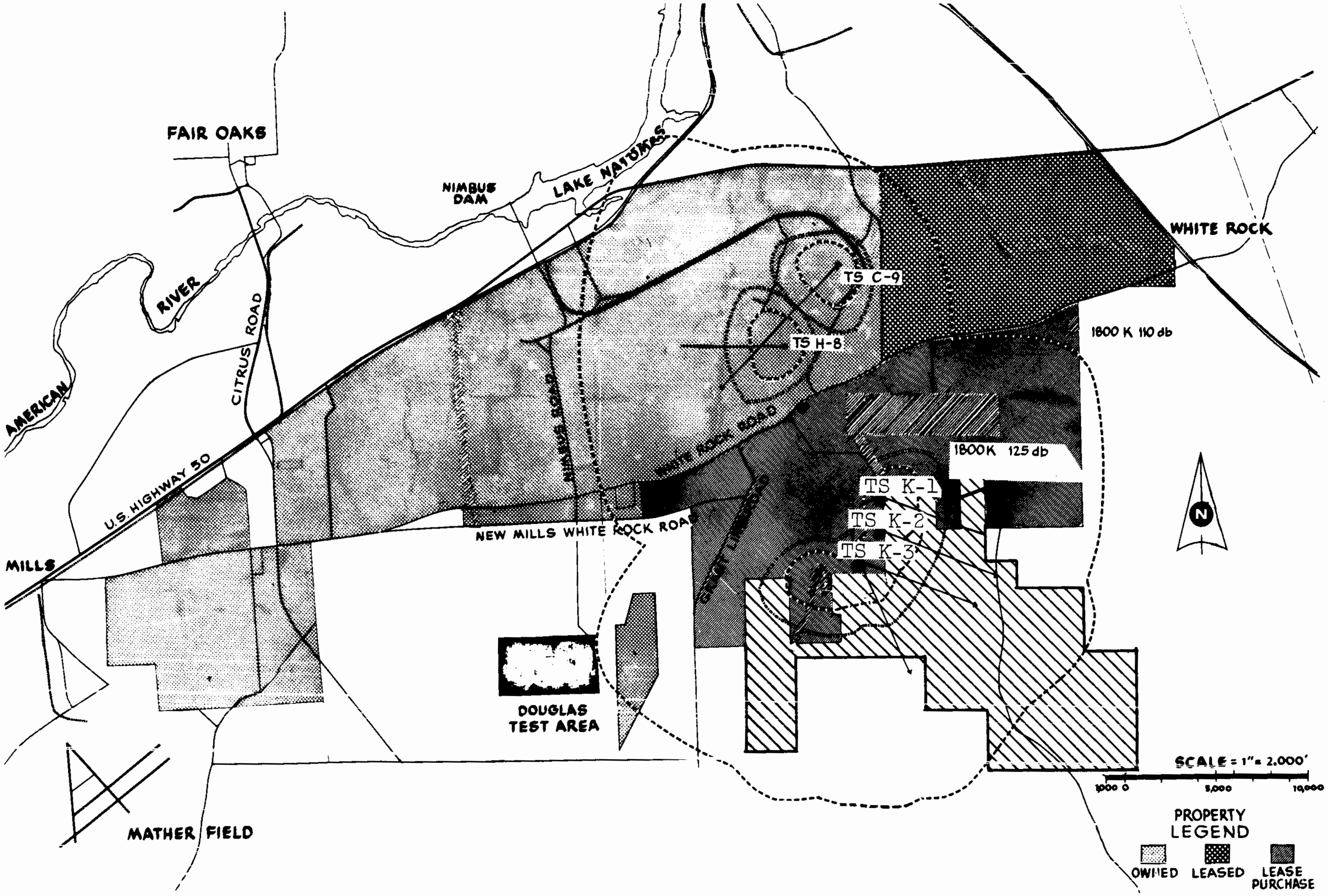
SACRAMENTO AREA MAP

AGC PROPERTIES, SACRAMENTO, CALIFORNIA



CF 12-29

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1965 ESTIMATES

ADDITION TO SPACE RADIATION EFFECTS LABORATORY

FOR ADDED CAPABILITIES

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

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

AUTHORIZATION LINE ITEM: Various Locations

LOCATION OF PROJECT: Newport News, Virginia

COGNIZANT NASA INSTALLATION: Langley Research Center

TYPE OF CONSTRUCTION PROJECT: Extension

FUNDING:

FY 1963 and Prior Years	$12,382,000
FY 1964 Estimate	105,000
FY 1965 Estimate	1,876,000
Total Funding Through FY 1965	$14,363,000

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$1,376,300
Building	Sq. Ft.	5,600	$21.16	118,500
Piling and cooling tower foundation	LS	---	106,000	106,000
Shielding	LS	---	815,000	815,000
Environmental controls	LS	---	142,900	142,900
Electrical utilities	LS	---	165,000	165,000
Demolition, excavating, and grading	LS	---	10,900	10,900
Utility trench	LF	60	300	18,000

	Unit of Measure	Quantity	Unit Cost	Total Cost
Equipment				$499,700
Instrumentation	LS	---	$300,000	300,000
Experimental physics facilities	LS	---	90,000	90,000
Radiation monitoring system	LS	---	5,000	5,000
Beam transportation system	LS	---	88,500	88,500
Extension of crane rails	LS	---	16,200	16,200
Design	---	---	---	---
Fallout Shelter	---	---	---	---
		TOTAL		$1,876,000

PROJECT DESCRIPTION:

The addition to the space radiation effects laboratory will include a neutron-meson experimental area together with the necessary shielding, beam transport systems, controls, instrumentation auxiliary equipment, and building services. Suitable internal targets will be provided for the production of neutrons and mesons by the collisions of the protons in the synchrocyclotron with these targets. High-density concrete and steel shielding will be utilized to minimize the thickness of this shielding wall between the synchrocyclotron and the neutron-meson area. Appropriate passages through the shielding wall for the neutrons and mesons will be provided.

PROJECT JUSTIFICATION:

Recent space flight experience has indicated an urgent need to study further aspects of radiation damage caused by secondary emission produced by the impact of energetic protons on spacecraft.

The secondary radiation capability, inherent in the accelerators in the space radiation effects laboratory, can be utilized by providing a a general purpose research area in which the secondary particles such as neutrons and mesons which occur when protons and electrons interact with the space vehicle surface can be studied. The laboratory will then have the unique capability of being able to conduct experiments with proton, electron, neutron, and meson beams in independent experimental areas, required to determine the effects of particle radiation encountered in space flight.

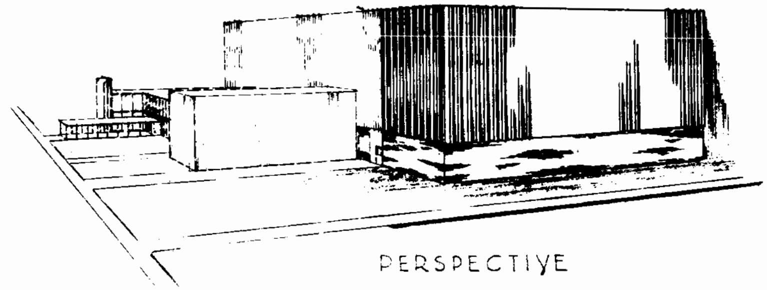
and the corrective measures required to minimize the hazards of this radiation.

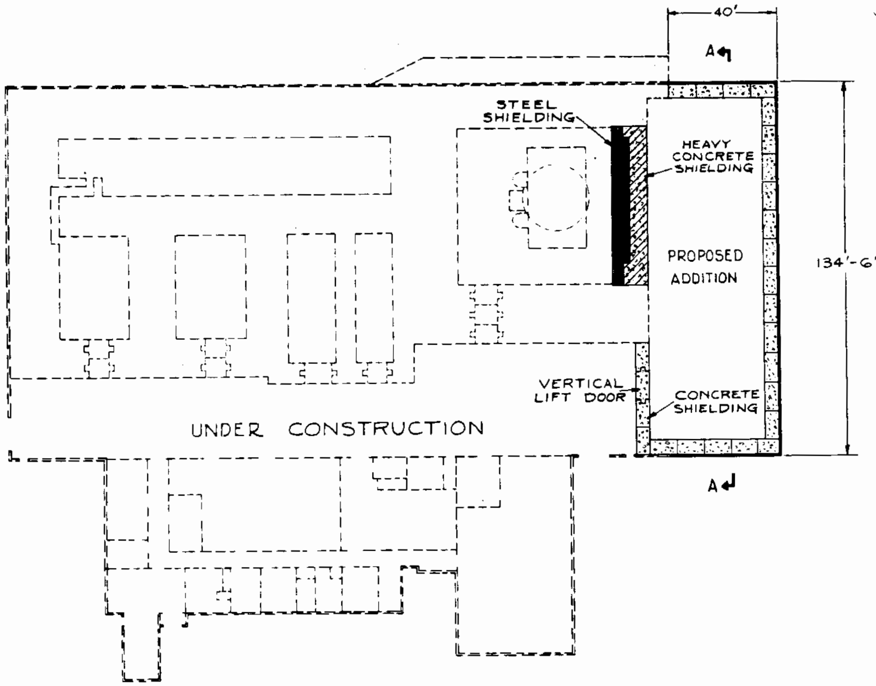
As time permits, the facility will be used for the education and training of the very specialized people needed for this work.

ESTIMATED FUTURE YEAR FUNDING: None

VARIOUS LOCATIONS
FISCAL YEAR 1965 ESTIMATES

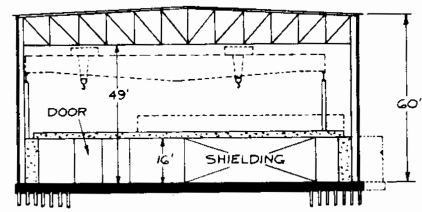
ADDITION TO SPACE RADIATION EFFECTS LABORATORY FOR ADDED CAPABILITIES





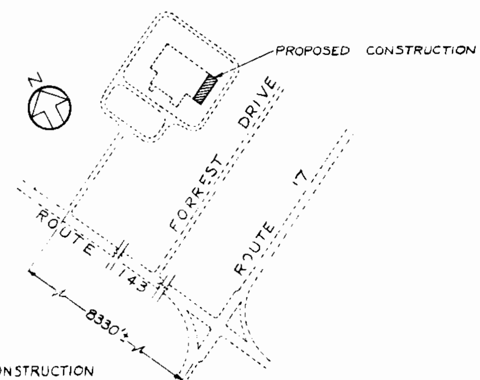
FIRST FLOOR PLAN

0 10 25 FT



SECTION A-A

0 5 15 25 FT



LEGEND
NEW CONSTRUCTION
PREVIOUSLY AUTHORIZED

LOCATION PLAN

0 100 200 FT

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1965 ESTIMATES

APOLLO NETWORK GROUND STATIONS - NEW STATIONS

PROGRAM OFFICE FOR THE INSTALLATION: Office of Space Science and Applications

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

AUTHORIZATION LINE ITEM: Various Locations

LOCATION OF PROJECT: Cape Kennedy, Florida
Northwest Pacific
Ascension Island

COGNIZANT NASA INSTALLATION: Goddard Space Flight Center

TYPE OF CONSTRUCTION PROJECT: New

FUNDING:

	Cape Kennedy	Northwest Pacific	Ascension Island
FY 1963 and Prior Years	---	---	---
FY 1964 Estimate	$15,000	$170,000	$170,000
FY 1965 Estimate	300,000	1,670,000	2,040,000
Total Funding Through FY 1965	$315,000	$1,840,000	$2,210,000

PROJECT COST ESTIMATE - CAPE KENNEDY:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$300,000
Instrumentation and operations building	Sq. Ft.	3,000	$29.00	87,000
Generator building	Sq. Ft.	1,000	25.00	25,000
Hydro-mechanical services	LS	---	20,000	20,000
Utilities	LS	---	58,000	58,000
Generators, switchgear and transformers	LS	---	90,000	90,000
Site preparation	LS	---	10,000	10,000

	Unit of Measure	Quantity	Unit Cost	Total Cost
Roads and parking	LS	---	$10,000	10,000
Equipment	---	---	---	---
Design	---	---	---	---
Fallout Shelter	---	---	---	---
		TOTAL		$300,000

PROJECT COST ESTIMATE - NORTHWEST PACIFIC:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$1,670,000
Instrumentation and operations building	Sq. Ft.	12,000	$53.75	645,000
Generator building	Sq. Ft.	3,000	46.67	140,000
Hydro-mechanical services	LS	---	20,000	20,000
Utilities	LS	---	295,000	295,000
Generators, switchgear and transformers	LS	---	385,000	385,000
Site preparation	LS	---	130,000	130,000
Roads and parking	LS	---	55,000	55,000
Equipment	---	---	---	---
Design	---	---	---	---
Fallout Shelter	---	---	---	---
		TOTAL		$1,670,000

PROJECT COST ESTIMATE - ASCENSION ISLAND:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---

	Unit of Measure	Quantity	Unit Cost	Total Cost
Construction				$2,040,000
Instrumentation and operations building	Sq. Ft.	12,000	$74.17	890,000
Generator building	Sq. Ft.	3,000	66.67	200,000
Hydro-mechanical services	LS	---	25,000	25,000
Utilities	LS	---	345,000	345,000
Generators, switchgear and transformers	LS	---	360,000	360,000
Site preparation	LS	---	140,000	140,000
Roads and parking	LS	---	80,000	80,000
Equipment	---	---	---	---
Design	---	---	---	---
Fallout Shelters	---	---	---	---
			TOTAL	$2,040,000
			GRAND TOTAL	$4,010,000

PROJECT DESCRIPTION:

This project provides for the construction of three (3) new stations for the Manned Space Flight Network (MSFN) to accommodate instrumentation systems required to support the Apollo program. The physical features of the stations will be virtually identical and the construction will differ only to conform with the type of construction used in each locale. The new MSFN Stations will be located at Cape Kennedy, Northwest Pacific and Ascension Island. The instrumentation systems for these facilties are being procured under prior year funding due to the developmental and fabrication lead-time involved.

The proposed facilities will include a 12,000 square-foot instrumentation and operations building (3,000 square feet at Cape Kennedy) to house elements of the integrated Apollo Unified S-Band System, communication systems, hardware for integration into the Apollo System, logistic support areas and general office space. The Cape Kennedy Operations Building will provide only for installation of consoles and power distribution equipment necessary to operate the S-Band Antenna System at a remote location. It is anticipated that the remainder of the system equipment can be installed in existing or other planned facilities. The antenna must be remotely located in order to avoid radio interference problems. A generator building of approximately 3,000 square feet (approximately 1,000 square feet at Cape Kennedy) will house the diesel generators and electrical distribution panels. A hydro-mechanical building will contain the collimation tower equipment and concrete foundations will be supplied for the antenna systems associated with the Apollo instrumentation. Provision is also made under this project for the necessary utility services for each station. Although, as noted above, the facilities to be constructed are basically identical, due to factors such as transportation costs and construction cost indexes which differ greatly due to the locations of the stations, separate cost estimates for each station are shown above.

PROJECT JUSTIFICATION:

The Manned Space Flight Network, which has proved successful in supporting Mercury flights to date, is in process of being modified to provide support to the Gemini project. As the manned flight program advances into the Apollo spacecraft phase with its series of progressively more complex orbital, cislunar and lunar space flights, the tracking, command, data acquisition and communications operations increase in complexity and will require additional and more complex ground support facilities. In order to provide the initial and minimum ground network coverage for the Manned Saturn IB flights, the new stations will be constructed and the existing ones will be modified to include the Apollo unified S-Band system. This is instrumentation designed to allow the ground station to transmit ranging signals, communications, and all other up-data to the spacecraft on one S-band carrier frequency, and to receive same from the spacecraft on a different S-band carrier frequency. To provide this capability, the additional facilities requested in this project are required to be completed prior to the end of calendar year 1965 in order to allow sufficient time for equipment installation, station checkout and network integration to support missions beginning in calendar year 1966.

ESTIMATED FUTURE YEAR FUNDING: None

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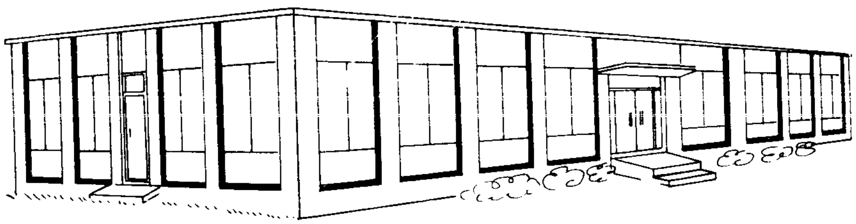
VARIOUS LOCATIONS

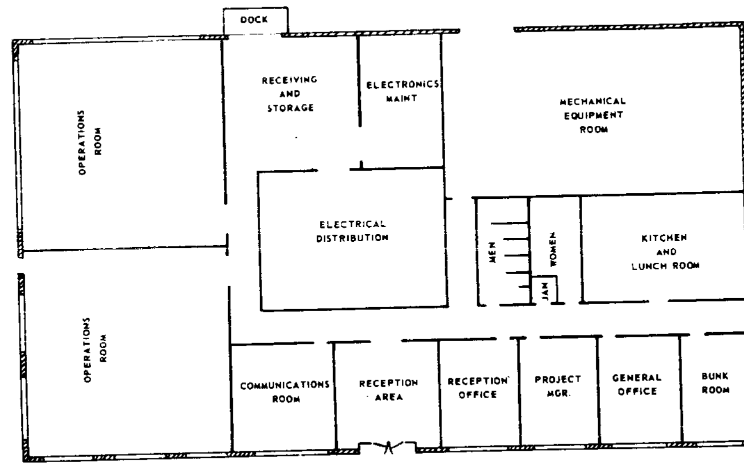
FISCAL YEAR 1965 ESTIMATES

APOLLO NETWORK GROUND STATIONS - NEW STATIONS

INSTRUMENTATION AND OPERATIONS BUILDING

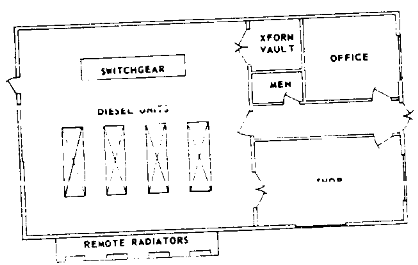


PERSPECTIVE

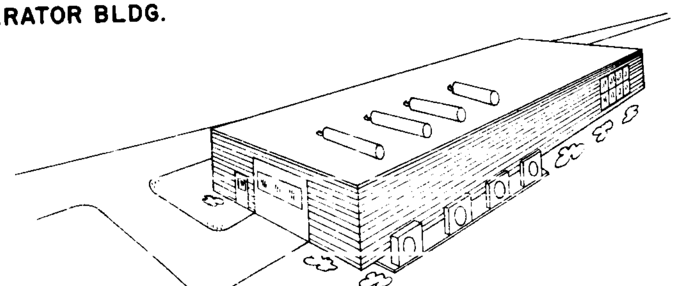


PLAN

DIESEL - GENERATOR BLDG.



PLAN



PERSPECTIVE

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CONSTRUCTION OF FACILITIES

FISCAL YEAR 1965 ESTIMATES

APOLLO NETWORK GROUND STATIONS
ADDITIONS TO EXISTING STATIONS

PROGRAM OFFICE FOR THE INSTALLATION: Office of Space Science and Applications

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

AUTHORIZATION LINE ITEM: Various Locations

LOCATION OF PROJECT: Corpus Christi, Texas
Guaymas, Mexico
Hawaii

COGNIZANT NASA INSTALLATION: Goddard Space Flight Center

TYPE OF CONSTRUCTION: Extensions

FUNDING:

	Corpus Christi Texas	Guaymas Mexico	Hawaii
FY 1963 and Prior Years	---	---	---
FY 1964 Estimate	$25,000	$30,000	$30,000
FY 1965 Estimate	380,000	475,000	475,000
Total Funding Through FY 1965	$405,000	$505,000	$505,000

PROJECT COST ESTIMATE - CORPUS CHRISTI, TEXAS:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$380,000
Instrumentation and operations bldg. addition	Sq. Ft.	2,500	$20.00	50,000
Generator building addition	Sq. Ft.	1,000	25.00	25,000
Hydro-mechanical services	LS	---	10,000	10,000

	Unit of Measure	Quantity	Unit Cost	Total Cost
Utilities	LS	---	$130,000	130,000
Generator, switchgear and transformers	LS	---	120,000	120,000
Site preparation	LS	---	40,000	40,000
Roads and parking	LS	---	5,000	5,000
Equipment	---	---	---	---
Design	---	---	---	---
Fallout Shelter	---	---	---	---
		TOTAL		$380,000

PROJECT COST ESTIMATE - GUAYMAS, MEXICO:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$475,000
Instrumentation and operations building addition	Sq. Ft.	2,500	$40.00	100,000
Generator building addition	Sq. Ft.	1,000	30.00	30,000
Hydro-mechanical services	LS	---	10,000	10,000
Utilities	LS	---	130,000	130,000
Generators, switchgear and transformers	LS	---	150,000	150,000
Site preparation	LS	---	40,000	40,000
Roads and parking	LS	---	15,000	15,000
Equipment	---	---	---	---
Design	---	---	---	---
Fallout Shelter	---	---	---	---
		TOTAL		$475,000

PROJECT COST ESTIMATE - HAWAII:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$475,000
Instrumentation and operations building addition	Sq. Ft.	2,500	$40.00	100,000
Generator building addition	Sq. Ft.	1,000	30.00	30,000
Hydro-mechanical services	LS	---	10,000	10,000
Utilities	LS	---	130,000	130,000
Generators, switchgear and transformers	LS	---	150,000	150,000
Site preparation	LS	---	40,000	40,000
Roads and parking	LS	---	15,000	15,000
Equipment	---	---	---	---
Design	---	---	---	---
Fallout Shelter	---	---	---	---
		TOTAL		$475,000
		GRAND TOTAL		$1,330,000

PROJECT DESCRIPTION:

This project provides for the augmentation of facilities at three (3) Manned Space Flight Network (MSFN) Stations to accommodate instrumentation systems required to support the Apollo program. These instrumentation systems are being procured under prior year funding due to developmental and fabrication lead-time. The MSFN stations to be augmented are located at Corpus Christi, Texas, Guaymas, Mexico, and Hawaii. The proposed effort under this project includes at each station the construction of an addition of approximately 2,500 square feet to the existing instrumentation and operations building and the addition of approximately 1,000 square feet to the existing generator building. The additions to existing buildings will house elements of the integrated Apollo unified S-Band system, additional communications systems, hardware for integration of existing instrumentation into the Apollo system, logistic support, diesel generators and distribution panels. A hydro-mechanical building will contain the collimation tower equipment, and concrete foundations for the antenna systems associated with the Apollo instrumentation will be installed. The proposed building construction will conform to the architectural design of each area. By extending or modifying existing utility services to each building, all necessary electrical, chilled water, steam and drainage systems will be provided to adequately support the additions or extensions to the existing stations. Separate cost estimates are shown above.

PROJECT JUSTIFICATION:

The Manned Space Flight Network, which has proved successful in supporting Mercury flights to date, is in process of being modified to provide support to the Gemini project. As the manned flight program advances into the Apollo spacecraft phase with its series of progressively more complex orbital, cislunar, and lunar space flights, the tracking, command, data acquisition and communications operations increase in complexity and will require additional and more complex ground support facilities. In order to provide the initial and minimum ground network coverage for the Manned Saturn IB flights, the new stations will be constructed and the existing ones will be modified to include the Apollo unified S-Band system. This is instrumentation designed to allow the ground station to transmit ranging signals, communications, and all other up-data to the spacecraft on one S-Band carrier frequency, and to receive same from the spacecraft on a different S-Band carrier frequency. To provide this capability, the additional facilities requested in this project are required to be completed prior to the end of calendar year 1965 in order to allow sufficient time for equipment installation, station checkout, and network integration check-out to support missions beginning in calendar year 1966.

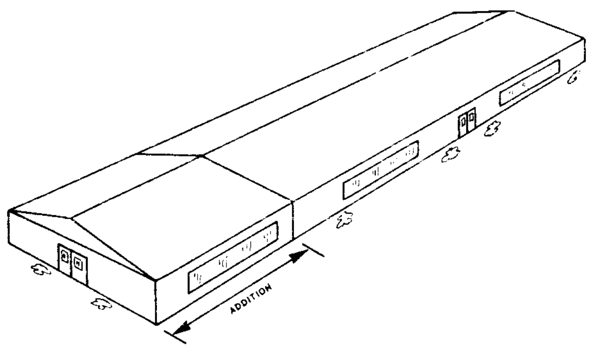
ESTIMATED FURTURE YEAR FUNDING: None

VARIOUS LOCATIONS

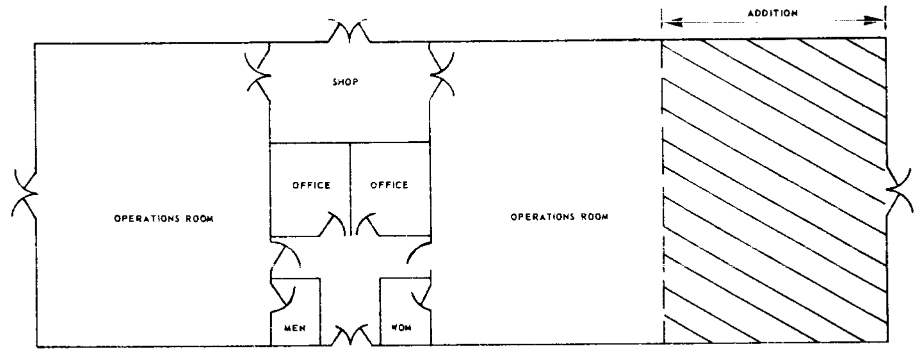
FISCAL YEAR 1965 ESTIMATES

APOLLO NETWORK GROUND STATIONS
ADDITIONS TO EXISTING STATIONS

INSTRUMENTATION AND OPERATIONS BUILDING

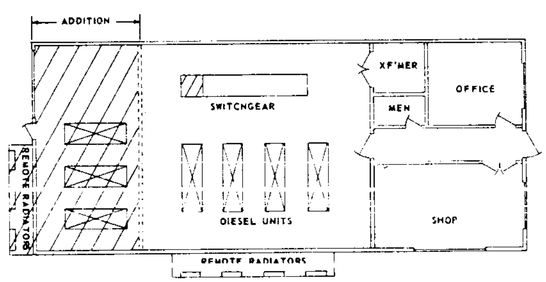


PERSPECTIVE

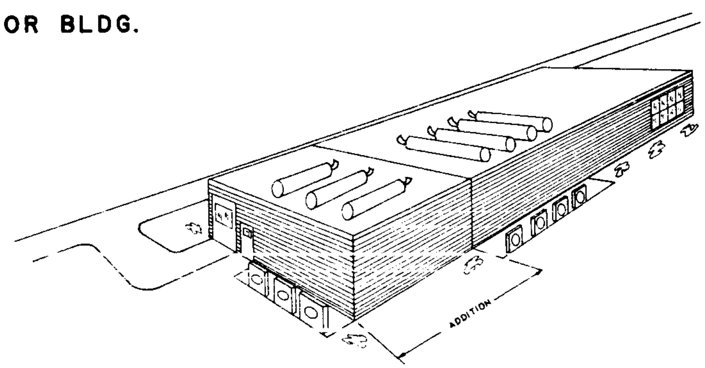


PLAN

DIESEL-GENERATOR BLDG.



PLAN



PERSPECTIVE

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