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NOTICE INSIDE

Research and Technology Operating Plan

SUMMARY

FISCAL YEAR 1973
RESEARCH AND TECHNOLOGY PROGRAM

(NASA-TM-X-68856) RESEARCH AND TECHNOLOGY OPERATING PLAN SUMMARY: FISCAL YEAR 1973 RESEARCH AND TECHNOLOGY PROGRAM (NASA) 1972 230 p

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SPECIAL NOTICE

Beginning with this issue, the contents and page layout for *Research and Technology Operating Plan Summary* have been changed It is suggested that the recipient of *RTOP Summary* read the Introduction in detail before attempting to locate desired items in the publication.

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INTRODUCTION

This publication represents the NASA Research and Technology program for FY 1973. It is a compilation of the "Summary" portions of each of the RTOPs (Research and Technology Operating Plans) used for management review and control of research currently in progress throughout NASA. The *RTOP Summary* is designed to facilitate communication and coordination among concerned technical personnel in government, in industry, and in universities. We believe also that this publication can help to expedite the technology transfer process.

The *RTOP Summary* is arranged in five sections. The first section contains citations and abstracts of the RTOPs. Following this section are four indexes. Subject, Technical Monitor, Responsible NASA Organization, and RTOP Number.

The Subject Index is an alphabetical listing of the main subject headings by which the RTOPs have been identified.

The Technical Monitor Index is an alphabetical listing of the names of individuals responsible for the RTOP.

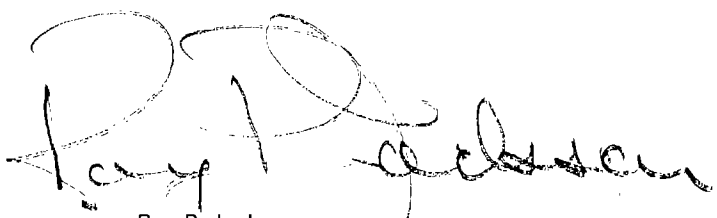
The Responsible NASA Organization Index is an alphabetical listing of the NASA organizations which developed the RTOPs contained in the Journal.

The RTOP Number Index provides a cross-index from the RTOP number assigned by the NASA responsible organization to the corresponding accession number assigned sequentially to the RTOPs in *RTOP Summary*.

As indicated above, responsible technical monitors are listed on the RTOP summaries. Although personal exchanges of a professional nature are encouraged, your consideration is requested in avoiding excessive contacts which might be disruptive to on-going research and development.

Any comments or suggestions you may have to help us evaluate or improve the effectiveness of the *RTOP Summary* would be appreciated. These should be forwarded to:

National Aeronautics and Space Administration
Office of Aeronautics and Space Technology
Resources and Institutional Management Division (RMS)
Washington, D.C. 20546



Roy P. Jackson
Associate Administrator for
Aeronautics and Space Technology

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Office of Aeronautics and Space Technology

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TYPICAL CITATION AND TECHNICAL SUMMARY

RTOP ACCESSION NUMBER → **W73-70004** **501-01-10** ← RTOP CURRENT NUMBER

RESPONSIBLE NASA ORGANIZATION → Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena

TITLE → **VISCOELASTIC PROPERTIES OF POLYMERS**

John W. Lucas 213-354-4530 ← TELEPHONE NUMBER

RELATED RTOPS → (502-01-05) ← TECHNICAL MONITOR

TECHNICAL SUMMARY → This is a program of fundamental research on the mechanical behavior of polymers It is intended to determine the molecular parameters which control rheological behavior. This has been successful in simple amorphous systems which are not chemically reacting. The goal now is to extend this work first to longer times, where degradation may set in, and then to shorter times, where the material is glass-hard. The general approach should involve the syntheses of both new and modified polymeric and prototype chemical structures, the characterization of these materials and the determination of chemical structure and property relationships. Applications for the mechanical properties work might range from improved solid propellants, expulsion bladder and valve seat materials for liquid propulsion, sealants for high-speed aircraft and new types of reinforced plastics.

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RESEARCH AND TECHNOLOGY OPERATING PLAN

a summary

FISCAL YEAR 1973

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

Aeronautics Research and Technology Base

W73-70001 **501-01-02**
Ames Research Center, Moffett Field, Calif.
PHYSICS AND CHEMISTRY OF SOLIDS
Glen Goodwin 415-965-5065

Studies of the physics and chemistry of metals as affected by embrittling gaseous and liquid species are to be conducted. A portion of the program will be directed toward gaining an understanding of the mechanisms of interaction of various fuels and oxidizers with steels, aluminum, and titanium alloys and other container materials. An integral part of this work is to be performed under stress embrittling conditions to simulate pressure-fed booster, transfer, storage and launch problems. Assessment of property changes and degradation will be made by mechanical measurements (e.g., strength, crack growth and hardness), degree of hydrogen charging in the metal, and determination of deterioration products in the fuel and metal. The other and more basic portion of the program will deal with the physics and chemistry of the very first stages of embrittlement of well-defined (as to crystallography and cleanliness) surfaces of high strength metals by gaseous agents using the newly evolving surface analytical technique of "Secondary Ion Mass Spectroscopy" (SIMS).

W73-70002 **501-01-03**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
PROPERTIES OF MATERIALS FOR ELECTRONIC APPLICATIONS
John W. Lucas 213-354-4530
(502-23-53; 502-33-93)

This is a program of experimental and theoretical research aimed at determining the basic relationships between electronic and defect structures of materials and their potentially useful electronic properties. The knowledge obtained will make possible the development of improved, or new, component concepts for NASA flight and ground-based electronic systems. During the coming year, the research will encompass theoretical studies of radiation coupling with infrared sensitive superconducting weak links, experimental investigations of radiation coupling in thin-film superconducting structures, charge transport and storage in and formation of highly insulating thin films, thermomagnetic and magneto-optic effects in films of various intermetallic compounds with low Curie-point temperatures and the effect of oxygen in these films, the effect of radiation damage on and noise properties in space-charge-limited currents in silicon, and photo effects associated with thin film Schottky barriers in gallium-arsenide.

W73-70003 **501-01-06**
Lewis Research Center, Cleveland, Ohio.
ATOMIC STRUCTURE AND PROPERTIES
J. C. Freche 216-433-4000
(501-21-20)

The broad objective of this work is to gain a better understanding of the basic structure and behavior of metallic and nonmetallic materials. The ultimate value of such an improved understanding will be in its utilization to produce new and improved materials particularly for aeronautical applications. The approach taken to achieve this improved understanding is to conduct basic research on both model material systems as well as more realistic compositions. Three broad classes of materials are included in the effort; these are alloys, coatings, and refractory compounds. The alloys portion is concerned with the structure of metallic phases as related to mechanical behavior with notch embrittlement and dispersion strengthening being prime areas of endeavor. The coatings effort deals with the stability of intermetallic materials. Refractory compounds are being investigated from a materials structure-fracture phenomenon relationship standpoint (i.e., the effects of material variable on fracture behavior are being studied).

W73-70004 **501-01-10**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
VISCOELASTIC PROPERTIES OF POLYMERS
John W. Lucas 213-354-4530
(502-01-05)

This is a program of fundamental research on the mechanical behavior of polymers. It is intended to determine the molecular parameters which control rheological behavior. This has been successful in simple amorphous systems which are not chemically reacting. The goal now is to extend this work first to longer times, where degradation may set in, and then to shorter times, where the material is glass-hard. The general approach should involve the syntheses of both new and modified polymeric and prototype chemical structures, the characterization of these materials and the determination of chemical structure and property relationships. Applications for the mechanical properties work might range from improved solid propellants, expulsion bladder and valve seat materials for liquid propulsion, sealants for high-speed aircraft and new types of reinforced plastics.

W73-70005 **501-21-23**
Langley Research Center, Langley Station, Va.
COMPOSITES
G. W. Brooks 703-827-2042
(501-22-03; 766-74-01)

The objective is to define and investigate superior reinforcements and matrix materials for filamentary composites and to study the fundamental mechanical and chemical behavior of structural composites. The work will focus on investigation of new or advanced filamentary materials, matrix materials and composites to establish mechanical properties, fabrication problems, and resistance to appropriate environments with a view toward their structural applications in advanced aeronautical vehicles. Laminates with controlled flaws and disbonds will be used in developing holographic techniques for nondestructive evaluation. Resin matrix development will emphasize systems that combine good thermo-oxidative stability and mild processing conditions. Studies will also be made of adhesives, resins, bonding of resin-matrix composites to structural metals and metal-matrix composites, and brazing metal-matrix composites to structural metals. This program will yield information on the fundamental behavior of advanced composites and will provide a basis for selecting advanced composites for further studies aimed at applications in flight vehicles.

W73-70006 **501-21-23**
Lewis Research Center, Cleveland, Ohio.
COMPOSITES
J. C. Freche 216-433-4000

The overall objective of this research is to develop fiber and laminate composite materials, structures, and components for various aeronautical applications. Both polymer and metal matrix composites must exhibit greater strengths, toughness, modulus of elasticity, and wherever possible, lighter weight than bulk, monolithic engineering materials. Superior property-to-weight advantages (e.g., specific weight or specific moduli) must be maintained at temperature levels of interest which range from cryogenic temperatures to over 2500 F. The work is oriented toward use of these materials in advanced gas turbine engines and major efforts are geared toward increasing use temperatures for fan blades, compressor blades, turbine buckets, and nozzle vanes, while maintaining superior property-to-weight advantages. The major objectives for the programs are as follows: 1. To develop or synthesize improved polymers suitable for use as matrix materials for temperatures up to 600 F. 2. To improve such properties of polymer matrices as thermo-oxidative stability, shear strength (in association with fibers) toughness, and nonflammability characteristics.

W73-70007 **501-21-20**
Lewis Research Center, Cleveland, Ohio.
ADVANCED MATERIALS FOR AERONAUTICS
J. C. Freche 216-433-4000
(501-01-06)

The objective of this RTOP is to provide improved materials, both metallic and nonmetallic, for use in advanced air-breathing power plants, particularly for aeronautical applications. Materials are sought that offer improvements not only in technical preformance but also in economy in terms of costs and life. The classes of materials to be investigated include Ni- and Co-base superalloys, Fe-base alloys, titanium alloys, dispersion strengthened alloys, protective coatings, and refractory compounds. Property improvements are sought by basic changes in materials per se, e.g., alloy compositional changes, and by process changes applied to existing and new materials. Material improvements are judged by the usual relevant property measurements. In addition, highly promising materials are evaluated by exposure to a simulated gas turbine engine environment. Plans are also being made for the ultimate evaluation of NASA-Lewis developments to be provided by engine tests of components. Primary efforts in this regard will be the evaluation of oxidation resistant dispersion strengthened alloys, e.g., TD-NiCrAl, as components in a gas turbine engine. Thus, the approach of this RTOP spans the wide spectrum of material and process development to advanced evaluation and engine testing.

W73-70008 **501-21-20**
Langley Research Center, Langley Station, Va.
ADVANCED MATERIALS FOR AIRCRAFT
G. W. Brooks 703-827-2042
(501-22-03; 501-21-26)

The objectives are: (1) to determine the behavior and the suitability of advanced materials for aircraft structural applications; (2) to conduct studies on advanced fabrication methods, materials behavior, and effects of environments on material preformance; and (3) to make metallurgical examination and studies to characterize the nature and magnitude of the material degradation. The work will consist of research to establish the properties of materials exposed to simulated aircraft environment and will include analytical studies on creep, oxidation, and diffusion. Suitable adjustment of heat treatment parameters or surface treatments to enhance performance of materials for aircraft applications will also be investigated. Research effort will be devoted to development and study of insulating coatings for actively cooled aircraft structures, to determine thermochemical interactions in ceramic-metal systems, and to study coating that reflect intense monochromatic radiation in the visible and near infrared wavelengths. Some attention will be given to study of advanced fabrication methods, to effects of fabrication on material properties; and to the application of nondestructive evaluation techniques to predict degradation of material properties. Effects associated with high-speed airflow and aqueous environments conducive to stress corrosion will be investigated to establish possible degradation in mechanical or physical properties of materials. Fracture surfaces obtained from materials tested under various loads and environments will be systematically characterized metallurgically to aid in interpreting materials failures in aircraft structures.

W73-70009 **501-21-22**
Langley Research Center, Langley Station, Va.
POLYMERS
G. W. Brooks 703-827-2042

The objectives are. (1) to conduct research on the preparation of new high performance polymers for aeronautical applications; (2) to characterize the chemical, thermal, and physical properties of these polymers and relate the properties to molecular structure; and (3) to adapt and test appropriate polymers as coatings and adhesives. The approach will emphasize research on processable, thermally-stable polymers which retain good mechanical properties at high temperatures. New aromatic and heteroaromatic polymers will be synthesized or otherwise obtained and their molecular structures systematically varied to determine how well selected properties such as improved thermooxidative stability and processability can be built into high performance polymeric materials. To this end, exploratory leads already emerging from Langley's polymer research program will be pursued. The study will employ routine polymer characterization techniques such as spectrometry, viscometry, osmometry, thermogravimetric analysis with associated mass spectrometry, elemental analysis and melt rheology. New characterization methods including torsional braid analysis, automatic dielectrometry, and thermomechanical analysis will also be used, especially for determining softening and transition temperatures. A test program will be established to evaluate the effects of

operating environment on polymeric adhesives and coatings. This information will lead to an understanding of the principles involved in developing adhesives and coatings, which in turn will define relationships between molecular structure and application properties and will direct future programs.

W73-70010 **501-21-22**
Ames Research Center, Moffett Field, Calif.
POLYMERS
Glen Goodwin 415-965-5065

The objectives are: to synthesize and characterize the physical and thermochemical properties of polymers and composites for potential applications in aeronautical technology; to formulate these materials into practical forms for application and evaluation as candidate aircraft components; and to study and understand the mechanisms and kinetics of ignition, flame spread, flame extinguishment and thermal and oxidative degradation in polymeric materials. The principal approach involves the syntheses of new and modified polymers, the characterization of these materials, the development of processing methods and their formulation into practical aircraft materials. Emphasis will be placed on the continued development of aromatic polycarbonates as high impact resistant, optically transparent polymers suitable for high speed aircraft windows with fire protection capability. In the area of materials degradation the approach involves the syntheses of both new and modified polymeric and prototype chemical structures, the characterization of these materials and the determination of chemical structure and property relationships as related to the area of ignition, flammability, thermal degradation and identification of combustion/pyrolysis products.

W73-70011 **501-21-26**
Langley Research Center, Langley Station, Va
FABRICATION AND PROCESSING
G. W. Brooks 703-827-2042
(501-21-20; 501-21-23)

The objectives are: to investigate and develop advanced methods for fabrication and joining of structural materials for aircraft applications, to determine possible changes in environmental resistance of materials produced by fabrication methods, and to apply the methods that are developed to fabrication and processing of aircraft components. The work will focus on investigation of new or advanced joining methods and on investigation of fabrication and processing methods for new or advanced structural materials. Other research areas to be studied include effects of fabrication and processing on material properties and applications of nondestructive evaluation techniques to predict degradation of material properties. This program will yield information on the status of advanced fabrication and joining methods for aircraft structural material, on the state-of-the-art of nondestructive evaluation techniques, and will provide a basis for selecting fabrication and nondestructive evaluation methods that may improve structural integrity, service life, and/or cost.

W73-70012 **501-21-33**
Lewis Research Center, Cleveland, Ohio
MATERIALS FOR HIGH POWER LASERS
Robert L. Davies 216-433-6608

This program involves the development of materials technology and materials for use in high power lasers. The program includes the development of an understanding of damage mechanisms in laser optics components, the improvement of suitable candidates for laser optics, and chemical compatibility studies of container materials for closed-cycle gas lasers. The major objectives of the program are: 1. To identify and develop candidate materials capable of serving as efficient and durable optics for the extraction of radiant energy from high powered CW laser systems. 2. To conduct fundamental studies into the basic degradation processes which cause failure due to interaction of the laser output with the window material. 3. To determine the compatibility of the containing materials with a laser gas system.

W73-70013 **501-21-21**
Lewis Research Center, Cleveland, Ohio.
FATIGUE, FRACTURE, AND LIFE PREDICTION
S. S. Manson 216-433-4000

A major objective is to obtain a better understanding of the failure or fracture mechanisms that are involved in the application of advanced materials to aeronautics structures or propulsion systems. A second major objective is to develop methods for predicting the life of specimens or components when they are subjected to constant temperature and monotonic loads or to complex patterns of temperatures and cyclic loads as a function of time. To achieve these objectives, research is underway to extend existing life prediction techniques and analyses, and to develop new methods for determining the stress and strain distributions in the vicinity of discontinuities such as flaws or cracks, as well as to understand the reaction of advanced materials to these discontinuities when subjected to various environmental conditions. Various approaches are also being examined for predicting the time to initiation of the first detectable cracks as a result of mechanical and thermal fatigue and to predicting the propagation rate of these cracks. Standard fracture test methods, NDE techniques, and specimens are being developed to properly characterize the fatigue and fracture behavior of materials and to provide background information for rational design procedures.

W73-70014 **501-21-21**
Ames Research Center, Moffett Field, Calif.
FATIGUE, FRACTURE, AND LIFE PREDICTION
Glen Goodwin 415-965-5065

The time dependent failure of structural metals caused by subcritical crack growth is being studied in order to develop analytical techniques and physical test criteria for predicting and minimizing the effects of this phenomenon. Such crack growth can be a direct result of either fatigue or environment-induced cracking or the combined result of both phenomena. Special emphasis shall be placed on the behavior of metal alloys in low pressure gaseous hydrogen and other aggressive environments. Concurrent studies shall concentrate on developing analytical failure criteria which are based on fracture mechanics concepts and which incorporate the effects of subcritical crack growth.

W73-70015 **501-31-71**
Ames Research Center, Moffett Field, Calif.
AST FUEL TANK SEALANTS
Glen Goodwin 415-965-5065
(501-38-12)

This RTOP includes the following areas of sealants research and technology: Synthesis, characterization, compounding and curing of sealant elastomers; thermal degradation and stress relaxation of gum and filled sealants, interaction of titanium with sealants; measurements of their dynamic properties; and their application to fuel tanks in advanced aircraft for flight testing. The objective is to develop fuel tank sealants which offer long service life under conditions encountered in advanced supersonic aircraft. The specific objectives are to: Synthesize, characterize and vulcanize sealant elastomers; study mechanism(s) by which they deteriorate on exposure to heat both in presence

and absence of fuels; select optimum sealant and determine its thermophysical and dynamic properties; and evaluate it by performing appropriate environmental and flight testing. Novel elastomers will be synthesized as candidate fuel tank sealants designed to meet flight requirements of Mach 2.7 - 3.0 and higher. The mechanism(s) of thermal degradation of these sealants will be investigated. Gum sealants will be selected, compounded and tested under simulated fuel tank conditions to establish their long term service life. The optimum sealant will then be applied to a fuel tank in an advanced aircraft and flight-tested.

W73-70016 **501-02-01**
Langley Research Center, Langley Station, Va.
BASIC RESEARCH AND ADVANCED CONCEPTS
G. W. Brooks 703-827-2042

The objectives are: to exercise new analytical tools to improve understanding of behavior of complex shell structures under thermal and mechanical loads and to demonstrate the feasibility of using newly developed rectangular cross-section boron filaments instead of the conventional round filaments in laminated composite structures. In-house and university studies will be performed to identify new phenomena and to conduct analytical and experimental studies of the mechanics of shell structural elements and components when subjected to load. A university program will be formulated to transfer complex analysis programs to the university to be exercised on selected problems. Candidate computer programs are BOSOR III and STAGS; candidate problems include thermal stresses, point loads, cutouts, and shape imperfections; stability under transverse shear; or postbuckling strength and collapse. Under contract, a supply of rectangular boron filaments will be fabricated by a process being developed with FY 72 funds. (Contract pending). The rectangular filaments will be laminated into multiple-ply unidirectional composite specimens whose cross-sections are similar in appearance to brick walls. The specimens with be tested in-house to determine the elastic constants and failure modes for such laminates. Use of rectangular instead of round filaments should improve the structural properties of laminated composite plates, particularly transverse to the fiber direction.

W73-70017 **501-22-01**
Langley Research Center, Langley Station, Va.
ANALYSIS AND DESIGN METHODS
G. W. Brooks 703-827-2042

The objectives are: to develop the technology for automating as much as possible of the preliminary and detailed design processes for advanced aeronautical vehicles; two high priority thrusts are to lay the foundation for incorporating the disciplines of (1) fatigue and fracture, and (2) flutter and aeroelasticity into automated systems; to improve fundamental structural and aeroelastic analysis and design methodology basic to multidisciplinary designs. IPAD (Integrated Programs for Aerospace Vehicle Design) development will continue in-house and on contract. In-house development of a small-scale pilot version of IPAD will include exercising the system developed in FY 72, expanding it to include other disciplines, and exploring ways to incorporate fatigue and fracture. Under contract, two system definition studies will be completed to formulate paper designs of an industrial version of IPAD. Aeroelasticity, flutter, and thermal stress consideration will be included in SAVES, an automated structural design system under development in-house for eventual incorporation into the in-house IPAD. SAVES development will be focused on wings for application to advanced supersonic technology vehicles. The planned extension of SAVES to include complete vehicle automated structural design capability will be postponed to facilitate this focused activity. Maintenance and improvements to NASTRAN will continue under contract and in-house. Basic plate and shell analysis and design methodology will be improved under selected contracts and grants for refining analysis and generating experimental data on the strength of stiffened shell structural components.

W73-70018 **501-22-04**
Langley Research Center, Langley Station, Va.
AEROELASTICITY
G. W. Brooks 703-827-2042

This RTOP is intended to provide improved capability for the treatment of aircraft aeroelastic problems, with emphasis in the area of flutter. In-house effort will be directed toward the development of new unsteady aerodynamic theories, the improvement of flutter analysis procedures, and the acquisition of advanced aeroelastic analysis capability from other sources. Contract and grant activities will support these objectives. The contract for the addition of aeroelastic capability to the NASTRAN structural analysis program will include advanced flutter analysis, aircraft response to turbulence, and elastic effects on stability and control. Other contracts and grants will cover unsteady transonic aerodynamic theory, flutter suppression using active controls, and optimization of structures with aeroelastic constraints. Methods for the analysis of transonic fighter maneuverability data obtained in the wind tunnel will be developed in-house. A comparison of flutter characteristics measured in different types and sizes of transonic wind tunnels will be made. Related aeroelastic research will be conducted under vehicle related RTOP's such as space shuttle, V/STOL, rotorcraft, active controls, advanced transport, and advanced supersonic technologies.

W73-70019 **501-22-05**
Ames Research Center, Moffett Field, Calif.
LOADS AND STRUCTURAL DYNAMICS
C. F. Coe 415-965-5880
(501-06-06; 502-32-04)

The effects of non-steady aerodynamic phenomena, such as boundary layer noise and panel flutter, are known and appreciated, but basic understanding of the cause of these effects is limited. An objective of this research program is to measure the unsteady forces within the boundary layer, including such factors as the intensity and spatial correlation of surface static pressures. Mathematical procedures will be developed to estimate the wind tunnel results, and guide the research program. Similarly, methods will be evolved to calculate structural response (and feedback) to the aerodynamic input. With regard to panel flutter, the damping influence of the boundary layer will be thoroughly examined.

W73-70020 **501-22-05**
Langley Research Center, Langley Station, Va.
LOADS AND STRUCTURAL DYNAMICS
G. W. Brooks 703-827-2042

The objectives of the work to be performed under this RTOP are to investigate and define the methods of predicting the flight loads, pressure distributions and aerodynamic characteristics of aerospacecraft in steady and unsteady flight conditions and to develop improved methods for predicting the dynamic response of aerospace type structures to oscillatory, random and transient loadings. Improved analytical procedures will be applied to optimization programs that consider dynamic factors. Some of the factors that will be considered include noise, flutter, gust response, active controls, vibration and other dynamic environments.

W73-70021 **501-22-07**
Langley Research Center, Langley Station, Va.
STRUCTURAL ACOUSTICS
G. W. Brooks 703-827-2042
(502-32-04; 501-22-05)

The objectives of this work are to develop fundamental information and understanding concerning the loadings exerted on a structure by its presence in and interaction with turbulent, flowing fluid; to develop techniques of determining structural stress and displacement response especially suited to acoustically loaded structures; and to apply these techniques to practical flight structures of current interest. A broad range of both analytical and experimental studies is required for various types of flight type structures that are excited by engine noise and/or flow induced noises. Experimental and analytical development of advanced methods such as the modal density for determining structural response to acoustic loads and noise transmission will be carried out. Fatigue of those structural configurations subjected to unusually intense acoustic loads such as engine acoustic liners will be studied.

W73-70022 **501-22-08**
Flight Research Center, Edwards, Calif.
FLIGHT LOADS MEASUREMENT TECHNIQUES
J. M. Jenkins 805-258-3311

Problems have occurred when flight-loads measurements have been required on aircraft which are subject to significant aerodynamic rating. The aerodynamic heating of flight structures induces non-uniform temperature fields throughout the structure. The non-uniform temperature fields lead to large induced thermal stresses which are sensed by the strain gages. If the objective is to measure aerodynamic loads only, then the unwanted temperatures induced strain-gage outputs must be accounted for and deducted from flight data. This operation is to be conducted by ground-temperature simulation of the aerodynamic heating, measuring the thermal responses of the strain gages and then utilizing this information as a thermal calibration for corrected purposes. This general concept is currently being explored utilizing the YF-12 (A/C No. 935) as a test bed. In addition to the thermal aspects, deflection measuring systems for in-flight use are being investigated using this aircraft.

W73-70023 **501-22-10**
Langley Research Center, Langley Station, Va.
SUPPORT OF DOD IN BALLOON ENGINEERING
G. W. Brooks 703-827-2042

An objective of this program is the development of equipment at LRC for measuring the biaxial structural characteristics of fabrics and films under controlled environments. Another is the development of contractors' manufacturing techniques to improve quality and reduce scrap rates of lightweight FTL balloon materials. An attempt will be made to improve material performance at temperature extremes by custom chemical synthesis of adhesives with glasseous phase transition at lower temperatures. A second approach to this problem is the fabrication on the flying thread loom and testing of a laminate of polyethylene and fibers. Mylar is stronger than poly, but is more brittle at tropospheric temperatures particularly when coated with adhesive. PRD-49 fibers offer significantly increased strength in both heavy and light balloon material applications. As part of this program, it is planned to manufacture and test a material weighing about 12 oz/yd square but having strengths approximately three times as high as the current material of the same weight. In addition, a material of equal strength, but less weight and very lightweight laminate for large balloons capable of achieving altitudes of 50 km with 250 pound payloads will be investigated. Such balloons could be used for pollution detection and the same material may be applicable to rocket launched high altitude or space deployed balloons. It is also proposed to study the effects on the thermal environment of some typical balloons if a tinted material is used to vary the solar absorptivity of the material.

W73-70024 **501-22-02**
Langley Research Center, Langley Station, Va.
STRUCTURAL INTEGRITY
G. W. Brooks 703-827-2042

This work covers several essential elements of a comprehensive, long-range plan to advance the science and technology of aerospace structural design toward conditions of optimum reliability, efficiency, and economy, while shortening the design time required. The ultimate goal is to develop a fully automated procedure for design. At present, three essential factors in the design process (fatigue, fracture, and nondestructive evaluation) rest on a technology base that is seriously behind the conjoined technologies of static strength and aeroelastic analyses. Consequently, fatigue, fracture, and NDI are the weakest links in the chain of design, and as such, demand special attention and high priority. The individual tasks here embrace a balanced mix of theoretical and experimental approaches which range from mathematically based models of fatigue and fracture phenomena, through the generation of urgently needed engineering data, to the conception, construction, test, and evaluation of bold new structural concepts. To the degree possible, the work anticipates the design problems and materials that will be encountered by the space shuttle, satellites, advanced subsonic and supersonic transports, rotary-wing aircraft, and vertical- and short-take-off-and-landing aircraft. The ongoing research includes such studies as ways to deal with stress concentrations, growth of cracks in complex structures, size effects, load histories, environmental effects, nondestructive testing, and economical ways to monitor cyclic strains in aircraft during service.

W73-70025 **501-22-06**
Flight Research Center, Edwards, Calif.
HYPERSONIC VEHICLE STRUCTURES TECHNOLOGY
Andrew E. Vano 805-258-3311

The program will attempt to experimentally validate significant hypersonic-vehicle structural concepts and investigate flight-loads measuring techniques for these structural concepts as they apply to the MHTV.

W73-70026 **501-22-06**
Langley Research Center, Langley Station, Va.
HYPERSONIC VEHICLE STRUCTURES TECHNOLOGY
G. W. Brooks 703-827-2042

Research and development is being carried out to establish a technology base from which the structures and thermal control systems for hypersonic vehicles can be designed. Included in the program are both experimental and analytical efforts on engine and airframe structure concepts which will withstand the rigors of extended and repeated use in a hypersonic environment. Research data obtained from experiments will serve to verify design and analysis methods and to establish design guidelines.

W73-70027 **501-22-03**
Langley Research Center, Langley Station, Va.
COMPOSITE MATERIALS APPLICATION TO AIRCRAFT STRUCTURES
G. W. Brooks 703-827-2042
(501-21-23; 766-74-01)

The objective is to conduct research on composite materials to resolve problems that may hinder their application, to develop the technology required for their utilization in future aircraft structures, and to establish confidence in the use of composites through longtime flight service of structural components on commercial transport aircraft and Army helicopters. The work consists of the following: Develop analytical methods to improve understanding of composite materials; evaluate behavior under various environmental conditions; develop concepts, fabrication, and nondestructive evaluation technology, develop new design methods and generate supporting test data to provide reliable design allowables for composite structural elements and components, fabricate and test critical components to demonstrate performance, conduct engineering studies to determine applicability of composites in primary or secondary structures of commercial or military aircraft and develop applications to operational helicopters and commercial transport. Both in-house and contractual efforts will be undertaken. The results of these studies will provide new technical information and flight-service experience that will develop confidence required to permit early application of filamentary composites in aircraft structures.

W73-70028 **501-22-03**
Lewis Research Center, Cleveland, Ohio.
COMPOSITE MATERIALS APPLICATION TO AIRCRAFT STRUCTURES
S. S. Manson 216-433-4000

Composite materials offer a high potential for reducing the weight of certain engine components and also airframe structural components. However, before full advantage can be taken of the unusual properties of composite materials in such applications, considerable material property and design information is needed. It is proposed that studies be continued that will: (1.) Develop (in-house) analytical design techniques for predicting structural characteristics of given composite configurations. (2.) Develop (in-house) analytical design techniques for optimizing composite structures for minimum weight. (3.) Develop (in-house) multiaxial testing facility for measuring the mechanical properties of fiber composites under complex loadings and environments. (4. Determine (by contract) the effects of residual stresses and thermal fatigue on the load-carrying ability of composite structures. 5. Develop (by contract) improved finite element capability consistent with NASTRAN requirements to permit improved stress analyses of fiber composite components.

W73-70029 **501-32-01**
Langley Research Center, Langley Station, Va.
AST STRUCTURAL DESIGN CONCEPTS AND WEIGHT STUDIES
G. W. Brooks 703-827-2042

The objectives are to assess relative merits of various structural concepts and materials for advanced supersonic aircraft configurations and to determine the structural approaches best suited for the AST environment and provide structural weight estimates based on in-depth structural design studies. Under contract, structural concepts will be developed for prescribed AST aerodynamic configurations. These concepts will be evaluated through design studies making use of the best available materials technology, design tools, and design criteria, and through simplified cost-benefit studies. The best concepts which would merit further evaluation by testing will be identified. Subsequently, similar studies will be carried out on an advanced variable-sweep configuration and an advanced arrow-wing configuration.

W73-70030 **501-32-02**
Langley Research Center, Langley Station, Va.
AST FLUTTER DESIGN MODULE
G. W. Brooks 703-827-2042

The objectives are to develop automated design methods with multidisciplinary capabilities for AST vehicles with particular attention to aeroelastic and flutter considerations and to perform design studies to assess good aeroelastic design practices and guide advanced structural concepts and materials studies. Under contract, developments in unsteady aerodynamic loads and flutter calculation procedures will be undertaken to improve their application in iterative design processes. Optimization techniques under aeroelastic constraints will be developed to replace cut-and-try procedures for alleviating aeroelastic problems. Future contract work will involve aeroelastic and flutter design studies and development of a multidisciplinary automated design system for AST vehicles by industry teams working at Langley using tools developed under contract and in-house.

W73-70031 **501-32-03**
Langley Research Center, Langley Station, Va.
AST LOADS AND AEROELASTICITY TECHNOLOGY
G. W. Brooks 703-827-2042

The objective of this RTOP is to develop technology in the area of loads and aeroelasticity to a sufficient state of readiness to provide an adequate base for confident initiation of development of advanced supersonic transports. Promising new approaches to the needed aerodynamic analysis will be vigorously pursued and focused theories will provide improved inputs to the flutter design module being developed (501-32-02). Loads analysis techniques including aeroelastic effects in considering nonlinear aerodynamics will be developed. Both existing and new wind tunnel experimental results will be used to guide and verify the new analysis technology. Related work is being done at Langley, Ames and Flight. In addition, U.S. Air Force Flight Dynamics Laboratory has related programs which are coordinated at least annually. The DOT/SST technical follow-on program has related tasks which have been considered in developing this program.

W73-70032 **501-32-04**
Flight Research Center, Edwards, Calif.
AST MATERIALS AND STRUCTURAL COMPONENTS
Alan L. Carter 805-258-3311
(501-32-05; 501-32-06)

The objectives are: to determine the structural performance of candidate AST materials and fabrication techniques (corrugated and honey comb sandwich, composites, conventional skin - stringer, etc.) subjected to load and thermal cycling, and to conduct a coordinated program of flight and laboratory tests on specimens supplied by Langley. For the flight program, representative panels would be designed, fabricated and flight rated under contract and installed on the YF-12 for exposure to realistic operating environment during NASA flight tests. Subsequently the panels would be subjected to thermal and load testing in the FRC Heat Facility. In addition, a series of small specimens, supplied by Langley, will be tested in the laboratory for additional background information.

W73-70033 **501-32-05**
Langley Research Center, Langley Station, Va.
AST - MATERIALS AND STRUCTURAL COMPONENTS - TITANIUM
G. W. Brooks 703-827-2042

The objective of this program is to advance titanium materials and structural component technology in order to provide combinations of materials and structural configurations that have long-time structural integrity and low weight. To achieve this objective a research program will be conducted on the important

technology areas including advanced fabrication methods, strength and fatigue characteristics of components produced by advanced fabrication methods, and the verification of the performance and capabilities of the fabricated hardware through in-service flight tests on the YF-12 airplane. The initial work will be accomplished with Ti-6Al-4V. Later work will include studies of new or improved titanium alloys to determine their potential role in future supersonic aircraft. The work will also include assessment of the relative merits of advanced structural concepts for wings and fuselage structure, to identify problem areas in such designs that may be related to aerodynamic heating, to demonstrate the effectiveness of advanced concepts by construction and test of representative components and to develop design allowables for structural elements and components. It is anticipated that this program will provide important advances in materials and structural component technology for advanced supersonic aircraft and will hopefully indicate approaches for achieving lower structural weight, improved structural integrity and lower fabrication costs.

W73-70034 **501-32-06**
Langley Research Center, Langley Station, Va.
AST - MATERIALS AND STRUCTURAL COMPONENTS - COMPOSITES
G. W. Brooks 703-827-2042
(501-32-05)

The objective is to develop and improve composite materials and structural component technology in order to achieve longtime structural integrity and low weight in future supersonic aircraft structures. The technology development program will consist of investigations of time-temperature-stress limitations for different types of high-temperature composite materials to determine their suitability for advanced supersonic aircraft applications. The program will also aim at development of new or improved resins, adhesives and coatings, performance of strength, fatigue and fracture tests to establish structural integrity for various types of composite materials in representative components, and fabrication, ground test and installation of suitable components on the YF-12 airplane for flight service evaluation. The work will include development of advanced structural concepts for wing and fuselage structure, assessment of problems related to aerodynamic heating to establish their influence on design, demonstration of the effectiveness of advanced concepts through construction and test of representative composite components, and development of design allowables for structural elements and components of high-temperature composite materials. The effects of simulated longtime supersonic aircraft environment exposure on elements and components will be established. The development of fabrication methods and nondestructive evaluation techniques will also be included. All of these programs will help to establish the future role of advanced composite materials in structural applications for supersonic aircraft and will help to generate the confidence required for the early application of such materials.

W73-70035 **501-32-07**
Langley Research Center, Langley Station, Va.
AST WIND TUNNEL TECHNIQUES FOR ACTIVE CONTROLS
G. W. Brooks 703-827-2042
(501-22-04)

The objectives of this program are to establish the feasibility of wind tunnel simulation of advanced active control concepts; to develop modeling and testing techniques for elastic mode suppression studies, that is, gust load alleviation, ride quality improvement, and flutter suppression; and to define expected accuracies in extrapolating the wind tunnel data to full scale values. This task is a continuation and extension of current Aeroelasticity Branch studies using an existing modified supersonic transport delta planform semi-span model wing and a cable mounted B-52 model. The delta wing model can be considered similar to that of an SST and will be used to develop flutter suppression modeling technology. A later model generally typical of an advanced supersonic transport wing would be studied to measure the effectiveness of a flutter suppression integrated active control system. The wind tunnel studies will be conducted in-house with contract support for system design and evaluation. Related activities are conducted by the U.S. Air Force Flight Dynamics Laboratory and a portion of this program is being conducted in cooperation with the USAFFDL.

W73-70036 **501-32-60**
Langley Research Center, Langley Station, Va.
SUBSONIC/SONIC CTOL TRANSPORT TECHNOLOGY: STRUCTURES AND MATERIALS (ATT)
W. J. Alford, Jr. 703-827-3586
(501-21-20; 501-22-01)

The objective of this RTOP is to address areas of supporting technology required to accelerate and bring to the ready state those structures and materials advancements which will result in cost effective applications in the next-generation long-haul high-subsonic CTOL transports. The primary emphasis will be on tasks defined to support the flight validation program which is a necessary precursor to acceptance of composites in commercial passenger transport service. The approach will entail early attention to structural design criteria for composites, consideration of advanced materials for engine noise reduction, and effort in manufacturing technology and verification hardware.

W73-70037 **501-03-02**
Langley Research Center, Langley Station, Va.
JOINT UNIVERSITY RESEARCH ON AIR TRANSPORTATION AVIONICS
G. B. Graves 703-827-3745
(135-06-01; 135-17-02)

The primary objective of this effort is to foster development of a university research capability across the disciplines that involve the avionics and flight control systems of aircraft and their interaction with the air traffic and airport airside operating environments. A secondary objective is to encourage university interest in interdisciplinary education that will provide engineers and scientists capable of attacking the system problems involved in these areas of air transportation. The planned approach is to establish a pilot program of research grants at several universities currently active in complementary technical areas. Joint university research projects and technical interchanges will be stimulated by this approach.

W73-70038 **501-03-11**
Ames Research Center, Moffett Field, Calif.
APPLICATION OF CONTROL AND GUIDANCE THEORY TO THE AUTOMATIC AND MANUAL CONTROL OF FUTURE STOL AND VTOL AIRCRAFT.
L. Roberts 415-965-5066
(768-81-03)

The purpose of this research is to develop the interrelationships between control theory and the design of flight control and avionic systems for STOL and VTOL aircraft. Consideration will be given to the definition of the mission and to the vehicle environment, including ATC and navigation aids, atmospheric and gust effects, and aircraft noise. Models of the aircraft and its subsystems must be developed for a variety of flight modes and these models used for analysis and synthesis

of STOL and VTOL aircraft guidance and control systems. The resultant models, along with suitable analysis and synthesis techniques will be applied to the synthesis of a complete control and guidance system for STOL and VTOL aircraft. The resultant system will be tested for pilot acceptability. As the analysis and synthesis of STOL and VTOL systems proceeds, it becomes apparent that new or improved mathematical theories are needed to improve the design procedure. Research will be conducted, largely through the grant and research associate programs, to provide these new and improved theories, and to demonstrate their applicability to the ongoing STOL and VTOL system designs.

W73-70039 **501-23-11**
Langley Research Center, Langley Station, Va.
AUTOMATED VTOL AVIONICS AND SENSOR TECHNOLOGY
G. B. Graves 703-827-3745
(776-75-02; 768-81-06; 760-63-04)

This effort will define and develop the advanced avionics technology required for reliable, all-weather operations of a viable short-haul transportation system in the 1980's. Technology developed under this RTOP along with coordinated efforts in aeronautics (760-63-04) and operating systems (768-81-06) are the major elements of an integrated LaRC program with the ultimate goal to develop and demonstrate operational capability of VTOL as a short-haul transportation system. The navigation, guidance, and control requirements of enroute, terminal area, and approach and landing of VTOL aircraft will be determined with emphasis on automatic operations. New technology will be used to develop low cost and reliable ratio-inertial navigation systems, displays, sensors, and hemispheric coverage landing guidance systems. Designs of functionally integrated systems will be implemented in prototype hardware for specific VTOL aircraft and flight tests will be conducted to evaluate and demonstrate systems performance. VTOL guidance, navigation and control requirements, and concepts will be investigated by extending previous analytical studies, simulation, and flight experiments (CH-46C) to include automatic flight and landing operations. Point designs for functionally integrated systems will be developed and demonstrated in flight operations for a jet-lift Harrier (1974) and for an advanced VTOL such as a lift-fan in 1977.

W73-70040 **501-23-21**
Flight Research Center, Edwards, Calif.
GENERAL AVIATION FLIGHT CONTROL SYSTEMS AND DISPLAYS
S. W. Gee 805-258-3311
(760-60-05)

This program is a coordinated effort to provide avionic system technology, development and criteria that will continue the improvements in safety and utility of all aircraft, particularly general aviation type aircraft. Various new concepts in flight control, navigation, and display systems are being investigated through the use of simulators and flight vehicles that will reduce the pilot's workload and enhance his performance by applying human factors engineering to system design.

W73-70041 **501-23-22**
Langley Research Center, Langley Station, Va.
AVIONICS FOR GENERAL AVIATION
G. B. Graves 703-827-3745

The objective is to develop avionics which will improve the safety and utility of general aviation aircraft operating in the environment with air carriers and military vehicles. One effort is in the development of collision-hazard warning techniques which are suitable for general aviation as well as other classes of aircraft. This work is based on an open-access CW Doppler technique operating at microwave frequencies with unique modulation method which permits the measurement of range and closing velocity, and the interchange of altitude information between aircraft. A low-cost transponder is required on each aircraft with the cost of associated interrogation and display equipment determined by aircraft performance. The cost of installations for low-speed, low-altitude aircraft would be much less than the cost for high-performance vehicles. Another effort is research on an aircraft position display based on a map overlay using liquid crystals. The display would be compatible with current VOR receiving equipment. It would aid the pilot in his navigation task and improve safety during adverse weather conditions.

W73-70042 **501-23-23**
Goddard Space Flight Center, Greenbelt, Md.
ATOMIC FREQUENCY STANDARD FOR FLIGHT APPLICATIONS
Fouad G. Major 301-982-5611

The objective is to develop an ultra-stable portable atomic frequency/time standard which, by virtue of its low ultimate cost, could be widely accepted and, hence materially contribute to the safety and economy of a frequency/time system of aircraft collision avoidance and be useful for other flight applications. A standard no larger than one-half cubic foot is envisioned in which the atomic resonance, acting as a frequency discriminator, has a fractional line width of better than 10 to the minus 10 allowing superior performance (better than one part in 10 to the 13th power; 1 for 1000 seconds averaging time) to be achieved with a relaxation of demands on the frequency locking servo electronics and, hence, minimum cost. Such a standard must be such that its atomic resonance line width and stability are not compromised by size reduction. This requires a radically new approach to the confinement and isolation of the reference atomic system. The approach which will be pursued is based on the suspension of free atomic ions in high frequency electric fields, whose feasibility has already been tested with regard to the number and lifetime of ions which may be stored. Specifically, ions of isotope 199 of mercury will be used which has a microwave hyperfine transition frequency of approximately 40.7 GHz. This resonance will be detected by an optical method using a mercury 202 lamp. Upon successful observation of the microwave resonance early in FY 73, contracts will be awarded for the engineering, layout, and fabrication of flight model ion frequency/time standards. Three prototype units are projected to be ready for flight tests in CY 75.

W73-70043 **501-23-31**
Langley Research Center, Langley Station, Va.
HIGHLY RELIABLE COMPUTERS FOR ACTIVE CONTROL SYSTEMS
G. B. Graves 703-827-3745

New digital computer architectural concepts, techniques, and advanced technology will be investigated and developed to improve the reliability and fault tolerance of digital computers for the NASA Digital Fly-by-Wire Program (Phase II) and the Active Control Technology Program. Hardware redundancy, software diagnosis, and self test and repair will be used to establish electronic systems with improved availability during flight, thereby providing flight safety and instilling pilot confidence. Other features will be incorporated to ease ground maintenance and shorten equipment down time. Effort will consist of: the establishment of advanced computer design capabilities and design aids; in-house investigations to validate

reliability improvements; specification of computers for specific programs; and development of new components and devices having potential for reliability improvement of digital systems. Maximum use will be made of past and ongoing space technology efforts.

W73-70044 **501-23-60**
Langley Research Center, Langley Station, Va.
SUBSONIC/SONIC CTOL TRANSPORT TECHNOLOGY: AVIONICS AND FLIGHT CONTROLS (AAT)
W. J. Alford, Jr. 703-827-3586
(501-15-01; 791-91-01; 766-73-01)

The objectives are: to establish adequate design criteria and requirements for flight controls and avionics for high subsonic/sonic CTOL transports; to establish terminal area operating requirements for high subsonic/sonic CTOL transports in the future terminal area environment; and to investigate conceptual control-system designs in light of the established requirements. The approaches are to identify constraining criteria for application of active controls and propose modifications; investigate center of gravity limitations and off-design conditions; define terminal-area impact on subsonic/sonic CTOL transport control of flight design requirements and conduct studies of the implementation of maneuver-load control, gustload alleviation, and reduced static stability for transport configurations and determine sensor, actuator, and computer requirements. This work will be closely coordinated with related efforts under RTOPs 135-19-07, 501-23-11, 501-23-12, 501-23-22, 501-23-42, 766-75-01, 766-75-02, 768-81-01, 768-81-02, and 768-81-05.

W73-70045 **501-09-02**
Langley Research Center, Langley Station, Va.
HUMAN RESPONSE TO THE AERONAUTICAL ENVIRONMENT
G. W. Brooks 703-827-2042
(501-29-11)

The objective of this work is to further the understanding of the psychophysiological effects of aircraft noise on people and to develop a quantitative understanding of individual response to noise exposure. This objective includes the development of research evaluation techniques and measuring scales along with accomplishment of research to assess effects of noise on sleep, subjective reactions, and hearing. Emphasis will be placed on laboratory studies with complementary studies in communities exposed to noise and with special overflight programs where selected juries are exposed to noise. Studies will be concerned with responses of people during both awake and sleep periods and under background noise conditions associated with outdoor, indoor, and inflight situations. Laboratory studies will be complemented by residential studies to obtain basic information on responses of people living near airports. Studies will evaluate both auditory and non-auditory effects of low frequency noise (below 300 Hz) on people. The development of methods for conducting meaningful laboratory tests will be directed toward obtaining improved stimuli presentation and improved subjective response measures. Included will be studies to generate testing methods and procedures to be used in the new Aircract Noise Reduction Laboratory. Studies will be conducted to evaluate hearing threshold shifts and will include effects ranging form temporary hearing effects to ear damage. Studies will be initiated to develop a program to futher the understanding of responses of people to sonic booms with special attention to low level sonic boom exposures.

W73-70046 **501-09-03**
Flight Research Center, Edwards, Calif.
HUMAN RESPONSE TO THE AERONAUTICAL ENVIRONMENT
W. R. Winter 805-258-3311
(501-29-21)

The objectives are to evaluate aircrew workload and performance, and identify factors influencing pilot error. The approaches are to: 1. study and define pilot tasks, workload and performance; 2. evaluate effects of various existing and proposed displays on performance; 3. correlate pilot performance on established tasks with physiological responses; and 4. study and define contingencies leading to pilot error in aircraft accidents.

W73-70047 **501-29-01**
Ames Research Center, Moffett Field, Calif.
ACCEPTANCE OF AIRCRAFT OPERATIONS - TECHNOLOGY ASSESSMENT
H. P. Klein 415-965-5094
(741-72-06)

The objectives of this program are to develop an understanding of the social effects of technology innovations, as exemplified by STOL transport systems, and to provide technology that will lead to improved safety and comfort of aircraft crews and passengers. Studies of both the short and long term social impacts (including economic, psychological and political of STOL as an element of the total transport system will be continued. Prototype seat/restraint systems will be designed, fabricated, impact tested and subjected to passenger comfort acceptance. Design, fabrication and testing of the liquid cooled collar for aircrew thermal protection of helicopter pilots will be completed.

W73-70048 **501-29-11**
Langley Research Center, Langley Station, Va.
ACCEPTANCE OF AIRCRAFT OPERATIONS - COMMUNITY NOISE
G. W. Brooks 703-827-2042
(501-09-02)

The objective of this work is to evaluate (a) noise characteristics of advanced VTOL and STOL aircraft, (b) acoustic retrofit systems for CTOL aircraft, and (c) noise alleviation procedures for aircraft and airport operations. This work will provide criteria for the prediction of community acceptance of aircraft operations/airport community noise. Emphasis will be placed on laboratory studies and airport-community studies/surveys which may be supplemented by programed overflight studies. These studies will be closely interrelated with/or in support of NASA project activities (STOL) and with the DOT/FAA (acoustic retrofit) and PONYA (DPRS) in programs to control aircraft and airport noise. The laboratory techniques employed will range from listening room testing with trained subjects to real-life situations where test environments represent the airport-community home and where the test subjects may be people plagued by aircraft noise. Survey programs will be initiated to improve and validate annoyance predictive equations and to provide data for presenting this information in a handbook form. Further studies will be made to evaluate the potential of alleviating airport-community noise exposure by means of runway selectivity based on dynamic preferential runway systems which have shown considerable promise in initial operations at JFK International Airport.

W73-70049 **501-29-12**
Langley Research Center, Langley Station, Va.
ACCEPTANCE OF AIRCRAFT OPERATIONS - RIDE QUALITY

G. B. Graves 703-827-3745

The objectives are: to establish the aspects of airplane flight that are critical to passenger acceptance of the quality of the ride experienced, and to establish criteria useful in the design of aircraft and ride smoothing systems and to establish limits in procedures for aircraft operations particularly in terminal areas so that the ride is generally acceptable. A research program is in progress which involves field studies using current scheduled airline systems. The flight characteristics of the aircraft and subject responses to the ride experiences are being measured. A simulation program is planned using three Langley simulators whose characteristics are such that frequencies of motion and vibrations ranging from less than one Hz to 35 Hz will be investigated. The visual aspects will be an inherent part of the simulation studies. Subjects and motions used and experienced in the field studies will be used and the elements of the motion critical to ride acceptance will be isolated. Field studies, using one or more airplane simulators, the General Purpose Airborne Simulator (GPAS) at FRC, the Total In-Flight Simulator (TIFS) at Cornell Aero Lab, and the Navion Variable Stability Aircraft at Princeton, will be performed to verify the findings of the ground-based simulations and the analysis of general flight studies. These experiments will be used for the establishment of an evolving set of criteria for ride smoothness requirements and operational limits as they regard airplane attitude, acceleration, and angular motions.

W73-70050 **501-29-21**

Flight Research Center, Edwards, Calif.

ACCEPTANCE OF AIRCRAFT OPERATIONS - RIDE QUALITY

W. R. Winter 805-258-3311

(501-29-12; 501-09-03)

This flight test program investigates the relationship of vehicle motion to passenger comfort. A variable stability aircraft provides the necessary in-flight control of vehicle motion and conditions from which an assessment of passenger ride quality can be made. The program will validate some existing simulator data and will provide flight data in new areas which are beyond most groundbase simulator capabilities. The effect is coordinated with other Government agencies and industry for the purpose of having a common basis and understanding from which ride quality criteria may be established.

W73-70051 **501-29-02**

Ames Research Center, Moffett Field, Calif.

FLIGHT MANAGEMENT SYSTEMS

H. P Klein 415-965-5094

(501-29-03)

This program will investigate flight management and crew/system interaction mechanisms and requirements for advanced aircraft. The program will develop working specifications for a fully integrated airborne flight system. Special attention will be given to safety, human factors and full system simulation. The objectives will: (1) determine system/pilot communication requirements (especially CRT displays) for aircraft flight management in the 1980's and define the content, format, location, functions, and pilot procedures for such displays; (2) determine pilot/system communication requirements and device specifications for entering alphanumeric data and system commands; and (3) integrate the results of objectives 1 and 2 in the design of a representative flight deck system. Full-flight simulation is being developed in the Ames Biotechnology Simulation Facility that involves piloted full mission profiles from take-off to landing. The simulation development is an in-house effort with some contracts to provide necessary computer programming and supportive studies as required. Evaluations will be made of the effects of the pilot-system interface and cockpit environment on: (a) the pilot's ability to be constantly apprised of past, present and (predicted) future system status; (b) the pilot's ability to monitor the system for exceeding performance tolerances or system failures; and (c) the pilot's ability to make decisions and execute them in an accurate and timely manner.

W73-70052 **501-29-13**

Langley Research Center, Langley Station, Va.

FLIGHT MANAGEMENT SYSTEMS

G. B. Graves 703-827-3745

The proliferation and increasing complexity of flight deck crew tasks (such as aircraft systems monitoring and control, traffic control, collision avoidance, etc.) make it mandatory to keep these functions within the crew's workload capacity - with a reserve margin for emergency situations. The task is to develop techniques for optimizing crew functions at both the systems and subsystems levels. The objective is to apply these techniques to the definition of efficient systems for advanced CTOL, VTOL, QUESTOL (in cooperation with ARC in appropriate areas), etc. Previous approaches have been primarily on an ad hoc, subjective basis resulting in a multitude of competing systems and procedures. The necessity for less confusion and conflict and for more standardization requires the application of objective methods for the design and development of viable systems and procedures. Therefore, this RTOP will concentrate on the following: (a) Development, evaluation, and validation of theories and analytical techniques which model the pilot and crew as information gatherers and processors, decision makers and system managers for use in systems design and evaluation. Use of conventional pilot models which treat the human as a servomechanism will be de-emphasized. (b) Development and validation of objective measurement techniques for determining workload under realistic conditions, as opposed to constrained and often-encumbered laboratory situations. Crucial to this activity is the application of the oculometer and development of on-line oculometer data analysis procedures. For example, complete oculometer data should be an effective alternative to physiological workload measures.

W73-70053 **501-29-03**

Ames Research Center, Moffett Field, Calif.

SIMULATION RESEARCH FOR AERONAUTICS

H. P. Klein 415-965-5094

(501-29-02; 501-09-01)

Research is being conducted on existing Ames simulators to identify, define and solve problems related to technology advances required for higher-fidelity more cost-effective simulators used for aircraft research and development and for pilot training. Specific programs underway include: (1) developing information on pilots' perception and use of motion cues in flight control tasks, (2) establishing minimum field-of-view requirements for CTOL and STOL simulation, (3) developing improved methods for quantifying pilot performance and workload in simulators, (4) developing techniques to measure the pilot's display information usage, (5) developing improved methods for generating landing scenes, and (6) developing models of the pilot's visual process. Concurrent research is also being carried out to develop advanced hardware and software to increase the number and fidelity of cues provided the pilot in aircraft research simulators. This work is based, in part, on previous research results from the programs described above and others. Specific work addressed in this program is: (1) investigation of the effectiveness of apparent vertical motion cues, e.g., seat cushion inflation, in replacing actual motions, and the development of better washout techniques for motion simulators, (2) development of improved

visual systems, including a better virtual-image lens system, wider field-of-view, and flying spot scanner techniques for generating visual cues without the use of a model-camera system and (3) development of more flexible and realistic control feed systems for aircraft simulation.

W73-70054 **501-29-14**
Langley Research Center, Langley Station, Va.
FLIGHT SIMULATION TECHNOLOGY - PILOTING CUES
G. B. Graves 703-827-3745

The objective of this research is to obtain the knowledge required to produce valid simulation of crew tasks in controlling vehicles under typical flight conditions while minimizing the complexity of the simulation equipment. Primary factors to be considered include the detail, resolution, and field-of-view of visual systems, the amount of motion and dynamic motion response, and the influence of other environmental factors such as noise. Existing simulators will be used to study vision and motion cue requirements for a range of flight conditions so that a better understanding can be obtained of the vision-vestibular system. The Real-Time Dynamic Simulator (RDS) is being used to study large-amplitude, low-frequency motions. The Vision-Motion Simulator (VMS), which incorporates a visual display mounted in a cockpit capable of rapid motion about all axes, will be used to investigate maneuvers involving higher frequency motions. In addition, attention will be given to evaluation of the factors involved in the use of simulators for training; here, the approach is to benefit by analysis of ongoing simulation work at Langley, including programs in the Differential Maneuvering Simulator (DMS).

W73-70055 **501-39-01**
Ames Research Center, Moffett Field, Calif.
SIMULATION TECHNOLOGY FOR AERONAUTICS
Leonard Roberts 415-965-5066
(501-26-08)

Simulation technology research and development is being conducted to develop advanced hardware to increase the number and fidelity of cues provided to the pilot in simulations of advanced aircraft. Results of this research and development are directly applicable to the development of advanced flight simulators for aeronautical research and for pilot training. Simulation technology is being advanced through the application of high-speed digital computers, through the development of highly sophisticated computer analysis and programming techniques, and through the development and operation of complex high-performance motion generating equipment. Current simulation technology is being restricted by limitations to the visual scene being presented to the pilot. Work under this RTOP in FY '73 is being concentrated on the development of techniques and equipment to improve the visual scene.

W73-70056 **501-39-11**
Langley Research Center, Langley Station, Va.
FLIGHT SIMULATION TECHNOLOGY - SIMULATION TECHNIQUES
G. B. Graves 703-827-3745
(501-29-14)

Computer based flight simulation studies permeate all phases of aerospace technology development, from conceptual design through pilot training. The alliance of flexible simulator hardware with high-speed computing equipment represents a research approach to problems that could not otherwise be practically solved. The objective of the work under this RTOP is to provide substantial improvement in NASA's capability for flight simulation through the integration of the specialized simulation aspects of computer science, applied mathematics, optics, and servomechanisms. Emphasis will be placed on computer techniques for visual scene generation to remove the field-of-view restrictions which encumber present systems. Effort will be undertaken on advanced mathematical and computing techniques to permit a high degree of simulation fidelity within reasonable computer memory and speed limitations. This also includes work on optimal strategies to handle the onset and washout cues to simulate flight motions within the limited displacements which are practical for ground simulators. Development and procurement will be undertaken on specialized systems which are capable of providing general support to a broad spectrum of aeronautical research programs where it has not been practical to support these efforts by individual program funding.

W73-70057 **501-04-01**
Ames Research Center, Moffett Field, Calif.
BASIC NOISE RESEARCH
L. Roberts 415-965-5066

This research is directed at improving the understanding of the fundamentals of aerothermodynamic noise generation and propagation. The primary objective is to develop improved and/or new methods for prediction of airfoil generated noise and noise generated in jet exhausts and in jet flap devices. The research will involve both analytical and experimental studies of aerodynamic noise generation in propulsion and lift producing fluid flows.

W73-70058 **501-04-01**
Lewis Research Center, Cleveland, Ohio.
BASIC NOISE RESEARCH
Arthur A. Medeiros 216-433-6654
(501-24-01)

This work is directed toward obtaining an understanding of the principles involved in the generation and suppression of turbomachinery and jet noise. The work includes both analytical and experimental studies. Experiments are conducted both on small-scale and full-scale hardware. Experimental results are used to guide analytical studies.

W73-70059 **501-04-01**
Langley Research Center, Langley Station, Va.
BASIC NOISE RESEARCH
G. W. Brooks 703-827-2042
(501-24-01)

The objectives of this work are to obtain improved understanding of the fundamentals of noise generation and noise suppression of gas turbine power plants of commercial, general aviation, and military CTOL aircraft under various operating conditions and for which such components as exhaust jets, burners, blades, and vanes are significant noise sources. The objectives include the identification of noise generation mechanisms, development of methods of predicting radiated noise, and the identification and evaluation of approaches to noise reduction. Both theoretical and experimental studies are involved and work will be accomplished in-house and under contract. Emphasis is placed on substantially improving the capability of existing jet noise research systems. Jet exhaust noise studies will be performed in-house on small models to correlate measurements of the flow field with near field and far field acoustic measurements in order to locate the virtual sources. Emphasis is on subsonic exit velocities for the purpose of defining the requirements for optimum jet exhaust noise suppressor designs. The effects of nozzle configuration, sound speed profiles, and combustion effects will be included. Contract and grant studies will evaluate the effects of combustion and nozzle

configurations and will develop improved analytical prediction procedures. In-house studies will be made to define high frequency blade loads as related to high pressure ratio operations.

W73-70060 **501-04-01**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
BASIC NOISE RESEARCH
R. R. McDonald 213-354-6186

The general objectives of this task are: (1) to obtain a correlation between the fluctuations and the intensity and frequency spectrum of the noise radiated from supersonic jets and (2) to reduce the noise generated by attempting to reduce the turbulence and the shear. Experimental measurements of the perceptive noise level are made at selected locations in the surroundings of high temperature jets emerging from a nozzle. The temperature of the air flowing through the nozzle is elevated by burning methanol or jet fuel as is done in a jet engine. However, the flow is mixed and controlled much more closely than in an actual engine. Compressed air is supplied on a steady state basis by an existing air compressor facility at pressures encountered in turbojet engines. Measurements of mass flow rate, gas temperature and pressure are made to determine the flow conditions. Velocity distributions in the jets are determined from measurements of pressures and temperatures obtained with probes. Three significant pieces of information are acquired from crossed laser beams set up as a Schlieren system. First, a radial distribution of the fluctuating density; second, the convection velocity of the moving eddies; and third a relationship between the fluctuating density and the radiated noise are established. Microphones are located so that the noise radiated from predetermined volume elements of the jet can be identified. The frequency spectrum is analyzed and correlations established between the fluctuating densities and the radiated noise. The tests are conducted in an anechoic chamber.

W73-70061 **501-04-02**
Ames Research Center, Moffett Field, Calif.
BASIC POLLUTION RESEARCH
Glen Goodwin 415-965-5065
(160-44-79)

The objective of this research is to provide basic data for use in the assessment of the impact on the atmosphere of jet-powered aircraft operations. The data will be used for the development of impact assessment models and for the planning of atmospheric experiments with jet powered aircraft. The approach involves theoretical studies of the production of pollutants by jet engines and of the interaction of these pollutants with the atmosphere; both chemical and hydrodynamical aspects will be considered. Sensitivity studies with theoretical models will identify critical chemical reactions for study in the laboratory. Both the theoretical and the experimental studies will be utilized in stratospheric and tropospheric pollution dispersion models that are being developed under other RTOP's.

W73-70062 **501-04-02**
Langley Research Center, Langley Station, Va.
BASIC POLLUTION RESEARCH
C. H. Nelson 703-827-2893

The objectives are: (1) to develop a mathematical description of the interaction of combustion emissions from aircraft with the stratospheric environment. The mathematical model will be concerned with the wake region in the immediate vicinity of the aircraft and will incorporate kinetics, mixing, and the space-time variation of the concentration of reactants; (2) to get a better understanding of the influence of various chemical and physical factors on the production of gaseous and particulate pollutants in high temperature combustion systems with emphasis on nitric oxide and soot formation. Some of the factors to be examined include the nature of the fuel, pressure, temperature mixing, and diffusion. These factors will be examined by using flame burners and a shock tube to produce well characterized combustion environments, (3) to develop a flight configured mass spectrometer to provide in situ measurements of contaminated from high altitude aircraft. A small mass spectrometer, previously designed and developed, will be altered to a flight configuration (over guideline item);

W73-70063 **501-04-02**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
BASIC POLLUTION RESEARCH
Rob Roy McDonald 213-354-6186

The objective of Part I of this RTOP is to measure the rate constants of key reactions in the upper atmosphere which affect the stability of the ozone layer and which involve pollutants emitted by high-flying aircraft. The approach is experimental in nature, and measurements will be made under conditions of temperature and pressure which simulate those of the upper atmosphere. The NO emissions from conventional aircraft gas turbines increases as operational combustion temperatures continue an increasing trend. The overal goal of Part II of this RTOP is to demonstrate how this emission can be minimized by judicious control of fuel-air mixing and thermochemistry. The near term objective is to evaluate the potential for significant NO reduction of such unconventional design concepts as increased fuel atomization, fuel prevaporization and premixing, product gas recirculation, staged combustion, nonadiabatic combustion, and various combinations of these. Initially, design studies will be made to delineate the impact of these concepts on NO and other pollutants. Analyses will emphasize mixing, and chemical equilibria/kinetics effects in attempting to exploit the relatively slow NO reaction.

W73-70064 **501-04-03**
Lewis Research Center, Cleveland, Ohio.
BASIC PROPULSION RESEARCH
Walter O. Logan, Jr. 216-433-6429
(791-91-10)

Realistic assessment of aeronautical mission requirements, propulsion technology needs, and engine component and system characteristics requires that fundamental criteria governing the operation of airbreathing propulsion systems be identified and explored on a systematic basis. In-house programs and NASA-supported university research will be initiated or merged with current programs to provide input on problems such as: Design characteristics and propulsion systems requirements for future aircraft and aeronautical missions; Fluid mechanics of advanced turbomachinery; Thermodynamic and fluid flow characteristics of combustion processes for operation in the hypersonic flight regime; Basic studies in other areas requiring an interdisciplinary viewpoint to perceive and define propulsion technology requirements.

W73-70065 **501-04-03**
Ames Research Center, Moffett Field, Calif.
BASIC PROPULSION RESEARCH
L. Roberts 415-965-5066

This effort is a continuation of the work to investigate

advance hypersonic inlet flow fields. The major objective is to conduct coordinated experimental and analytical studies of hypersonic inlet flows in which the effects of coupling between the inlet, fuel injection system and combustor will be evaluated, and in which fuel injection and combustor pressure rise are simulated so that the effects of these factors on mixing, flow distortion and inlet performance can be determined. A body of detailed internal flow data, urgently needed to enable assessments of analytical methods, will be obtained. The study will be conducted utilizing both in-house and contract efforts, and will be conducted in phases.

W73-70066 **510-04-02**
Lewis Research Center, Cleveland, Ohio.
BASIC POLLUTION RESEARCH
R. A. Rudey 216-433-6160
(501-24-02; 501-24-18)

The concentration of various particulate and gaseous pollutants in the region of the atmosphere between 20,000 and 40,000 feet will be measured by employing sampling devices on commercial air transports. These measurements will be used to establish baseline data on the contaminants in the atmosphere in order to deduce the contribution of jet aircraft to atmospheric pollution, and basic studies will be conducted to develop and better understand the factors involved in the formation and dispersion of jet engine pollutants. This information may then be used to determine the necessary steps required to reduce pollution by jet aircraft. Components to be measured include hydrocarbons, carbon monoxide, oxides of nitrogen, oxides of sulphur, ozone, water vapor, and total particulates.

W73-70067 **501-24-01**
Lewis Research Center, Cleveland, Ohio.
NOISE TECHNOLOGY
A. A. Medeiros 216-433-6654
(501-04-01; 765-68-01)

Research is performed on fan and jet source noise and its suppression. Engine noise testing will be conducted with the CTOL MK I Quiet Engines incorporating an acoustically treated nacelle. In the fan source noise research, the effects of several aerodynamic design principles on noise will be investigated The 6-foot fan acoustic test rig will be used to evaluate the design changes. Jet source noise research will be conducted to determine the effect of nozzle scale and geometry changes on noise over a wide range of subsonic and supersonic jet velocities. The J-85 hot jet facility and several smaller hot and cold flow support test rigs will be used in this study. Full-scale J-85 suppressor nozzles, including novel designs, will be evaluated to assess noise suppression characteristics at both low and high jet velocities. Acoustic liner technology for exhaust jet noise suppression is being investigated. This work is being conducted by Boeing under a NASA contract (NAS3-15570).

W73-70068 **501-24-01**
Langley Research Center, Langley Station, Va.
NOISE TECHNOLOGY
G. W. Brooks 703-827-2042
(501-04-01)

The objective of this work is to develop technology for use in the reduction of propulsion systems noise. Included are objectives (a) to develop and verify methods of predicting the propagation of sound in and radiation from acoustically lined ducts for airflow and (b) to develop and verify methods of predicting the performance of resonator and expansion chamber exhaust mufflers for reciprocating and rotary engines. A broad range of both analytical and experimental studies is required. This includes precision measurements of the sound fields inside of finite ducts with airflow of varying cross sectional areas and with and without acoustical treatment materials. Also required are studies of model scaling, test techniques including spinning mode synthesizer applications and the evaluation of the acoustical performance of duct liner materials at ambient and elevated temperatures. In-house materials and duct propagation studies are planned and these will be augmented with contract studies. A basic need is the development of exhaust muffler performance prediction methods for the basic behavior of the resonator elements and their interactions with adjacent resonators and with the main exhaust flow, and the application of computer techniques to the optimization of muffler performance.

W73-70069 **501-24-02**
Lewis Research Center, Cleveland, Ohio.
POLLUTION TECHNOLOGY
R. A. Rudey 216-433-6160

Various techniques for reducing pollutant emissions will be investigated in full-scale primary combustors, various combustor segment rigs and in basic flame tube-type rigs. Techniques that will be explored for reducing nitric oxide emissions will include reduced reaction zone dwell-time, prevaporization of fuel, and premixing of fuel and air prior to combustion. Improved fuel atomization and primary zone fuel-air ratio optimization will be investigated for measuring carbon monoxide and unburned hydrocarbon emission. Extensive tests will be required in order to evolve combustor configurations which combine low pollutant engine characteristics with acceptable levels of other required combustion performance characteristics. A contract program will be conducted to identify the odor causing constituents in gas turbine engine exhaust at engine idle conditions. A contract program will be initiated to study pollutant emission characteristics of small engine combustors and to develop technology for reducing these emissions. A contract program will be initiated to develop technology related to dividing and distributing fuel to many low-pressure premix-type fuel injectors to be used for investigating fuel distribution effects on emissions.

W73-70070 **501-24-18**
Lewis Research Center, Cleveland, Ohio.
CLEAN COMBUSTOR TECHNOLOGY
R. A. Rudey 216-433-6160

A three-phase program will be initiated to generate and demonstrate the technology required to develop advanced CTOL aircraft engines with lower exhaust emissions than is possible using current technology. The effort is primarily aimed at advanced commerical engines with compressor pressure ratios of 20 to 35 but will also consider military engine requirements. Primary emphasis will be placed on reducing nitric oxide emission but reductions in unburned hydrocarbons, carbon monoxide, smoke, and particulates will also be sought. These reductions in pollutant emissions will be accomplished with minimum and acceptable sacrifices in other normal combustion performance requirements. The three phases will consist of initial screening of candidate configurations (e.g., NASA, LeRC swirl-can combustor), experimental testing of best candidates, and an actual demonstration of the best design(s) in a modern high pressure ratio engine. This effort is a change in scope of an existing activity started in FY 1972 under RTOP 132-86-02.

W73-70071 **501-24-05**
Ames Research Center, Moffett Field, Calif.
INLET TECHNOLOGY
L Roberts 415-965-5066

The objective of this research is to provide information

needed in the design and operation of efficient air induction systems for supersonic aircraft. The specific areas receiving attention are: (1) a general understanding of basic flow problems encountered (flow fields at inlet entrance, boundary layer growth, interaction with shocks, separation, bleed, etc.,) and derivation of mathematical design procedures; (2) more detailed studies of two general classes of inlets, two-dimensional and axisymmetric; (3) continuous up-dating of available computer programs derived to aid in inlet design, and (4) flow distortion and fluctuations at the compressor face. The research studies are both analytical and experimental, and involve in-house, grant, and contract efforts.

W73-70072 **501-24-05**
Langley Research Center, Langley Station, Va.
SUBSONIC AND SUPERSONIC INLET TECHNOLOGY
R. E. Bower 703-827-3285

The objectives are: to develop an understanding of the inlet and propulsion system requirements for advanced aircraft, to determine the types of designs which satisfy these requirements, and to provide the technology required to assure successful operation of these inlets. The research is applicable to both military and commercial aircraft. Currently primary emphasis is directed toward developing reliable methods for predicting the pressure distributions on inlet and nacelle surfaces at subsonic and transonic speeds. Contracts have been awarded to Grumman Aerospace and General Electric Corps. to develop analytical methods for predicting these pressure distributions. Experimental research on axisymmetric nacelles and rectangular, ramp-compression-surface inlets is being conducted in-house for correlation with the analytical results. Design procedures will be developed from this information.

W73-70073 **501-24-05**
Lewis Research Center, Cleveland, Ohio.
INLET TECHNOLOGY
M. A. Beheim 216-433-4000
(501-24-03; 501-24-13)

Basic inlet technology will be developed to improve the methods for design of supersonic inlets. These methods include prediction of their steady-state and dynamic performance and compatibility with the airframe and engine. Inlet operating conditions from takeoff with noise suppression through subsonic cruise and transonic acceleration to supersonic cruise Mach numbers will be covered. These methods will include a comprehensive set of computer programs to analyze the viscous and inviscid inlet flows and empirical data correlations from a matrix of supersonic cruise and dash inlets operating in both isolated and installed environments. Methods will be developed to evaluate such barrier problems as inlet-engine compatibility, inlet-airframe compatibility and isolation of propulsion systems in single or twin nacelles. Effects of scale and flight conditions will be evaluated. Experimental programs will take place in 10x10, 8x6 and on the F-106 aircraft. Computer programs will be developed in-house and on contract and analysis will be compared with experimental results.

W73-70074 **501-24-06**
Langley Research Center, Langley Station, Va.
NOZZLE TECHNOLOGY
R. E. Bower 703-827-3285
(501-17-01)

A prime goal of jet exit research is to achieve exhaust nozzle designs capable of near ideal conversion of the pressure and thermal energy of the engine internal flow into thrust of the exhaust jet; and, to devise and investigate exhaust nozzle mechanisms which permit variation of throat size and nozzle expansion ratio to maintain this near ideal performance over any required range of vehicle airspeed and nozzle pressure ratio. An equally important goal is realization of systematic design procedures for incorporation of single or multiple exhaust nozzles into an airframe to yield a configuration not penalized by loss of thrust or increase in drag related to the exhaust nozzle installation. A further goal is continued study of boundary layer and jet mixing, and of jet effects on base and boattail drag, and to reduce to science the knowledge of these mutual interferences between exhaust jet plume, airframe, and external airstream, with a view to exploit these phenomena for achievement of improved vehicle performance. The term exhaust nozzle here is meant to include jet noise suppressors and thrust reversers. Studies of the effect of jet deflection on lift induced on the airframe will be continued. This work is directed toward aircraft configurations of high maneuverability and increased range. Exploitation of jet entrainment of the external flow to improve pressure recovery on the airframe and to reduce induced drag on the wing will be continued. Investigation of exhaust nozzles capable of jet noise attenuation yet having high performance over a wide speed range will be continued.

W73-70075 **501-24-07**
Lewis Research Center, Cleveland, Ohio.
FAN AND COMPRESSOR TECHNOLOGY
M. J. Hartmann 216-433-6650

Approaches to reduce fan and compressor weight, to improve performance, and to reduce noise generation will be investigated. Reductions in component weight can be obtained by increasing stage pressure ratio, thus reducing the number of stages and by increasing the flow rate to obtain a smaller diameter. Low noise requires optimization of blade row spacing, rotating speed and blade loading. These light weight fans and compressors must also operate efficiently and without stall over a broad range of operating conditions including severely distorted inlet flow. (a) Blading for higher stage pressure ratio compressors must be designed to operate at higher Mach numbers and higher levels of aerodynamic loading. (b) Approaches such as casing treatment to improve stall margin and distortion tolerance for high Mach number, high loading stages must be studied. (c) High flow capacity designs with high axial velocity and low hub tip ratio which will be applicable to high bypass ratio turbojet engines will be studied. (d) Low noise fans with optimized blade spacing and blade shapes designed to minimize shock noise must be investigated. (e) Initial steps must be taken to develop three-dimensional design techniques which will accurately predict flow choking limitations and three dimensional shock configurations. (f) Promising concepts developed in single stage studies will be incorporated into multistage designs to study stage matching effects.

W73-70076 **501-24-08**
Lewis Research Center, Cleveland, Ohio.
COMBUSTOR TECHNOLOGY
R. A. Rudey 216-433-6160

Primary combustor research will establish the technology necessary for combustors having high performance and good durability at operating conditions typical of advanced commercial and military aircraft. Three different types of primary combustors are under investigation: a ram induction combustor, a swirl-can modular combustor, and a one-side-entry combustor. Extensive tests are needed to assess the overall merit of these different designs. Primary combustors of three sizes will be investigated with varying configurations considered for each individual size. The reheat burner program will be aimed primarily at the mixed-flow, high core engine turbine exhaust temperature type

of engine. Reheat burner concepts such as swirl-can modular elements, fuel prevaporizing and premixing configurations will be investigated. Research will be conducted on combustor liner cooling, jet penetration and mixing, primary zone mixing, fuel injection, swirl-can modules, high energy ignition systems, and short length combustor inlet diffusers.

W73-70077 **501-24-09**
Lewis Research Center, Cleveland, Ohio.
TURBINE TECHNOLOGY
Jack B. Esgar 216-433-6625
(501-21-31; 501-38-13)

The turbine program includes research on turbine aerodynamics, turbine cooling, and turbine life. Each of these areas are interrelated, and it is not practical to conduct research in one area without considering how the other areas will be affected. Advanced cooling schemes for very high gas temperature operation will require increased use of film and transpiration cooling. The effects of these and other types of cooling air discharge are being investigated from the standpoints of both heat transfer and aerodynamics, and the effects on blade life will be investigated in the future. The turbine aerodynamics research is also investigating the effect of air discharge in the form of a jet flap for providing pneumatic variable geometry to the turbine. Investigations are being made on multistage turbines with work factors from 3 to 5 for application to high bypass ratio lift or cruise engines. Heat transfer, fluid flow, aerodynamics, and life investigations are underway for a variety of convection, film, and transpiration configurations for turbine sizes ranging from those for helicopter engines to high spool turbines for turbofan engines. Fundamental heat transfer investigations on film and transpiration cooling are also continuing. Turbine cooling problems become much more severe at the very high heat fluxes that are encountered with turbine inlet temperatures in excess of 3000 F, and high gas pressures encountered with compressor pressure ratios in the range from 30 to 40. Design and fabrication of a turbine rig to investigate the aerodynamic, heat transfer, and life problems encountered with these high temperature, high pressure turbines will be accomplished using CofF funds.

W73-70078 **501-24-10**
Lewis Research Center, Cleveland, Ohio.
SUBSIDIARY MECHANICAL COMPONENTS
W. J. Anderson 216-433-4000
(502-01-07; 502-31-51)

Basic materials, development, design theory, analysis and experimentation will be performed for extreme conditions with lubricants, lubrication systems, component materials and component designs for bearings and seals of advanced aircraft turbine engines to achieve efficient performance, reliability and extended life Materials, fabrication techniques, design and lubrication techniques for gearing will be developed. Analytic techniques for balancing, determining and controlling the dynamic behavior of shafts and rotors will be developed and corroborated experimentally to provide better design tools for high speed turbomachinery, shafting and transmissions.

W73-70079 **501-24-19**
Ames Research Center, Moffett Field, Calif.
AST PROPULSION NOISE
L. Roberts 415-965-5066
(760-61-01; 501-24-11)

This RTOP covers research to reduce the noise level of supersonic aircraft. The noise comes from two sources, turbulent jet mixing from the engine exhaust, and compressor noise. Much research in these areas has been conducted in the past, however nearly all was done at zero forward speed. Recent work has indicated that the jet turbulent mixing noise reduction expected at forward speed does not occur with mixer suppressor nozzles, thus expected noise reductions do not materialize. From the standpoint of compressor noise, distortion at the compressor face arising from aircraft attitude and flow around the airframe can increase noise. This increase in noise can probably be avoided by proper engine placement and/or careful inlet design. Solution of these problems requires research at forward speed in a ground based facility, that is in a wind tunnel. The proposed program develops techniques for noise measurements in wind tunnels and provides for the necessary research measurements. The first study is of compressor and exhaust noise using a J-85 engine and existing inlet and suppressor hardware. This nacelle-alone study in the Ames 40- by 80- Foot Wind Tunnel will develop both techniques and privde research information. The second program will involve studies of small scale mixer nozzles at forward speed. The third program will study installation effects. With results from the first 3 studies and DOT sponsored studies, the best inlet and exhaust devices will be selected for nacelle-alone studies in the wind tunnel. Finally, using all these results plus aerodynamic results, an advanced airframe-engine concept will be developed and studied at large scale.

W73-70080 **501-24-20**
Ames Research Center, Moffett Field, Calif.
AST POLLUTION REDUCTION TECHNOLOGY
Glen Goodwin 415-965-5065
(501-04-02; 501-24-02; 501-24-18)

The basic objective is to develop an understanding of the interaction of supersonic jet exhausts with the upper atmosphere to provide data which can be used to assess jet wake impact on the natural atmospheric composition. Detailed objectives are to determine the composition of the Jet Wake and the perturbations (chemical, hydrodynamic) in the stratosphere caused by the passage of supersonic aircraft individually and on semiregular schedules in a specified air corridor; and to determine the appropriate jet wake models for use in impact assessment studies. The Program will be accomplished in four phases. Phase I will provide data to evaluate the methods, feasibility and value of conducting an airborne experiment to achieve the above objectives. In Phase II the complete flight plan will be developed, cost estimates will be made and study data assembled and evaluated from Phase I so the value of the flight experiment can be stated and recommendations made to NASA Hqrs., to continue the program. Phase III is the flight experiment portion of the program where chase aircraft intercept and measure components in the wake produced by the source aircraft. In Phase IV data from all Phases will be evaluated and correlated to meet the program objectives. Reports will be prepared and submitted to the various concerned organizations.

W73-70081 **501-24-20**
Langley Research Center, Langley Station, Va.
ADVANCED SUPERSONIC TRANSPORT POLLUTION REDUCTION TECHNOLOGY
E. S. Love 703-827-2893

The objective of work to be performed under this RTOP is to evaluate the use of laser radar techniques for application to studies of jet wake composition and dispersion in the stratosphere. This work is in support of the cooperative NASA-DOT jet wake experiment program being developed under the management of Dr. L. Poppoff of Ames. The work under this RTOP will include analytical studies required to make a preliminary evaluation of the feasibility of using either ground or airborne lidar techniques for monitoring the wake from a jet aircraft flying in the stratosphere. Results from on-going Langley experimental and

analytical studies in lidar sensing of the atmosphere will provide basic inputs to this evaluation and will be supplemented by studies focused on the specific problem of monitoring an aircraft wake in the stratosphere.

W73-70082 **501-24-60**
Lewis Research Center, Cleveland, Ohio.
SUBSONIC/SONIC CTOL TRANSPORT TECHNOLOGY DEVELOPMENT: PROPULSION
M. A. Beheim 216-433-4000
(791-91-02)

NASA has initiated an effort to study the application of advanced technology to the improvement of future subsonic/sonic commercial transport aircraft designed for flight speeds up to Mach 0.98. The results of this study are to be resolved in terms of economic factors involving a complex interaction of parameters such as aircraft drag, propulsion efficiency, operating costs, low-speed flight characteristics, propulsion and aircraft noise, and propulsion system exhaust emissions. Detailed analyses of these factors have been completed through in-house and contract studies, and documentation is in progress. Results of these and other studies indicate that the installation effects on representative airframe configurations have a significant effect on the economic performance of the aircraft and the propulsion system. The studies also identified areas where advanced technology would decrease noise and improve the system economics. The approach is to continue wind-tunnel studies of installation effects using half-span and full-span models with powered engine simulators. Also, investigations of fan noise and performance characteristics for fan pressure ratios from 1.8 to 2.0 with main emphasis on two-stage fans will be initiated. Also, wind-tunnel studies on integrated engine and nacelles directed at noise suppression, transonic optimization, and maintainability will be initiated.

W73-70083 **501-24-04**
Lewis Research Center, Cleveland, Ohio.
ENGINE TECHNOLOGY
J. H. Povolny 216-433-6624
(501-24-05; 501-24-08)

The objective is to develop the technology relative to turbine engine systems required for future subsonic and supersonic aircraft. Particular emphasis will be placed on seeking an understanding and solution of the dynamic interaction problems associated with flight systems. The latest turbojet and turbofan engines designed for both subsonic and supersonic cruise and supersonic dash applications will be used in the investigations. Exploratory and performance evaluations will be made of systems applicable to the ATT and military airplanes currently being designed. This effort is concerned with the effects of inlet produced environment on the engine and the interactions of the various engine components as well as interactions between the engine and the inlet. This effort is closely related to the inlet, inlet control, and inlet engine dynamics research described in RTOP 501-24-05.

W73-70084 **501-24-11**
Ames Research Center, Moffett Field, Calif.
VTOL TECHNOLOGY
L. Roberts 415-965-5066
(760-62-01)

This RTOP covers acoustic and performance research on lift fan propulsion systems. Lift fan propulsion systems require special consideration because of the desirability of limiting depth and weight which restricts acoustic treatment. In addition the fans operate in severe distortion which affects performance and increases noise. For the former difficulty, detailed knowledge of noise sources in lift fan turbomachinery are required. For the latter, detailed integration studies are required. The proposed program attacks these problems. Studies with a statorless fan will provide data on a lift fan free of rotor-stator interaction noise, with possibly improved performance, and will provide valuable data on rotor alone noise. Past studies have shown advantages to serrations for rotors and on NASA quiet fan B. Further cascade studies have shown an advantage to serrations for transonic cascades. Serrations will be studied on the statorless fan, on the LF 336 fan and on a model fan to tip Mach numbers of 1.2. Another stator for the LF 336 fan will be fabricated which theoretically gives the same advantage as 2 chords spacing. Finally, research will be conducted with inlet stators to reduce inflow distortion and limit the increase in noise with crossflow.

W73-70085 **501-24-11**
Lewis Research Center, Cleveland, Ohio.
VTOL TECHNOLOGY
W. L. Stewart 216-433-6131

NASA is engaged in a program directed at the investigation of commercial VTOL aircraft employing direct lift fan engines. Responsibility for VTOL airframe and aircraft studies is at Ames and is covered under another RTOP. The propulsion needs of the program are the responsibility of Lewis Research Center and include (1) establishing a technology base for lift fan engines, and (2) providing propulsion support to Ames for their aircraft studies as required. The engine technology program is directed at the investigation of problems associated with the engine components, integration of the engine components, engine installation effects, and engine noise generation. Lift engine configurations being considered include remote drive fans, driven by either turbojet or turbofan gas generators, and integral drive fans.

W73-70086 **501-24-12**
Langley Research Center, Langley Station, Va.
STOL AND RTOL PROPULSION TECHNOLOGY
R. E. Bower 703-827-3285
(760-61-02)

The basic objective is to develop propulsion technology required to minimize the noise of short takeoff and landing (STOL) and reduced takeoff and landing (RTOL) aircraft. Work under this RTOP will be closely coordinated with the aerodynamic and configuration development work under RTOP 760-61-02. In-house and contract analytical and experimental studies will be made to develop an understanding of fundamentals and to develop prediction techniques. In-house anechoic chamber and wind-tunnel investigations of lift augmentation noise and noise reduction techniques will be conducted. Contracts and grants will be used to determine noise of low-pressure ratio, low tip-speed fans suitable for EBF and upper-surface-blowing propulsion systems, and to study airfoil and flap noise generation and suppression.

W73-70087 **501-24-12**
Lewis Research Center, Cleveland, Ohio
STOL TECHNOLOGY
Raymond J. Rulis 216-433-6651
(741-89-04; 765-69-01)

The objective of this RTOP is to develop the propulsion technology required to support the development of a viable STOL aircraft system. Major program elements are: (a) evaluation of high bypass fans for aerodynamic performance and noise; (b) determination of installation effects on fan engines with

acoustically treated nacelles; (c) evaluation and development of light-weight composite materials and structures for high bypass fans; (d) development and optimization of acoustic treatment for jet engines; (e) jet-flap interaction evaluation including the design and testing of jet velocity reducers.

W73-70088 **501-24-14**
Lewis Research Center, Cleveland, Ohio.
LOW COST SMALL ENGINE TECHNOLOGY
Harold Gold 216-433-6684
(501-24-07, 501-24-08; 501-24-03)

An effort is being made to establish a general base of low-cost engine technology which could be directly applied to turbojet and turbofan engines in the 500 to 1000 pound thrust range. Such engines would be suitable for application to a wide range of non-recoverable missiles and drones and to general aviation aircraft where in both cases broader use of gas turbine engines is currently inhibited by their cost. Contribution to small gas turbine engine cost reduction in the size and the number of stages required and use of low-cost materials. In addition, use of novel construction and fabrication techniques for axial flow compressor and turbines is being investigated. The feasibility of these low cost approaches is being demonstrated by the fabrication and testing of an expendable engine of 600 pounds thrust for possible ordnance use.

W73-70089 **501-24-15**
Lewis Research Center, Cleveland, Ohio.
HIGH PERFORMANCE SMALL ENGINE TECHNOLOGY
W. L. Stewart 216-433-6131

The objective of the program under this RTOP is to investigate problems associated with achieving high performance in advanced small gas turbine engines for such applications as small aircraft, helicopters, APU's and automotive use. As the size of these engines is reduced it becomes increasingly difficult to achieve the aerodynamic and thermodynamic performance of the associated components while maintaining the required simplicity and ruggedness. Programs underway include the investigation of advanced small centrifugal and mixed flow compressors, cooled axial- and radial-inflow turbines, combustors, as well as advanced bearings and seals required for the high rpm's encountered in these applications.

W73-70090 **501-24-16**
Lewis Research Center, Cleveland, Ohio.
HYPERSONIC PROPULSION TECHNOLOGY
E. A. Lezberg 216-433-4000
(501-04-03)

Engine testing of the HRE, Aerothermodynamic Integration Model will be conducted at the Plum Brook, HTF over a Mach number range of 5-7 to provide information on component interactions, ignition, combustion mode transition and performance. Testing should span about a 6 to 7 month period beginning in the first quarter of FY 1973, and include tests at two pressure (altitude) levels and at angle of attack

W73-70091 **501-24-16**
Langley Research Center, Langley Station, Va.
HYPERSONIC RESEARCH ENGINE
K. F. Rubert 703-827-3675

The objectives are: to define a practical, high-performance, Mach 3-8 liquid hydrogen hypersonic ramjet engine of laboratory size building a full-scale, water-cooled, aerothermodynamic integration model (AIM), and a full-scale, hydrogen-cooled, structures assembly model (SAM) of the HRE; and measuring the aerothermodynamic performance from Mach 5 to 7 with the AIM and evaluating at Mach 7 the engine structures thermal performance and low cycle fatigue characteristics; and to advance and crystallize the technology of hypersonic airbreathing propulsion systems and evaluate the requirements for future research. The superior fuel economy of airbreathing propulsion requires that such systems be reexamined in light of the current technology for application to any new hypersonic atmospheric flight mission.

W73-70092 **501-24-17**
Lewis Research Center, Cleveland, Ohio.
NUCLEAR PROPULSION TECHNOLOGY
F. E. Rom 216-433-4000
(112-27-15)

The objective is to assess the feasibility and safety of operation of nuclear propulsion systems for very large advanced subsonic aircraft, air cushion vehicles and other transportation and mobile reactor application. Analytical studies supported by limited experimental research on key powerplant components will be conducted. Work will focus on the problems of: safety and fission product containment, long-life and heavy powerplant components, and integrated reactor-shield-containment system conceptual design. The safety work is directed toward developing methods for containing fission products in the event of crash. The containment system must not rupture due to crash impact or to fission product decay heat after impact. The component work is directed toward high burnup fuel elements (20 percent); high shutdown margin, low fuel inventory reactors; low weight radiation shields; and compact light-weight heat exchangers and coolant circulators. The conceptual design work is directed toward developing a minimum weight reactor-shield-containment vessel system by using each component for several functions, e.g., as radiation shielding, impact energy absorber, and thermal protection of the containment vessel after core meltdown.

W73-70093 **501-06-01**
Langley Research Center, Langley Station, Va.
COMPUTATIONAL AERODYNAMICS
P. J. Bobbitt 703-827-3561

The objectives are: To develop and apply analytical and numerical procedures which can be used reliably, accurately, and efficiently for the study of complex aerodynamic flow fields throughout the range of flight speeds by advanced high speed computers; to apply the procedures to two- and three-deminsional bodies and configurations and to account, in special cases, for viscosity at least to the extent of coupling boundary-layer displacement and separation effects with the inviscid flow field; To develop improved methods for calculating turbulent boundary layer flows and for predicting the effects of shock-boundary layer interaction. Analytical and numerical procedures will be developed for the prediction of pressure distributions, aerodynamic characteristics, flow fields and heat transfer for inviscid and coupled inviscid-viscous flows with attached boundary layers, detached lee side flows with vortex formation and other interactions. Both linear and nonlinear flow equations will be applied as appropriate. Mathematical techniques required typically depend on the problem, however, finite-element, finite-difference relaxation, timeasymptotic, characteristics and integral methods are the most commonly used for solving nonlinear problems. Linear problems will generally be solved by the distribution of various types of singularities whose strengths are determined by the solution of a matrix equation.

W73-70094 **501-06-01**
Ames Research Center, Moffett Field, Calif.
COMPUTATIONAL AERODYNAMICS
V. L. Peterson 415-965-5859
(501-06-05; 501-06-08)

The purpose is to develop numerical methods and computer programs that can be applied reliably and effectively for the study of fluid dynamic problems throughout the range of flight speeds by both serial and parallel processing computers. Intended applications are the numerical simulation of subsonic, transonic, supersonic and hypersonic fields for both inviscid and viscous flows including the unsteady case. Proposed methods will be analyzed to determine their order of accuracy, stability, convergence, dissipation, and dispersive properties. The most promising methods will be incorporated in advanced aircraft synthesis programs. A graphics scheme having an interactive capability, displaying the solution as the computations are being executed will be used to determine the ability of each method to compute significant flow features. The high speed CDC 7600, and Illiac IV systems will permit computations using both approximate methods and the full Navier-Stokes equations for solving the flow field over complex two- and three-dimensional shapes for steady and unsteady cases. Other objectives include studies of the interference caused by the model support and by the wind tunnel walls which may be either solid or porous, and the effects of unsteady flow.

W73-70095 **501-06-01**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
COMPUTATIONAL AERODYNAMICS
John W. Lucas 213-354-3247
(501-06-07; 501-06-09)

The object of this RTOP is to develop a new theory of differential systems, and a unique capability for symbolic manipulation by computer; and to apply these to selected important equations of continuum mechanics. This approach makes possible systematic and exhaustive analysis of sets of nonlinear partial differential equations for properties and special solutions previously found by ad hoc methods. Examples are: (1) invariance transformations, (2) general similarity solutions, (3) generalized characteristics, (4) integral conservation theorems, (5) functional variable transformations and discovery of superposition principles, (6) separation of variables, and (7) variational principles. Of these, (3), (4) and especially (7) are of direct applicability in writing programs for numerical computation. The method is based on the modern calculus of exterior differential forms, and is especially appropriate for nonlinear equations such as occur in describing fluid flows. The systematic structure of the theory alloys the use of computer analysis. In joint work at IIT and JPL a unique series of computer programs has been developed for noncommutative symbolic calculation with exterior differential forms. These have now been applied at JPL to the derivation and systematic analytical integration of the equations for the invariance generators of sets of differential forms. It is from these that the most general similarity solutions are found. An important theoretical advance to be attempted will be to apply the new theory to the systematic discovery of variational principles. These are used in relaxation computer calculations of complex flows, and again have previously been found by ad hoc methods.

W73-70096 **501-06-02**
Ames Research Center, Moffett Field, Calif.
DEVELOPMENT OF COMPUTATIONAL AERONAUTICAL CODES FOR ILLIAC
Glen Goodwin 415-965-5065
(501-06-01; 501-06-03, 501-06-08)

The objective is to develop efficient, reliable, and accurate computer programs to be used on Illiac IV for numerically calculating three-dimensional flow fields, both inviscid and viscous, around wings and wing-body combinations at angle of attack for a Mach number range from subsonic through supercritical to supersonic. Included will be the creation of a new parallel processing program language, CFD code, and the development of software to support this language on both the Illiac IV, and any other serial processing machine. The generalized relaxation techniques presently used on serial processing machines for flow field calculations will be extended to more complex configurations including swept wings with taper and camber. The extension of these techniques is practical only because of the computing speed and storage capabilities of the Illiac IV. For the viscous calculations, in regions with strong adverse pressure gradients, the simplified equations for the existing eddy viscosity models will be replaced with a full set of Navier-Stokes equations The CFD code language will be developed to permit those interested in fluid flow simulation to make the transition from serial processors to parallel processors in a simple manner. The software developed will include translators which will permit the CFD code to be translated into a code for direct execution on Illiac IV, and also to be translated into FORTRAN to provide programs for testing or simulating Illiac IV programs on serial processing machines.

W73-70097 **501-06-03**
Ames Research Center, Moffett Field, Calif
PHYSICAL MODELING AND VERIFICATION OF ILLIAC COMPUTER CODES
Glen Goodwin 415-965-5065
(501-06-02; 501-06-08)

The objective is to perform fundamental experiments designed to verify three-dimensional Illiac IV computer codes and to provide the necessary modeling of the physics of turbulent flows to be included in these codes. The Reynolds numbers of interest will extend from the low values of conventional wind tunnels up to the practical range of existing and future aircraft for the transonic and supersonic speed regimes and the types of flows studied will emphasize pressure gradients, separation, and shock interaction regions. Initially, experimental verification of a three-dimensional, transonic inviscid-flow computer code at sufficiently high Reynolds number to preclude occurrence of dominant viscous effects will be obtained; the trailing-edge Kutta condition will be experimentally investigated to provide a physical model for computer code input that will result in the resolution of the theoretically predicted and experimentally measured lift-curve for airfoil sections at angle of attack. Completely documented turbulent flows at high Reynolds number will be provided to verify the variable pressure-gradient boundary-layer codes. An existing helium blowdown facility will be modified to provide transonic and moderately supersonic air flows through an 18-inch square test section at Reynolds numbers of 0.5 x 10 to the 6th power to 25 x 10 to the 6th power per foot for lengths to 8 feet. Measurements of skin friction, mean velocity and temperature profiles, fluctuating velocities and density, shear stress across turbulent boundary layers undergoing favorable and adverse pressure gradients and near shock interaction regions will be documented for Reynolds numbers to 200 x 10 to the 6th power. Apparatus and techniques will be developed as necessary to provide the measurements at the high pressures attendant with the high Reynolds numbers.

W73-70098 **501-06-04**
Langley Research Center, Langley Station, Va.
VORTEX AERODYNAMICS
R. E. Bower 703-827-3285
(501-38-13)

The technical objectives are to provide an improved understanding of the formation and effects of various types of vortex flows in all speed ranges and to develop improved analytical design and analysis methods that include the effects of these vortex flows. Primary emphasis will be on the wing leading-edge vortex flow associated with slender supersonic cruise vehicles, the vortex lift associated with maneuver strakes and wing tip separation, and the vortices encountered in leeward regions and juncture areas of hypersonic configurations. Both in-house and contract research will be used to accomplish the objectives. In-house wind-tunnel tests will be used to study the effects of vortices on aerodynamic performance, stability and control, aerodynamic heating, surface loading and flow field characteristics associated with both cruise and maneuvering vehicles. In the analytical area, the possibility of including vortex effects in modern finite element lifting surface theories will be investigated through both in-house and contract efforts. The vortex breakdown phenomena and the effects of vortex flow on multiple lifting components will be investigated by both analytical and experimental methods.

W73-70099 **501-06-04**
Ames Research Center, Moffett Field, Calif.
VORTEX AERODYNAMICS
L. Roberts 415-965-5066
(506-06-01; 501-38-13)

The objectives of the research are to provide a basic understanding of the wing trailing vortex system and to accelerate the vortex dissipation in order to reduce the hazard to following aircraft. This basic understanding will result in the ability to predict the vortex intensity, given the conditions of the generating wing and the atmosphere. This involves the measurement of the three components of vortex velocity and turbulence up to large distances behind the wing for various conditions of angle of attack, wing sweep, flap deflection, etc. Accelerating the vortex dissipation can be accomplished by three means, turbulent diffusion, vortex bursting, and vortex instability. The research objective is to develop a more thorough understanding of these mechanisms so that the wing can be tailored to enhance the vortex dissipation. The approach to this research is both experimental and analytical and includes both in-house investigations and studies performed under contract and university grant.

W73-70100 **501-06-05**
Flight Research Center, Edwards, Calif.
AIRFOIL AND CONFIGURATION AERODYNAMICS
E. J. Saltzman 805-258-3311

The objective is to provide concepts for improved airfoils, components and configurations for advanced subsonic, transonic, supersonic and hypersonic aircraft. The improvements sought are in the area of performance, i.e., aerodynamic efficiency. The work will be primarily experimental, utilizing available freeflight vehicles, and will be aimed at (1) investigating local aerodynamic flow phenomena which affect aircraft efficiency and which are essentially independent of the aircraft configuration, but are dependent on the flow properties, the local geometry, the surface conditions and Reynolds numbers achieveable with the research aircraft, and which cannot be achieved with ground facilities; (2) investigation of boattail and base drag aerodynamics and studying means of reducing these forms of drag; (3) investigation of the effects of upstream flow conditions and surface imperfections on flow separation; (4) measurement of the penalties of surface imperfections in thick turbulent boundary layers; (5) provision of experimental confirmation for the---

W73-70101 **501-06-05**
Ames Research Center, Moffett Field, Calif.
AIRFOIL AND CONFIGURATION AERODYNAMICS
L. Roberts 415-965-5066
(501-06-01; 501-06-07; 501-06-08)

This RTOP covers experimental investigations on airfoils, components, and configurations for advanced subsonic, transonic, and supersonic aircraft. The objectives of this research are: to provide basic aerodynamic information on advanced and/or improved airfoils, to improve the basic understanding of complicated flow situations such as flow separation on multi-element high-lift wing configurations, and to determine the potential configuration advantages of the R. T. Jones antisymmetric wing concept for use on Remotely Piloted Vehicles (RPV). The airfoil data will be for use on both fixed and rotary-wing aircraft. This work will be primarily experimental and will be conducted in-house. Complimentary theoretical investigations are covered in RTOP 501-06-01.

W73-70102 **501-06-06**
Ames Research Center, Moffett Field, Calif.
NONSTEADY AERODYNAMICS
C. F. Coe 415-965-5880

The principal objective of this research is to obtain an improved understanding and definition of the unsteady aerodynamic pressures and forces associated with aircraft buffet as affected by aerodynamic and geometric parameters and an improved understanding of the reaction or coupling of the aircraft structure to the unsteady aerodynamics. Wind tunnel tests, verified by selective flight tests, will be conducted to obtain unsteady loads, pressures and model response characteristics for conditions from buffet onset throught maximum buffet and 'wing rock' onset (incipient stall). Additional wind tunnel parametric studies will be made to assess various approaches toward alleviation of wing buffet.

W73-70103 **501-06-08**
Ames Research Center, Moffett Field, Calif.
TURBULENT BOUNDARY LAYERS
V. L. Peterson 415-965-5859
(501-06-01)

This continuing effort is to conduct analytical and experimental investigation of turbulent boundary layer flows under conditions where our present understanding of such flows is inadequate and must be improved. These conditions, for which the flow may be separated or attached, include (1) flows over highly curved surfaces providing severe adverse pressure gradients (with and without bleed or mass injection), (2) flows in the immediate region of, and downstream of, shock-wave boundary-layer interaction, and (3) flows subject to variation of edge entropy and vorticity. In addition, this effort is concerned with the problem of obtaining improved methods for predicting the skin friction and heat transfer rates used for estimating aircraft performance, and with the development of advanced computer programs, for predicting flows for both internal and external configurations. This RTOP is a consolidation of 501-06-07 and -08. It is requested that the funds be consolidated to form a total of $175K for the new 501-06-08.

W73-70104 **501-06-08**
Langley Research Center, Langley Station, Va.
TURBULENT BOUNDARY LAYERS
M. H. Bertram 703-827-3406
(501-06-07)

This work is to improve our ability to predict the behavior of turbulent boundary layers and turbulent free mixing for

aeronautical design purposes. Basic theoretical and experimental research to be done on turbulent boundary layer phenomena including effects of compressibility, pressure gradients, mass and heat transfer and three-dimensional flow. Studies are to include interaction of turbulent boundary layers and shock waves, the development of physical models of turbulence, and separated turbulent flows and an examination of means for reducing turbulent skin friction drag in subsonic and supersonic flows. A coordinated theoretical and experimental program is done in which theoretical models are postulated based on the physics of the situation, with inputs from carefully conducted experiments to measure surface shear and heat transfer and probe the structure of the turbulent boundary layer by standard techniques and by means of hot wires, lasers and other advanced measurement techniques.

W73-70105 **501-06-10**
Langley Research Center, Langley Station, Va.
INSTRUMENTATION RESEARCH
R. E. Bower 703-827-3235

Advanced wind tunnel and flight instrumentation and measurement techniques will be developed to satisfy advanced aeronautical research testing requirements. Funds and manpower expended will be aimed at performing research and developing instrumentation broadly applicable to aeronautical testing programs and because of their broad applicability are not properly chargeable to any one aeronautical subprogram or project. Specifically the work will include such things as the development of instrumentation required to define wind tunnel flow quantities (i.e., semiconductor materials, ion implantation, and micro construction techniques), and heat transfer and force measurement using similar techniques, stream composition by adapting and using miniaturized mass spectroscopic techniques.

W73-70106 **501-06-10**
Ames Research Center, Moffett Field, Calif.
INSTRUMENTATION RESEARCH
L. Roberts 415-965-5066

A laser velocimeter system incorporating a 4-watt Argon laser and an AEDC signal processor, based on the back scattering technique, is to be developed for measuring velocities in the Ames test facilities. Measurements made with the laser velocimeter will be compared with those made in the same test facility, and for the same flow conditions, using a hot wire anemometer. Mean velocity, turbulence intensity, and Reynolds stress components are to be measured.

W73-70107 **510-06-05**
Langley Research Center, Langley Station, Va.
AIRFOIL AND CONFIGURATION AERODYANMICS
R. E. Bower 703-827-3285
(501-06-01; 501-15-01; 760-64-01)

The objective is to provide improved airfoils, components, and configurations for advanced subsonic, transonic, supersonic, and hypersonic aircraft. The improvements sought are in the areas of performance, stability and control, aeroelasticity, and aerodynamic heating. The work will be primarily experimental and will be aimed at: (1) providing experimental confirmation for the analytical results on airfoils, components, and configurations studied under the "Computational Aerodynamics" RTOP; and (2) stimulating research in investigating untried 'far-out' design ideas which are not pinned down to a particular aeronautical system. Examples include supercritical airfoils, leading and trailing edge high lift devices, variable-sweep wing and tails, and anti-spin configurations.

W73-70108 **510-06-08**
Flight Research Center, Edwards, Calif.
TURBULENT BOUNDARY LAYERS
E. J. Saltzman 805-258-3311

Free flight vehicles of relatively large scale will be utilized to generate thick turbulent boundary-layers which will be studied using the latest available instrumentation and techniques to improve our ability to predict the behavior of turbulent boundary layers for aeronautical design purposes. The objectives are basic theoretical and experimental research on turbulent boundary-layer phenomena including effects of compressibility, pressure gradients, mass and heat transfer and three-dimensional flow and roughness. Studies are to include interaction of turbulent boundary layers and shock waves, the development of physical models of turbulence, and separated turbulent flows, an experimental flight program of carefully conducted experiments which probe the structure of the turbulent boundary layer by means of hot wires and other advanced measurement techniques. The flight results will be compared with results from ground facility experiments and with available theoretical predictions and reported through the normal NASA publication media.

W73-70109 **501-06-11**
Ames Research Center, Moffett Field, Calif.
SONIC BOOM
V. L. Peterson 415-965-5859

Analytical and experimental studies are in progress to minimize sonic boom, as well as to develop an improved understanding of sonic boom phenomena. New and advanced theoretical methods will be used to establish flight profiles which will produce acceptable levels of sonic boom pressures on the ground for both supersonic and hypersonic configurations. The results from these studies will be used to design vehicles which generate minimum sonic boom intensities. The configurations will be tested and the data compared with the analytical results.

W73-70110 **501-06-11**
Langley Research Center, Langley Station, Va.
SONIC BOOM
R. E. Bower 703-827-3285

The objective of this work is to develop an improved understanding of sonic boom phenomena to provide more accurate prediction and measurement techniques, and to develop design methods that will lead to advanced low-boom economically viable SST and HST configurations. The research will be accomplished by wind-tunnel and laboratory experimentation, by conduct of theoretical studies, by engineering assessment of conceptual airplane designs, and by acquisition and analysis of data from flight test programs. In-house activities will be supplemented by university grants and by aerospace industry contracts.

W73-70111 **501-06-07**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
BOUNDARY LAYER STABILITY AND TRANSITION
John W. Lucas 213-354-4530
(501-06-01; 501-06-09)

The objective of this program is to provide improved understanding of the fluid mechanical processes involved in the transition to turbulence within supersonic boundary layers. Through coordinated theoretical and experimental studies, the relationship between boundary layer stability and transition is investigated, and other mechanisms relating to the onset of turbulence are explored, with a view toward gaining insight into the relation

between laboratory and free-flight observations of transition. The program relies heavily on the unique performance of the JPL wind tunnels and upon computer programs perfected through lengthy development.

W73-70112 **501-06-07**
Langley Research Center, Langley Station, Va.
BOUNDARY LAYER STABILITY AND TRANSITION
M. H. Bertram 703-827-3406
(501-06-08)

This research is done to improve the understanding and prediction of boundary layer stability and transition because of the importance of transition behavior on aerodynamic heating and its influence on thermal protection systems, on aircraft lift-drag ratios, on missile observables and on vehicle dynamics. Emphasis will be on understanding the role of the fundamental factors that affect transition as measured in ground facilities and in flight in order to improve the correlation of such measurements and to establish a base of information for design applications. Means will be investigated for the control of the wind tunnel environment to more closely simulate the conditions of flight. Using models of simple geometry, such as slender cones, the effects of the disturbance environment on transition as measured in wind tunnels and ballistic ranges will be identified and evaluated. Attention must be given to disturbances introduced by model surface and structure as well as the tunnel environment. Through boundary layer control and other disturbance suppression devices, 'quiet' supersonic tunnels which would suppress adverse environmental disturbances are to be developed. The program is primarily experimental but with close theoretical support and should be directed toward understanding of fundamental processes.

W73-70113 **501-06-09**
Langley Research Center, Langley Station, Va.
TUNNEL AND SCALE EFFECTS ON TRANSONIC FLOW
R. E. Bower 703-827-3285
(760-64-01)

The objective is to determine the wind tunnel and scale effects on flow characteristics at transonic speeds including correlation between wind tunnel and flight. Research will include determination of model support interference, tunnel wall constraints, and flow quality. Studies and development of ground-based facility concepts to achieve the desired flow characteristics will be undertaken. Systematic studies will be made of scale effects on the transonic aerodynamic characteristics of wings, bodies, and complete configurations. Experimental pressure and flow field surveys will be made at the highest attainable Reynolds numbers. The following concepts of facility design will be studied analytically and experimentally at model scale to assess the most feasible facility approach: (A) injector-driven closed circuit tunnel of 2 meter size (200 psia stag); (B) a cryogenically cooled facility for maximum Reynolds number at minimum dynamic pressure. Operation of a prototype model of a 3-D magnetic suspension and balance system will be undertaken. The various facility studies will be supplemented by analytical and experimental efforts to develop transonic test section designs for minimum wall-boundary interference.

W73-70114 **501-06-09**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
TUNNEL AND SCALE EFFECTS
John W. Lucas 213-354-4530
(501-06-01; 501-06-07)

This is a program of coordinated theoretical and experimental investigations of transonic flow in wind tunnels with particular emphasis on the effects of viscosity on simple flow geometries. Interference problems unique to transonic flow wind tunnel testing are investigated. The investigations include studies of transonic scaling and similarity together with studies of support interference, model geometry alteration, blockage, boundary-layer/shock-wave interactions, tunnel geometry and free-flight model acceleration effects. During the coming year, the effort will emphasize experimental studies of the effects of both laminar and turbulent boundary layer separation on shock wave dynamics for biconvex airfoils and tunnel floor mounted bodies. Parallel theoretical studies will guide this phase of the experimental program. Experiments to assess the magnitudes of wind tunnel interference sources on the aerodynamic characteristics of simple models will be continued. The task objectives are ultimately to provide an understanding of viscous transonic flows and to define wind tunnel interference effects in order to build a firm foundation for reliable transonic wind tunnel testing programs.

W73-70115 **501-06-09**
Ames Research Center, Moffett Field, Calif.
TUNNEL AND SCALE EFFECTS ON TRANSONIC FLOW
L. Roberts 415-965-5066
(136-13-01; 136-13-04)

The general objective of this research is to develop improved transonic wind tunnel test techniques in order to ensure reliable correspondence between viscosity-dependent data obtained from scale-model tests and that from full-scale flight tests. Tunnel wall constraints, flow quality and means for simulating higher Reynolds number flows through the use of dense gas mixtures will be investigated analytically and experimentally.

W73-70116 **501-26-01**
Flight Research Center, Edwards, Calif.
HANDLING QUALITIES - CRITERIA FOR HIGHLY AUGMENTED VEHICLES
H. A. Rediess 805-258-3311

The overall objective of this effort is to advance the fundamental knowledge of flight dynamics and to exploit this knowledge to develop methods for optimizing specific flight control or performance goals and to improve flight test analysis techniques. Analytical studies, computer simulations and flight test investigations are being performed both in-house and under research contracts and grants to meet this objective. The range of command responses of augmented aerospace vehicles that optimizes the pilot-vehicle performance for specific missions or a specific task within a mission. The main emphasis will be to investigate criteria for desired command responses that are meaningful to the systems designer and not needlessly restrictive as to the system concept employed. This activity will also study and document the relationship between the stability and control characteristics of airplanes in general and the pilot's assessments of the handling qualities, through the use of simulators (both fixed-based and airborne) and the actual airplanes. Effects of turbulence on the flying and ride qualities will be of major concern.

W73-70117 **501-26-02**
Ames Research Center, Moffett Field, Calif.
HANDLING QUALITIES - TURBULENCE/FLEXIBILITY EFFECTS
Klein H. P. 415-965-5094

Aircraft response to atmospheric turbulence is a prime factor in the design and operations of all aircraft. In order to study these phenomenon accurate models of the turbulence are needed. An effort is continuing to develop realistic turbulence models. Two in-flight programs will be conducted to: a) evaluate

turbulence models using a variable stability aircraft and; b) measure gust velocities at two points in order to provide data for spatial gust distribution effects. Analytical efforts will provide a statistical program for predicting the effects of turbulence on handling and ride qualities, and on structural loads. The ride qualities and handling qualities of large, flexible aircraft are major factors affecting pilot-vehicle performance. Research is needed to: (a) refine currently available ride qualities criteria; (b) develop analytical pilot/vehicle system models which account for the effects of ride qualities on pilot control performance; (c) determine ride qualities/handling qualities/turbulence model interactions. Several piloted simulation studies will be carried out. Initial studies will use the Vertical Acceleration and Roll Device (VARD) to determine the effects of cockpit vibration at several selected levels and frequencies on pilot performance for different sets of idealized vehicle dynamics. In a subsequent study on the VARD, the effects of ride qualities associated with low-altitude high speed penetration missions of a large, flexible bomber aircraft will be determined.

W73-70118 **501-26-04**
Langley Research Center, Langley Station, Va.
VEHICLE DYNAMICS - STALL/SPIN/HIGH A (DIRECTLY PROPORTIONAL TO) CHARACTERISTICS
R. E. Bower 703-827-3285

The broad objective is to expand fundamental knowledge of the stall/spin characteristics of aircraft, and to determine the effects of these characteristics in terms of piloting the aircraft. Specific objectives are: (1) to investigate the fundamental nature of stall/spin including the development of methods for theoretical analysis, (2) to investigate use of control systems for automatic spin prevention, (3) to determine aerodynamic characteristics at high angles of attack, and (4) to determine characteristics which produce a spin-resistant airplane. The methods of approach include wind-tunnel force tests, theoretical analysis, piloted simulator tests, and dynamic model tests.

W73-70119 **501-26-04**
Ames Research Center, Moffett Field, Calif.
VEHICLE DYNAMICS - STALL/SPIN/HIGH A (DIRECTLY PROPORTIONAL TO) CHARACTERISTICS
L. Roberts 415-965-5066

The primary emphasis in this program will be on the identification of aerodynamic characteristics leading to out-of-control aircraft motions brought about by flying at high angles of attack, improvement of methods for predicting these characteristics, and the application of these findings to the definition of new criteria for designing vehicles capable of performing controlled maneuvers over an expanded angle-of-attack envelope. Insofar as possible Ames will continue to conduct high angle-of-attack force tests, of various aircraft under development, in the high Reynolds number 12-foot wind tunnel to provide data needed in spin investigations conducted by Langley. Ames also has agreed to provide wind-tunnel test time and aerodynamic consultation to the Flight Research Center in support of their program to investigate problems related to aircraft spin with a remotely piloted scale model of the F-15 airplane. The Ames program is an integrated effort involving analysis, wind-tunnel investigations, piloted simulator studies and coordination with Air Force and NASA flight investigations. This program is divided into the following four specific projects:---

W73-70120 **501-26-05**
Langley Research Center, Langley Station, Va.
ADVANCED CONTROL APPLICATIONS
R. E. Bower 703-827-3285
(766-75-02; 742-73-01)

The objectives are: to develop a broad base of technology in advanced control systems which make available to the designer the ability to improve the performance of aircraft by reducing the size to stabilizing surfaces, by allowing a wider choice of configuration and wing loading, by avoiding undesirable flight regimes which might impose hazardous loads or loss of control, and by making the aircraft less sensitive to turbulence and gusts; and to investigate and encourage the adoption of techniques allowing maximum utilization of these principles by incorporating these considerations in the early design stages of an aircraft. Analytical studies to investigate the application of several aspects of modern control theory to airplane dynamics and control systems synthesis are conducted. These studies include methods for decoupling the airplane responses to individual control inputs, the development of synthesis techniques for complex multivariable control systems which operate over a wide range of flight conditions, the application of adaptive control techniques, and the synthesis of gust-alleviation systems. Simulation studies to investigate the effect of promising systems on pilot opinion and handling qualities are utilized. Systems for gust alleviation, maneuver load control, and structural mode damping applicable to modern airplane configurations are developed.

W73-70121 **501-26-06**
Flight Research Center, Edwards, Calif.
ADVANCED CONTROL APPLICATIONS - FLY-BY-WIRE EXPERIMENTS
C. R. Jarvis 805-258-3311
(766-75-01)

The overall objective of this joint effort with LaRC is to provide the technology required for the implementation of advanced reliable digital fly-by-wire systems in future aircraft. In Phase IA, flight tests will be conducted on the single-channel digital system in an F-8C aircraft to determine the basic system and operational performance. These tests will investigate handling qualities and aircraft response, turbulence and engine noise effects, filter and gain variations, and high angle of attack areas during low speed and cruise flight. In Phase IB, through a cooperative effort with LaRC, a dual-channel digital fly-by-wire system using multi-purpose aircraft computers will be developed and flight tested in the F-8C aircraft. Software development and simulation support for this phase will be provided by LaRC. In Phase II, through cooperation with LaRC, a reliable multichannel fly-by-wire system will be developed and flight tested using information attained from Phase IA and IB.

W73-70122 **501-26-07**
Flight Research Center, Edwards, Calif.
IN-FLIGHT SIMULATION TECHNOLOGY--GPAS
J. J. Perry 805-258-3311

The objective is to develop the General Purpose Airborne Simulator (GPAS) hardware in support of Flight Dynamics research efforts in the improvement of aircraft flying and ride qualities in turbulence, and simulation efforts in the conduct of simulation technology programs. Model-controlled system electronics for the direct lift controls (DLC) and side force generators (SFG) are installed. Present airborne analog computer with modern digital computer system to fully utilize expanded capability is replaced. Turbulence measuring and simulation techniques to measure turbulence intensity and simulate model aircraft's response to turbulence are developed.

W73-70123 **501-26-08**
Ames Research Center, Moffett Field, Calif.

GROUND-BASED SIMULATION TECHNOLOGY
Leonard Roberts 415-965-5066

Research in the area of flight simulation technology is being conducted with the objective of defining simulator fidelity requirements for a broad scope of piloting tasks. The results of this research will promote the most efficient use of costly motion and visual systems in both research and training simulators. Flight research and simulation facilities at Ames, especially the large-amplitude motion devices and the visual simulation systems, are being utilized in this program. Current aircraft development programs, utilizing extensive simulation work, are providing a framework for the development of simulator fidelity requirements. New information regarding human motion perception characteristics will aid in the establishment of analytical methods for defining simulator motion requirements. Several studies of visual cue requirements will be conducted as a contractual effort. Research on flight dynamics problems in simulation facilities requires continuous efforts in re-configuring simulation facilities, improving computational and data acquisition capabilities, and providing additional cues and improved cue fidelity as required by various research program requirements. The funding of the upgrading and support of Ames simulation facilities has been submitted under the ROS budget in FY '73. This RTOP provides for the procurement of special purpose computers, graphics, and peripheral equipment and the development and procurement of computer software which as ADP equipment has been specifically excluded from the Ames ROS allocation.

W73-70124 **501-26-09**
Flight Research Center, Edwards, Calif.
SIMULATOR DEVELOPMENT
J. P. Smith 805-258-3311

The objective of this work is to provide the ground-based simulation facilities required for support of flight dynamics research. This effort will be accomplished by the analysis of program requirements, and the design, development, and construction of the necessary ground-based simulation facilities and equipment.

W73-70125 **760-60-05**
Flight Research Center, Edwards, Calif.
GENERAL AVIATION FLIGHT DYNAMICS - CONTROL AND DISPLAY
M. R. Barber 805-258-3311
(501-23-21)

The objectives are: to identify and demonstrate the optimum levels of stability control, and handling qualities for general aviation aircraft that can be achieved through the application of modern control technology; and to define minimum system characteristics that permit realizing these levels. Flight and simulator studies will be continued in control display interactions. Degradation of system and component performance will be used in addition to mixing control modes between axis in order to define minimum system characteristics. Economical system mechanizations that provide these characteristics will be explored. Studies will be made of benefits, including direct lift/drag control devices in a flight path command mode of control.

W73-70126 **760-61-01**
Ames Research Center, Moffett Field, Calif.
STOL AERODYNAMIC PERFORMANCE - TWO DIMENSIONAL LIFT AUGMENTATION AND NOISE STUDIES
L. Roberts 415-965-5066
(760-61-02)

This RTOP covers research on Ames STOL aerodynamics and noise studies. The problem is to provide an aerodynamically efficient, quiet, powered lift system. The work includes advanced augmentors, cruise augmentors, and basic noise studies. Contracted studies have shown that augmentor noise can be reduced below the goals by careful nozzle design and effective acoustic treatment. High pressure ratio air and special engines having relatively poor cruise fuel consumption are required for propulsion. Means to quiet the compressor noise is the critical item for noise reduction. In-house, Ames has developed a low pressure augmentor that is inherently more quiet and could use existing relatively quiet and efficient engines. This approach, combined with a cruise augmentor is being studied under contract. In-house efforts will continue to improve the augmentor. The acoustic and physical properties of high aspect ratio and distributed jets representative of powered lift systems will be studied theoretically and experimentally in an attempt to improve noise predictions for this type of noise source. The noise generated by an airfoil in a jet will be studied in-house.

W73-70127 **760-61-02**
Langley Research Center, Langley Station, Va.
STOL AERODYNAMIC PERFORMANCE - CONFIGURATION STUDIES
R. E. Bower 703-827-3285
(501-24-12)

The objective is to provide the technology required for improved performance and handling qualities of powered-lift short takeoff and landing (STOL) and reduced takeoff and landing (RTOL) aircraft configurations that are designed for low noise. This work will be closely coordinated with that under RTOP 501-24-12. Primary emphasis in FY 73 will be placed on configurations with propulsion systems using the principle of attached flow on the upper surface to reduce noise. Theory, wind tunnels, static rigs, and simulators will be used to provide basic aerodynamic and handling qualities data through parametric ranges when appropriate. Design studies will be used to determine the problems and potential of integrating these results to minimize noise. This is a consolidation of RTOP requests 760-61-01, 760-61-02, and 760-61-03.

W73-70128 **760-61-02**
Ames Research Center, Moffett Field, Calif.
STOL AERODYNAMIC PERFORMANCE - CONFIGURATION STUDIES
L. Roberts 415-965-5066
(760-61-01)

This RTOP covers research to improve performance, stability, and control and reduce noise of promising powered lift STOL transport concepts. Large scale models will be used to study low speed performance, and smaller models suited for high speed wind tunnels will be used to study use of the augmentor in cruise. The large-scale DeHavilland model will be modified by incorporating an advanced, quiet, augmentor. A large scale half-span model will be built with the Ames developed low pressure augmentor. The low pressure expanding duct IBF will be tested in FY 1973. A study will begin of means to configure STOL aircraft to reduce noise.

W73-70129 **760-61-03**
Ames Research Center, Moffett Field, Calif.
STOL FLIGHT DYNAMICS
L. Roberts 415-565-5066
(766-71-02)

Generalized analytical studies, ground based simulation, and flight research will provide data for the revision and extension of existing handling qualities criteria for application to powered

lift STOL transport aircraft. Data will apply to the following critical areas: flight path, airspeed, and attitude control; landing flare in the presence of ground effect; and roll and yaw control for cross-wind operation. The program will be coordinated with the C-8 augmentor wing, QUESTOL, and OV-10A research aircraft programs. The latter aircraft will be utilized in a coordinated simulation flight program to study handling qualities problems related to flight path control, power management, and minimum speed selection. The C-8 and QUESTOL flight programs are covered by RTOPS 766-71-02 and 741-86-01 respectively. Tentative certification criteria based on studies of representative STOL aircraft will be developed in cooperative FAA/NASA piloted simulation studies on the Flight Simulator for Advanced Aircraft. These results will contribute to generalized criteria for all concepts. Development of procedures for demonstrating compliance to the criteria will also be undertaken.

W73-70130 **760-62-01**
Ames Research Center, Moffett Field, Calif.
VTOL AERODYNAMIC PERFORMANCE
L. Roberts 415-965-5066
(501-24-11)

This RTOP covers research on the aerodynamics, performance, stability and control of promising jet-lift VTOL transport configurations, including a better understanding of propulsion-aerodynamic interactions. Analytical methods for predicting these characteristics will be improved. Large scale studies of a research model, both in and out of ground effect will continue. Large scale studies of aircraft components will continue, as will research on the noise generated by jet lift VTOL aircraft at forward speed. Analytical studies, in-house and under contract, will continue to improve prediction methods. Cruise aerodynamics will be studied both experimentally and analytically and the control system work will be extended to improve the characteristics of the system.

W73-70131 **760-62-01**
Langley Research Center, Langley Station, Va.
VTOL AERODYNAMIC PERFORMANCE
R. E. Bower 703-827-3285

The basic research objective is to provide the technology required for improved performance, stability, and control of promising lift-fan or lift-jet VTOL configurations that would have application in civil and military transports as well as military fighter and attack aircraft. An additional objective of these investigations is to use experimental results to assist the development of more useful analytical methods for predicting the aerodynamic characteristics and gain a better understanding of propulsion-aerodynamic interactions. Limited fundamental studies will be continued in-house and by contract to develop, through theory and experiment, engineering design methods for optimizing the aerodynamics of lift-fan V/STOL aircraft. University grants will augment the in-house analytical work. A major emphasis will be placed on investigations of promising lift-fan transport configurations in the V/STOL tunnel. Dynamic-stability and free-flight tests of a selected configuration can be made in the full-scale tunnel In addition, exploratory wind-tunnel research under this RTOP will also be concerned with a general study of a VTOL fighter-type configuration using the ejector-augmented-lift principle or the deflected thrust concepts suitable for application in the Navy sea-control concept.

W73-70132 **760-62-02**
Ames Research Center, Moffett Field, Calif.
VTOL FLIGHT DYNAMICS
L. Roberts 415-965-5007
(760-61-03; 760-63-05)

This research is directed toward developing design and certification criteria for satisfactory manual control of jet or fan lift VTOL aircraft. Two areas are of primary concern: control of the aircraft for precise decelerating approaches to hover; and precision control in hover. Flight and simulation studies have indicated that thrust vector management to control speed and position relative to the flight path is the primary problem to be solved to obtain satisfactory manual control during the IFR approach. Analysis and simulation, centered on a Lift-Fan Research Transport configuration will be conducted to evaluate various techniques of automating control of the magnitude and direction of the thrust, and to develop improved concepts. A simulation of the XV-5B aircraft will be developed based on flight and wind tunnel data. This will provide a means of verification of other simulations of lift fan aircraft. In addition, it will be used to quantify all factors contributing to the excessive pilot work load in the decelerating approach and to determine what modifications are required to convert the XV-5B into an interim aircraft for further flight research on handling qualities prior to the development of the Lift Fan Research Transport. Control systems for precise control of hovering aircraft will be considered for both commercial and military applications. Candidate systems for specific VTOL aircraft will be developed through analysis and simulation. In flight verification and extension of results will be accomplished with the X-14B variable stability aircraft. The long range plan includes simulations and eventual in-flight verification to establish certification criteria for VTOL commercial aircraft ---

W73-70133 **760-62-02**
National Aeronautics and Space Administration, Washington, D.C.
V/STOL FLIGHT DYNAMICS
Ralph W. May, Jr. 202-755-2405

Flight and ground-based simulation research is being carried out by Ames and Langley with V/STOL aircraft to study handling-qualities and terminal-area operation problems of such aircraft. As part of the overall investigation, the Navy X-22 tilt-duct, V/STOL airplane is being utilized in a program funded by the Navy, Air force, FAA and NASA. The X-22 has a wider allowable descent envelope than most other VTOL aircraft and reduced cruise-to-approach crew work-load requirements. These two significant factors of the X-22 make this aircraft particularly suitable for extending the terminal area operations research already performed to determine minimum airspace requirements and associated terminal area flight procedures for IFR operations.

W73-70134 **760-63-01**
Ames Research Center, Moffett Field, Calif.
ROTORCRAFT AERODYNAMICS AND DYNAMICS - ANALYSIS AND TESTS OF ROTORCRAFT FLOW FIELDS AND SYSTEM ELEMENTS
L. Roberts
(760-63-02)

Much of the improvement in helicopter performance achieved in the past has been the result of semi-empirical cut-and-try approaches. To ensure more orderly progress, future analyses will require more sophisticated treatments of the flow fields and rotor blade motions. The latter are even more necessary in order to study the equally pressing problems of rotor noise, dynamic loads and stability. These new analyses require laboratory verifications such as are obtainable in full scale wind tunnel testing, and those involved in such investigations need the analyses in order to insure meaningful research. For these ends, several existing theories will be procured and consolidated with

in-house programs. Such theories or program will incorporate aeroelastic effects, non-uniform flow field effects based on free-wake calculations, oscillating airfoil effects and considerations of the three dimensional flow field at the rotor's blade tips. These theories will be used to develop improved rotor blade designs for performance and noise requirements, and to develop means for the reduction of vibratory loads and the improvement of rotor and rotorcraft stability. They will also be used to evaluate promising concepts of rotor control such as the controllable-twist-rotor, jet-flap applications on both jet and shaft driven rotors, and feed back control methods on hingeless rotors. This program will be a joint NASA and Army AMRDL effort.

W73-70135 **760-63-02**

Ames Research Center, Moffett Field, Calif.

ROTORCRAFT AERODYNAMIC AND DYNAMICS TEST AND ANALYSIS OF ROTOR SYSTEMS AND CONFIGURATIONS - HELICOPTER

L. Roberts 415-965-5066

(760-63-01; 760-63-03)

This RTOP covers research on performance, dynamic loads, stability, control system, and noise characteristics of advanced helicopter rotor concepts and configurations. Large scale wind tunnel tests will be conducted to evaluate these configurations and provide a data base to improve analytical techniques for future concept evaluation. Development of the High Performance Rotor test rig will be completed and test of the baseline rotor conducted. The baseline blade set will be modified with extensive instrumentation to measure surface pressures, boundary layer characteristics and acoustics. Tests will be conducted of a series of rotors with modified tip planforms designed for noise reduction, which will permit noise/performance trade offs and provide data for correlation with acoustic theory. Tests of the Controllable Twist Rotor are conducted to determine performance/stress trade off. Tests of a hingeless rotor with a hub moment feedback control system are conducted to determine rotor steady state and transient response and transfer functions, both open and closed loop. Tests of the Reverse Velocity Rotor in the 12-food wind tunnel are conducted. Techniques for measuring blade vibratory shear forces on HPR are developed.

W73-70136 **760-63-02**

Langley Research Center, Langley Station, Va.

ROTORCRAFT AERODYNAMIC PERFORMANCE - TEST AND ANALYSIS OF ROTOR SYSTEMS AND CONFIGURATIONS

R. E. Bower 703-827-3285

Analytical and experimental studies will be made to identify factors contributing to the aerodynamic, structural, and noise characteristics of rotors. University grants and contracted studies will be continued to define wake geometry and analytical procedures which include wake characteristics in predicting airloads, structural responses, performance and noise. In-house experimental studies will be continued to better define unsteady local-flow parameters significant in rotor blade section lift analysis and blade airfoil development. Analytical, wind tunnel, and whirl tower investigations will be made to determine performance, dynamic loads, vibrations, and noise characteristics of advanced rotor concepts, rotorcraft configurations, and tail rotor arrangements. Advanced research rotor systems will be developed specifically for flight tests on the Rotor Systems Research Aircraft (RSRA). Work will proceed on the necessary studies, supporting technology, design, and development of a series of advanced rotor systems in order to begin flight testing on the RSRA in F.Y. 1976. These programs will, in general, be carried out jointly with the Langley Directorate of the Army Air Mobility R and D Laboratory.

W73-70137 **760-63-03**

Ames Research Center, Moffett Field, Calif.

ROTORCRAFT AERODYNAMICS AND DYNAMICS - ANALYSIS AND TESTS OF SYSTEMS AND CONFIGURATIONS - TILT ROTOR

L. Roberts 415-965-5066

(760-63-01; 760-63-02)

This RTOP covers activities in research and supporting technology for the tilt rotor aircraft program to provide a sound base for definition of performance, dynamic loads, stability, control system and noise characteristics of advanced tilt rotor concepts and configurations. In-house development of a 4 and 9 degree of freedom math model of tilt rotor dynamics will be completed and correlated with full scale wind tunnel data. Development of more sophisticated models of the complete aircraft and its various subsystems will continue, including control systems for mode suppression. Contracted analyses and tests will be conducted for rotor control systems for gust alleviation and blade load suppression. Contracted analyses and in-house tests will be conducted for airfoils specifically optimized for the tilt rotor. Contracted analyses and tests will be conducted to study rotor wind interference problems.

W73-70138 **760-63-04**

Ames Research Center, Moffett Field, Calif.

ROTORCRAFT FLIGHT DYNAMICS - TILT ROTOR AIRCRAFT

L. Roberts 415-965-5066

(767-78-01)

This RTOP describes a program to define and perform simulation and flight investigations for the tilt rotor transport aircraft to generate a more thorough data base required for use by designers, civil and military operators, and regulatory agencies in handling qualities, dynamics and flight control for this type of aircraft. The flight experiments for this program will be conducted on the tilt rotor research aircraft as a vehicle reasonably representative of a tilt rotor transport aircraft. A simulation will be set up for the tilt rotor transport aircraft to investigate the operational boundaries, stabilization and control requirements, and performance of this type of aircraft as a function of design and operational parameters. It is planned to set up this simulation in conjunction with the Aeronautical Projects Office simulation of the Tilt Rotor Research Aircraft. This simulation will then be used for specific evaluation of proposed configurations for the research aircraft by the Aeronautical Projects Office (RTOP 767-78-01) and for the research and technology investigations to establish design and operational criteria as described in this RTOP which will consider aircraft of size and performance suitable for operational military or commercial applications.

W73-70139 **760-63-04**

Langley Research Center, Langley Station, Va.

ROTORCRAFT FLIGHT DYNAMICS

R. E. Bower 703-827-3285

(768-81-06)

Using broad capability helicopter in-flight simulators as primary tools, conduct research is required to develop improved design and certification criteria (primarily in areas of handling qualities and overall flight characteristics) for various classes of VTOL vehicles such as lift-fan transports as well as helicopters and other rotorcraft. Such research required for both manual IFR flight simulations, as well as for advanced vehicles having automated flight and active control capability with satisfactory provision for pilots to monitor and take over flight control

manually with particular emphasis on flight in the terminal areas is to be conducted. Representative types of problems to be investigated include defining the requirements and flight/operational characteristics of advanced flight control systems including active controls, inherent stability and augmented stabilization, cockpit displays and pilot controls including pilot workload, vehicle/piloting interfaces with groundbased and onboard navigation systems for manual flight in IFR conditions, and vehicle/piloting interfaces with automated flight systems. The CH-46 in-flight simulator will be used heavily in FY 1973 and preparations made to phase in a CH-47 in-flight simulator with improved capability. The SH-3A test helicopter will be used for cockpit display-pilot workload studies, and the large CH-54 helicopter will be used to examine size and weight effects on handling qualities. Handling qualities research on the X-22 aircraft will be conducted by this RTOP (joint Navy/Air Force/FAA/NASA program with NASA funding provided directly by NASA Headquarters).

W73-70140 **760-63-05**
Langley Research Center, Langley Station, Va.
ROTORCRAFT - ADVANCED TECHNOLOGY CIVIL HELICOPTER
R. E. Bower 703-827-3285

The objective of this effort is to initiate a coordinated program to expedite the entry of an advanced technology helicopter into an integrated VTOL short-haul transportation system. The approach will involve contract efforts in the areas of vehicle operational data acquisition and preliminary studies of the technology application potential and of the vehicle/air-transportation system interface requirements.

W73-70141 **760-64-01**
Langley Research Center, Langley Station, Va.
SUBSONIC/SONIC AIRCRAFT - AERODYNAMIC PERFORMANCE
R. E. Bower 703-827-3285
(501-06-05; 501-15-01)

The objective is to provide the required data base to evaluate configuration aerodynamic performance, stability and control characteristics of advanced subsonic/sonic transport concepts (apart from the mainline and primary alternate ATT Configurations) in both cruise and terminal area flight regimes. Transonic and low-speed wind-tunnel investigations to obtain three-dimensional force, moment and flow data on advanced subsonic/sonic transport aircraft beyond the mainline and primary alternate configurations to be investigated in the ATT program under RTOP 501-15-01 are conducted.

W73-70142 **760-64-01**
Ames Research Center, Moffett Field, Calif.
SUBSONIC/SONIC AIRCRAFT AERODYNAMIC PERFORMANCE
E. W. Perkins 415-965-5852

This RTOP covers investigations of the aerodynamic performance, stability and control characteristics, and airport and community noise characteristics of (1) advanced transport aircraft concepts capable of operating at transonic and low supersonic speeds such as the R. T. Jones antisymmetric design and (2) transport aircraft capable of operating at reduced takeoff and landing distances (RTOL) compared to conventional transports. For the antisymmetric wing-body configuration tests will be conducted for subsonic, transonic and supersonic Mach numbers up to M equals 1.5. The data will be compared with theory, and this information will be used for mission studies to assess the antisymmetric configuration potential for advanced transport consideration. Concurrently, an analytical and experimental investigation of nacelle-airframe interference effects on engine type and nacelle size, shape and location will be made. This combined effort will be accomplished both in-house and on contract.

W73-70143 **760-64-02**
Ames Research Center, Moffett Field, Calif.
SUBSONIC/SONIC AIRCRAFT - FLIGHT DYNAMICS
M. D. White 415-565-5009

Analysis and piloted simulator studies and flight evaluation of reduced take-off and landing (RTOL) aircraft will be conducted. The initial steps in the program will be to select candidate control and display systems based on current STOL and CTOL research. Mathematical models will be developed based on aerodynamic data from wind tunnel tests and theoretically based computations. Piloted simulation will be conducted to establish optimum system parameters and certification criteria. In flight verification will be performed on demonstration aircraft.

W73-70144 **760-64-03**
Ames Research Center, Moffett Field, Calif.
CIVIL AIRCRAFT DEVELOPMENT TESTING
S. L. Treon 415-965-5850

Aircraft companies in the course of developing commercial aircraft, seek time in the Ames wind tunnel facilities, on a fee basis, for the purpose of studying the Reynolds number sensitive characteristics of wing high lift devices at subsonic speeds and the drag, the static stability and control, and inlet airframe interactions of their designs at transonic speeds. The results of these studies are frequently of mutual benefit to both the aircraft company and NASA.

W73-70145 **760-64-60**
Langley Research Center, Langley Station, Va.
SUBSONIC/SONIC CTOL TRANSPORT TECHNOLOGY: AIRFRAME AND NACELLE AERODYNAMICS (ATT)
W. J. Alford, Jr. 703-827-3586
(760-64-01; 760-64-02)

The objective is to establish as a basis for development of improved subsonic/sonic CTOL transport systems, a foundation of advanced technology in supercritical aerodynamics. Transport configuration wind tunnel tests in relation to systems studies and the development of a means for accurately analyzing and predicting the interference effects of configuration components are continued. An experimental data base for designing large high-speed transport aircraft incorporating wing mounted nacelles (both 2 and 4 engines) is provided. A practical approach for incorporating gust load, maneuver load and flutter suppression controls in advanced wing designs is developed. The development of practical approaches for incorporating effective control high-lift devices in supercritical wing designs is continued. Overall nacelle configurations (flow through and powered) for practical transport aircraft operating near the speed of sound are developed.

W73-70146 **760-65-01**
Ames Research Center, Moffett Field, Calif.
SUPERSONIC TRANSPORT - OPTIMUM DESIGN/CCV
T. J. Gregory 415-965-5881
(760-65-04; 760-65-07; 750-65-08)

The objective of this research effort is to privide information in areas where experience has shown that design knowledge for advanced supersonic transport aircraft is incomplete. The potential performance gains to be realized by relaxing conventional

aerodynamic stability requirements (CCV concepts) will be assessed by theoretical studies and wind tunnel tests. These efforts will be coordinated with related studies on the handling qualities criteria and control system mechanization techniques for CCV supersonic transport aircraft proposed under RTOP's 760-05-07 and 760-05-08. Correlation of theoretical and experimental results from wind tunnel tests and flight tests will be made. Theoretical methods for improving the prediction of flow fields about arbitrary shapes will be developed.

W73-70147 **760-65-03**

Langley Research Center, Langley Station, Va.

AST - AERODYNAMICS AND PERFORMANCE (CONCEPTS)

R. E. Bower 703-827-3285

(760-65-01; 760-65-04)

The objective of this program is to develop the aerodynamic technology which would serve as a basis for an advanced supersonic transport aircraft in terms of maximum aerodynamic performance at both supersonic and subsonic speeds and to provide sufficient control power for all phases of flight. The approach to be taken is to develop, through in-house and contractor effort, airframe stability and control power criteria for advanced arrow-wing configurations with active controls. Wind tunnel investigations especially at high angles of attack and off-design Mach numbers are to be conducted to improve those aerodynamic characteristics identified as critical in the studies. From these investigations, aircraft modifications are to be indicated which are most apt to produce improved performance. Multiple solutions to a given aerodynamic problem will be sought in order to afford the designer options in the total job of configuration integration and optimization. Other configurations such as blended arrow-wind and variable-sweep transports are to be examined and an assessment of their subsonic stability, control and performance is to be made.

W73-70148 **760-65-04**

Langley Research Center, Langley Station, Va.

AST - AERODYNAMICS AND PERFORMANCE (THEORY)

R. E. Bower 703-827-3285

(760-65-01; 760-65-03; 760-65-01; 760-65-04)

The objective of this program is to formulate and validate improved analytical techniques or empirical methods for the design and for the prediction of the aerodynamic behavior of advanced supersonic transport configurations at both subsonic and supersonic speeds. The approach to be followed is to make an assessment of available analytical and/or empirical methods for designing and predicting the aerodynamics and performance of advanced supersonic transport configurations. These methods will be improved, when required, and new techniques will be utilized to show the effect of configuration changes on the particular component involved, and also on the overall performance of the aircraft. Emphasis will be placed on the development of aerodynamic design and/or analytical methods for detailing surface pressures, flow field information, and for handling leading edge separation and the attendant vortex flows.

W73-70149 **760-65-04**

Ames Research Center, Moffett Field, Calif.

DEVELOPMENT AND VERIFICATION OF METHODS FOR PREDICTING THE LOW-SPEED AERODYNAMIC CHARACTERISTICS OF ADVANCED SUPERSONIC TECHNOLOGY AIRCRAFT

L. Roberts 415-965-5066

The research performed under this RTOP is to develop and evaluate aerodynamic theories for use in predicting the high-lift characteristics of advanced supersonic technology aircraft, including wing-body interference and ground effects.

W73-70150 **760-65-05**

Flight Research Center, Edwards, Calif.

AST - COOPERATIVE AUTOPILOT/SAS/PROPULSION CONTROL SYSTEM

G. J. Matranga 805-258-3311

(501-24-21)

Significant airplane flight path disturbances, attributable to the propulsion system, have been observed on the XB-70 and YF-12 airplanes at high speed. This RTOP proposes to develop wind tunnel and analytical techniques for predicting airframe/propulsion system interactions of advanced supersonic aircraft and to determine the feasibility and benefits of a cooperative autopilot/SAS/propulsion control system. This goal would be achieved by conducting simulator and analytical studies to determine the possible benefits to be derived through the use of such an integrated control system on the YF-12. Contracts would be let for the design, construction, and installation of such a system on the YF-12. Flight tests then would verify the benefits that can be obtained by such a system in an operational environment.

W73-70151 **760-65-06**

Ames Research Center, Moffett Field, Calif.

DEVELOPMENT OF FLEXSTAB FOR AST

L. Roberts 415-965-5066

The aeroelastic deflections experienced by large supersonic aircraft both in steady state and maneuvering (perturbed) flight have a major impact upon performance, stability, control, and the internal loads arising from such deflections. A major objective of this research is to develop improved analytical methods and to incorporate such improvements in the FLEXSTAB system of computer programs for calculating stability and control of flexible aircraft. Both longitudinal and lateral-directional motions are included. Modifications are planned that will provide improved lateral-directional results, more complete loads information, effects of active controls, and improved representation of non-linear aerodynamics. As modifications are made, the FLEXSTAB program will be validated by comparing computed results with experimental measurements from both flight and wind tunnel tests.

W73-70152 **760-65-07**

Ames Research Center, Moffett Field, Calif.

AST - HANDLING QUALITIES CRITERIA FOR ACT-CONFIGURED ADVANCED SUPERSONIC AIRCRAFT

L. Roberts 415-565-5066

(760-65-08)

Studies on the Ames piloted motion simulators and a parallel analytical effort will be directed toward the development of quantitative criteria for ACT-configured advanced supersonic airplanes. The initial simulations will use available mathematical models of the Concorde and B2707-300 airplane, and will be supported by analysis and trade-off studies. Stability and operating procedures will be systematically varied and the stability augmentation and control required to cope with each level of stability determined. Both longitudinal and lateral characteristics will be considered, and the operating procedures required for noise abatement will be included. Results will be utilized in a contractual investigation to determine performance gains to be realized through configuration changes that employ active controls. Prospective new designs will be investigated in later program phases.

W73-70153 **760-65-08**
Ames Research Center, Moffett Field, Calif.
TECHNOLOGY DEVELOPMENT FOR ACT-CONFIGURED SUPERSONIC AIRPLANES II - INVESTIGATION OF CONTROL SYSTEM MECHANIZATION TECHNIQUES
Leonard Roberts 415-965-5066
(760-65-07)

The objectives are to determine failure modes of alternative control system mechanizations, the ability of the crew to react to these failures and the resultant effect on control system design requirements. Piloted motion simulator studies will be conducted to investigate the acceptability of various redundancy concepts in terms of the control stability and responses in normal operation and the ability of the pilot to detect and react to failure in the systems. Math model will be developed on the basis of contracted efforts of Boeing extending current Phase I and Phase II SST technology follow-on efforts sponsored by DOT, and data from in-house studies at LaRC and ARC. Emphasis will be placed on actuator systems and structural support compliances scaled to the size of the SST class of airplane. This effort is complimentary to RTOP 760-65-07 and will be carried out jointly with that RTOP.

W73-70154 **760-65-09**
Langley Research Center, Langley Station, Va.
ADVANCED SUPERSONIC TECHNOLOGY: SYSTEMS STUDIES
R. E. Bower 703-827-3285

This RTOP covers the conduct of systems studies which will identify and assess the impact of new technologies applicable to future supersonic commercial aircraft. It is necessary to determine how these advancements can be successfully integrated into a design for a supersonic cruise aircraft. In particular, to investigate such areas as subsonic/supersonic performance, economics, safety, comfort, and those characteristics such as noise, pollution, etc., which interact with the social community. Contractual system studies will evaluate advanced supersonic technology in aerodynamics/configurations, propulsion, structures, materials, flight controls, and avionics. The impact of these new technologies will develop into a base of knowledge for design. These studies will define the state of readiness and evaluate high risk and recommend the actions necessary to minimize these high risk areas. This work will be supported and complemented by program elements under Langley Research Center, Lewis Research Center, Ames Research Center, Flight Research Center, and the Department of Defense (DOT-FAA); covering fundamental aerodynamic and structural technology, propulsion, inlet and nozzle studies, flight research support of programs and inputs from SST technical follow-on program of the DOT-FAA. The proposed contracts shall be a level of effort over a period of two (2) years with three (3) or more contractors for one (1) year with options for the second (2nd) year with only two (2) contractors.

W73-70155 **760-66-01**
Ames Research Center, Moffett Field, Calif.
HYPERSONIC AIRCRAFT AERODYNAMIC PERFORMANCE
V. L. Peterson 415-965-5859

Recent mission studies indicate that hypersonic, hydrogen-fueled aircraft with airbreathing engines offer attractive performance capabilities for both civil and military aircraft. Such studies must be supplemented by detailed studies of various components of a configuration, particularly the air induction system with emphasis on the effects of inlet shape on the vehicle aerodynamics. Sufficiently detailed information on the various inlet flow components (e.g. boundary layers and shock-wave boundary layer interactions in three-dimensional flows) must be acquired so that advanced computer programs can be developed to provide the performance estimates needed to establish a more credible basis for conducting future mission studies.

W73-70156 **760-66-01**
Langley Research Center, Langley Station, Va.
HYPERSONIC AIRCRAFT AERODYNAMIC PERFORMANCE
R. E. Bower 703-827-3285
(501-04-03)

The purpose of this work is to provide the technology for the design of efficient, practical, hypersonic airbreathing aircraft. A number of aircraft systems are being studied. These include hypersonic transports, military strike and reconnaissance vehicles, hypersonic research airplanes, and the airbreathing launch vehicle. The airbreathing launch vehicle which is capable of providing a truly low-cost space logistics system can fill an expected need in the NASA/DOD program in the 1985-1995 time period. The hypersonic transport, with its long-range capability and cruise sonic boom levels that may be acceptable over populated areas, has the potential of providing a major step in air transportation in the latter part of the century. Airbreathing vehicle systems must fully exploit the interactions between aerodynamics, propulsion, structures, trajectory selection, etc., to achieve maximum overall efficiency and operational flexibility. Detailed work on configuration concepts, reliable prediction techniques, full-scale Reynolds number effects, engine-airframe integration, etc., will be vigorously pursued to provide the technological base necessary. The technology for all three systems needs to be demonstrated in flight before commitment to mission hardware is made. The hypersonic research aircraft will be used as a focal point in the technology development.

W73-70157 **760-66-02**
Langley Research Center, Langley Station, Va.
HYPERSONIC RESEARCH AIRPLANE CONCEPT DEVELOPMENT
R. E. Bower 703-827-3285
(760-66-01; 501-04-03; 501-22-06)

The purpose of this work is to develop an advanced concept for a hypersonic research airplane (HRA) designed to demonstrate in flight much of the technology required for future transport, military, and space-launch hypersonic airbreathing systems. Particular emphasis will be placed on incorporating features in the HRA to demonstrate efficient hypersonic airbreathing propulsion and long lived structures. This program will be conducted by interdivisional groups assisted by industrial design specialists. Systematic, in-depth studies will be conducted to develop an HRA concept embodying the most promising aerodynamic, propulsive and structural features required for future operational systems derived from the ongoing technology programs. Feed back from the HRA will provide major focus and guidance for the ongoing programs. The projected schedule for the HRA requires that the concept be defined and the pre-project R and D be completed in 1975. The detailed design, development and procurement of the HRA would be initiated in 1976 with the flight research program beginning in 1982.

W73-70158 **760-67-01**
Langley Research Center, Langley Station, Va.
MILITARY AIRCRAFT - AIRCRAFT AND MISSILE AERODYNAMICS
R. E. Bower 703-827-3285
(791-94-01; 501-17-01)

The objective is to develop advanced concepts which will provide the aerodynamic technology for the design of military systems. Research conducted under this RTOP will provide the aerodynamic technical base for the Advanced Fighter Technology program (LRC RTOP 791-94-01). The approach to be used will combine both analytical and experimental techniques. Studies of airplanes will include advanced aerodynamic concepts such as wing warp, maneuver devices, component interference and second-order area rule at lift. Particular emphasis will be placed on the improvement of performance, stability and control characteristics in the high angle-of-attack range at subsonic, transonic and supersonic speeds. The subsonic studies will also include wing buffet, oscillatory stability and post-stall aerodynamics, including spin damping. Studies of missiles will provide the technology for advanced missiles at all speeds for various mission requirements including the aerodynamic stability and control characteristics of surface-to-air, air-to-ground, air-to-air, and surface-to-surface missiles with wing, tail, canard, or jet controls. Develop missile configurations for future application through mission determination, trade studies, and performance evaluations. Emphasis is to be given to aerodynamic problems of fundamental importance to a class of configurations to permit a later selection for a specific development.

W73-70159 **760-67-01**
Ames Research Center, Moffett Field, Calif.
MILITARY AIRCRAFT - AIRCRAFT AERODYNAMICS
L. Roberts 415-965-5066
(501-26-04)

Experimental and analytical studies will be made to provide the aerodynamic technology for design of advanced military aircraft. Large-scale low-speed wind tunnel studies will be conducted on components and integrated configurations to derive information on high-lift devices, lift and drag, stability and control, effects of engine power, and effects of variations in wing geometry. Specific military aircraft development programs will be supported.

W73-70160 **760-67-03**
Langley Research Center, Langley Station, Va.
MILITARY AIRCRAFT - VECTORED THRUST MANEUVERABILITY
R. E. Bower 703-827-3285

The objective of this research is to explore and define the potential for increased maneuverability of fighter-type aircraft through the use of thrust vectoring. The achievement of a high longitudinal deceleration, an increased normal acceleration and rate of turn, with a reduction in time to turn may result in increased combat capability for defensive and offensive tactics through vectoring in forward flight (VIFF). The objective is to be accomplished in three phases. The first two phases are primarily to open the envelope of the Harrier to permit unrestricted vectoring at rated thrust over the structural envelope of the airplane. These first two phases are to be conducted under a joint agreement with the United Kingdom, Ministry of Defense. Phase III is to be an NASA research program for an extensive exploration and evaluation of vectoring for possible application to advanced fighters. The phases are further defined as follows: Phase I (a) Documentation and qualitative flight evaluation of VIFF effectiveness to 500 KIAS and 80-percent fan rpm, using the NASA Kestrel and MOD Harrier aircraft. (b) Checkout and validation of the Langley Differential Maneuvering Simulator (DMS) for VIFF studies and use of the DMS to evaluate vectoring effectiveness with Harrier type aircraft. (c) Supporting wind-tunnel tests to obtain aerodynamic interactions at high speeds. (d) Utilize the NASA Kestrel aircraft for further documentation, minor wing modifications to improve vectoring capability, and support of the NASA/MOD effort

W73-70161 **760-67-05**
Flight Research Center, Edwards, Calif.
MILITARY AIRCRAFT - REMOTE PILOTED VEHICLE
R. D. Reed 805-258-3311

This program involves the design and construction of three 3/8 scale remote piloted F-15 fighter aircraft configurations to be air-launched, flown through high angle-of-attack maneuvers and recovered by horizontal landing on Edwards Dry Lake or by parachute recovery. These vehicles are to be flown to gather needed flight data at angle-of-attack values at, near, and beyond the aircraft stall or departure. The overall objectives are to develop a remote piloted vehicle (RPV) test technique that is well suited to stall/spin type research; to obtain high angle-of-attack data specifically for a 3/8 scale F-15 configuration up to and including post-stall, prespin conditions; and to assess advanced control systems in pre-stall, post-stall, and pre-spin flight.

W73-70162 **760-17-01**
Ames Research Center, Moffett Field, Calif.
DOD ASSISTANCE
M. D. White 415-965-5009
(136-63-02; 760-74-01; 764-74-01)

Technical assistance, consultive services, and facility support will be provided to the DOD in support of aircraft development programs. Included are research efforts to develop new criteria to aid in assuring satisfactory handling qualities of piloted aircraft and to define and develop techniques for improvement of marginal or unsatisfactory handling characteristics of new airplane designs. Ground based and airborne flight simulators will be employed as required. Specific weapon systems programs for which support is planned during FY 1973 include the F-14, the B-1, the KC-135, and the Light Weight Fighter. A potential area for future support is the B-1 and the Light Weight Fighter. Reporting on past support of the A-10 will be completed.

W73-70163 **760-17-01**
Langley Research Center, Langley Station, Va.
DOD ASSISTANCE - SPECIFIC MILITARY DEVELOPMENT PROGRAMS
R. E. Bower 703-827-3285

The objective is to determine the aerodynamic characteristics of models and model components at subsonic, transonic, and supersonic speeds. Current emphasis is focused on the USN F-14, USAF F-15, USAF B-1, USAF F-4, USAF A-X and several foreign vehicles. Future emphasis will be on the USAF lightweight fighter prototype and the tilt prop/rotor V/STOL concept. Results will be obtained by means of wind-tunnel investigations conducted over appropriate ranges of aerodynamic variables to determine forces, moments and loads, as well as by the use of the many available analytical programs. Analysis of the results will be performed and documented

W73-70164 **760-16-01**
Ames Research Center, Moffett Field, Calif.
DOT ASSISTANCE - CERTIFICATION CRITERIA DEVELOPMENT
L. Roberts 415-565-5066

The DOT will be assisted in the development of supersonic transport airworthiness standards and of flight test procedures for demonstrating compliance. This will be accomplished by piloted simulation studies to be conducted jointly by DOT and NASA. Airworthiness authorities from the United Kingdom and France will participate as appropriate.

W73-70165 **501-08-05**
Langley Research Center, Langley Station, Va.
STRATOSPHERIC MONITORING USING LASER RADAR
C. H. Nelson 703-827-2893

The objective of this research involves the experimental and theoretical investigation of the scattering characteristics of the aerosol layers commonly associated with the lower stratosphere. The experimental phase will utilize an optical radar to obtain measurements of the volume backscatter function at a number of wavelengths through the visible. In addition, measurements of depolarization due to this aerosol layer will be studied. The theoretical approach will include: comparison of experimentally measured volume backscatter function as a function of wavelength with accepted models of aerosol scattering; determination of cross-section variation by using experimental measurements of depolarization; determination of a systematic variation of these layers with latitude and a calibration of the optical radar measurements by comparison with in situ measurements.

W73-70166 **501-08-10**
Langley Research Center, Langley Station, Va.
ATMOSPHERIC PARAMETERS
R. E. Bower 703-827-3285

The objectives are: to investigate and define atmospheric parameters for use in the design, and development and operation of CTOL and V/STOL aircraft. Primary emphasis will be given to definition of clear air turbulence and mountain wave turbulence. The approach utilizes the new Langley 48 inch Optical Radar System. Two experiments are planned to define and better understand those atmospheric processes that contribute to formation of turbulence. Supporting data will be obtained by aircraft and balloon flights. An over guide line request is made to continue studies of the spectra of atmospheric turbulence using an instrumented B-57 airplane and the investigation of radiation environment at altitudes of SST type aircraft.

W73-70167 **501-08-10**
Marshall Space Flight Center, Huntsville, Ala.
ATMOSPHERIC PARAMETERS
G. H. Fichtl 205-453-3168
(133-61-10)

The natural environment is one of major consideration in the design and safe operation of aeronautical systems (conventional aircraft, V/STOL vehicles, etc.). The objectives of the research under this RTOP are concerned with two areas of the natural environment, namely, (1) the definition of the mean wind and turbulent environment at and around airports (including V/STOL ports) and at cruise altitudes for aeronautical system design and operation, and (2) the feasible modification of fog at airports to improve visibility. The first objective will be accomplished through the development of empirical/theoretical models. In the region of the atmosphere near the ground, the atmospheric boundary layer, these models shall define (a) the mean wind profile, (b) mean and instantaneous wind shear, (c) the statistical properties of turbulence (spectra, higher-order statistics, etc.), (d) the modification of atmospheric flows as the air passes from rough to smooth terrain (a typical situation around an airport), (e) the structure of wakes behind buildings (aircraft towers, control towers, etc.) and natural obstructions such as hills, trees, etc., and (f) the structure of the mean and turbulent flow in the cold air outflow of thunderstorms. The second objective is to study fog and its life cycle by lab and field testing programs and by a parallel program to develop reliable instrumentation for measuring various parameters such as visibility, fog drop concentration, remote sensing of atmospheric characteristics in the fog, and haze nucleus measurements. Laboratory experiments with controlled fogs containing haze nuclei should be performed to qualify the fog development and field instrumentation concepts.

W73-70168 **501-38-17**
Ames Research Center, Moffett Field, Calif.
AIRPORT AIR POLLUTION
Glen Goodwin 415-965-5065
(160-75-22; 501-04-02)

The purpose will be to analytically evaluate the environmental impact of future V/STOL passenger transportation systems in the context of realistic background air pollution environments in high traffic, multiple airport urban areas. The scope of the work will include developing: (a) a source model of present and future air transportation system emissions, (b) a dispersion model of advection and diffusion, (c) a model of the photochemical processes occurring in the atmosphere, (d) two meteorological models (one statistical and one predictive) to provide inputs to the dispersion model, and (e) a source and sink inventory model of the San Fransico Bay Area emissions contributing to the background levels for demonstration and field verification purposes. The models will then be used to carry out sensitivity studies of engine emissions, STOL operational profiles, STOL-port locations, and air traffic levels in their effects on urban air quality under typical meteorological conditions.

W73-70169 **501-38-17**
Langley Research Center, Langley Station, Va.
AIRPORT AIR POLLUTION
C. H. Nelson 703-827-2893

This RTOP covers two principal areas of research and investigation. The first area is concerned with the anticipation and assessment of potential environmental problems associated with the operation of advanced air transport systems such as V/STOL, ATET, HST, AST, Space Shuttle, and other emerging air transportation systems. Factors which would be considered in the assessment of potential problems would be: operational modes; use frequency; and volume, nature, and dispersion of exhaust emissions coupled with the nature of the surroundings in which the system would function. Such an effort would be a continuing one, reassessing new information as it becomes available, discontinuing interest in those systems which no longer pose significant problems, and through contractual or in-house research, attempt to provide solutions to those problems which have been identified. The second work area would be directed towards the development and improvement of techniques used in the formulation of numerical dispersion models. Work would be oriented towards the requirements of models used to predict the effect of airport operations on pollution levels in the surrounding areas. Such modeling would also allow the prediction of the effect of altering airport operations in various ways, the relative contributions of aircraft and nonaircraft operations, peak short-term pollution concentrations, and the concentrations downwind of the airport. Work in this area would be pointed not towards the development of a dispersion model for a particular airport, but to the the development of techniques and component models which---

W73-70170 **501-38-12**
Langley Research Center, Langley Station, Va.
TIRE TRACTION AND BRAKING
G. W. Brooks 703-827-2042

Aircraft operations on runways where heavy braking is

required, yet directional control must be maintained, presents requirements on antiskid systems, tires and runway that are vital to aircraft safety and passenger comfort as well as being necessary to procedures for alleviating airport congestion. Further, airfield roughness can contribute to high takeoff, landing and taxi loads on the aircraft. The objectives of this RTOP are: (1) to improve the performance of braking systems, (2) to improve the performance and lifetime of pneumatic tires, (3) to develop new landing gear systems that would permit continuous use of prime runways regardless of crosswinds, thus relieving congestion problems during weather condition, (4) to evaluate cornering capabilities under heavy braking so that high speed turn-offs can be designed to increase the flow of traffic at congested airports, (5) to define acceptable levels of runway and taxiway roughness, and (6) to relate the character of runway surface to braking and cornering performance. Research to meet these objectives will employ full scale aircraft and landing gear systems in addition to scaled models of pneumatic tires and landing gear systems. Tests will be conducted at the Aircraft Landing Loads and Traction Facility, airport runways, including the landing research runway at Wallops Station, ground test vehicles and various laboratory equipment.

W73-70171 **501-38-12**
Ames Research Center, Moffett Field, Calif.
TIRE TRACTION, BRAKING
Glen Goodwin 415-965-5065
(501-38-19)

The objectives are: To improve aircraft braking and control on the runway by the utilization of improved materials for aircraft tires and brake linings; to develop and evaluate improved elastomeric materials for use in tires for present and future high speed aircraft having improved properties and less wear than conventional aircraft tire materials; and to develop and evaluate composite materials based on p-polyphenylene which could serve as long wearing and improved frictional materials for aircraft brake linings. Tread vulcanizates composed of improved elastomers and various polyblends of natural rubber will be evaluated by performing stress relaxation measurements and other tests. Improved processing and curing methods will be sought in order to yield elastomeric materials having improved thermochemical and physical properties, especially at elevated temperatures. Brake lining compositions based on p-polyphenylene will be evaluated on a brake tester, and other tests will be performed to assess their performance as improved linings for aircraft. Other studies will include composite formulation and processing optimization based on test results obtained.

W73-70172 **501-38-12**
Lewis Research Center, Cleveland, Ohio.
TIRE TRACTION, BRAKING
C. David Miller 216-433-4000

The objective is to improve aircraft braking to reduce frequencies of accidents due to airplanes sliding off sides of runways or running off ends of runways, particularly after aborted takeoffs. Through grants at the University of Michigan and RPI, and through in-house analytical effort, a concurrent two-pronged approach is directed toward (1) a basically new method of braking designed to dissipate aircraft kinetic energy into a thermally conductive runway surface and (2) improvement of materials and systems for conventional brakes.

W73-70173 **501-38-18**
Langley Research Center, Langley Station, Va.
CROSSWIND LANDING FOR STOL OPERATIONS
R. E. Bower 703-827-3285

The objective is to investigate STOL crosswind landing problems and methods of extending the crosswind limits for landing. A flight investigation will be conducted to determine the relation between airplane control, airplane response, piloting technique, flight safety margins, and crosswind limits during the STOL-type landing operations. A flight investigation will also be conducted to determine the effects of wind gradient modification by fences. An analytical study and model tests will be conducted to investigate crosswind landing gear configurations and a crosswind landing gear will be designed, built, and flight tested. Studies also will be made of control concepts such as the use of airfoil generated side force for crosswind landing control.

W73-70174 **501-38-11**
Langley Research Center, Langley Station, Va.
AIRCRAFT OPERATING EXPERIENCES
R. E. Bower 703-827-3285

Statistical data on the operational experiences of general aviation airplanes are being collected and analyzed. The data are collected during routine operations by the use of NASA instrumentation. The data provide information on the ground and flight loads, airspeed and altitude operating practices, and the turbulence environment. The information obtained provides a continuous basis for comparing actual airplane operations with concepts used in design, for detecting unanticipated operational aspects, and provides a reservoir of data useful in the design and development of airworthiness requirements for new types of airplanes.

W73-70175 **501-38-13**
Ames Research Center, Moffett Field, Calif.
HAZARD AVOIDANCE AND ELIMINATION (WAKE VORTEX)
M. D. White 415-965-5009
(501-06-04)

The trailing vortex systems generated by aircraft can be hazardous to other aircraft following along or near the same flight path. Flight test measurements will be made in order to increase the basic knowledge of the structure of trailing vortices and their dissipation mechanisms. This data will supplement and overcome shortcomings of wind tunnel and tower measurements. In addition, devices which show promise of accelerating the vortex dissipation in the wind tunnel can be quantitatively examined in flight. Hot wire anemometers will be mounted on the nose boom of a probe aircraft and will be used to gather velocity and temperature data at various separation distances. From the measured velocity data a picture of the total flow field will be constructed in space and time. Investigations will be made of the vortex wakes left by conventional aircraft as well as those left by powered-lift STOL aircraft.

W73-70176 **501-38-13**
Langley Research Center, Langley Station, Va.
HAZARD AVOIDANCE AND ELIMINATION
R. E. Bower 703-827-3285

The objective is to provide basic technology data for the improvement of the level of safety in aircraft operations. (1). Technical assistance is being provided to various agencies having safety of flight problems. (2) The feasibility of using Raman optical radar to obtain a remote measurement of visual ranges along the glideslope which will be usable to a pilot will be studied. (3) The investigation of means for accelerating breakup or dissipation of aircraft trailing vortices will be continued.

W73-70177 **501-38-13**
Lewis Research Center, Cleveland, Ohio.
HAZARD AVOIDANCE AND ELIMINATION
Patrick T. Chiarito 216-433-6941

The objective is to provide basic data for the improvement of the operational safety of civil and military aircraft. Through NASA supported research, which complements research conducted by other segments of the aviation community, devices and techniques which overcome operational problems are provided. These problems are presented by the desire to improve the safety of airplane operations while extending the mission of the airplane and improving the economics of its operation. Commercial and general aviation aircraft, including V/STOL, subsonic and supersonic, will be considered. Specific areas of current interest include: lightning hazards to aircraft avionics, rotor burst protection, detection of incipient structural failure, ozone hazard in high altitude aircraft, wind shear effects, and icing tests, lubrication sump fire hazards, and aircraft altimetry systems.

W73-70178 **501-38-13**
Marshall Space Flight Center, Huntsville, Ala.
HAZARD AVOIDANCE AND ELIMINATION
Robert M. Huffacker 205-453-1156
(113-61-13)

The laser Doppler technique is used to: (1) develop a clear air turbulence detection system for research purposes and to act as an on-board warning system for aircraft; and (2) continue the development of laser Doppler technology and its application for measuring natural and induced turbulence in the atmosphere. During FY'73 three major tasks, leading to a program to flight test a breadboard CAT detection system beginning in early FY'74, will be completed. The Germanium windows will be tested and changes required to ensure improved performance identified. A test to establish compatibility of the CAT system with the (CY990) aircraft will be completed. Modification to the system indicated as required by the mating test will be made and an extensive ground test program to establish system operating characteristics will be completed. In parallel with these efforts, work will be continued to establish the feasibility of using Laser Doppler Systems as general atmospheric measurement instrumentation. Analyses and tests will be performed with ground-based laser Doppler instrumentation to determine operational constraints, data processing techniques, atmospheric losses, and to optimize optics configurations.

W73-70179 **501-38-15**
Langley Research Center, Langley Station, Va.
ENGINE NOISE AND SONIC BOOM EFFECTS
G. W. Brook 703-827-2042

The objective of this work is to provide basic information on noise and sonic boom induced seismic responses and building damage as a basis for defining acceptable sonic boom exposures for communities during repeated operations. The seismic study involves the collection and collation of data available from extensive air force measurements of natural and man-made seismic disturbances so that direct comparisons can be made with similar data from noise and sonic boom tests. Some additional measurements may be made for some particular man-made disturbances such as highway traffic, etc. The structural damage study is analytical and involves a statistical approach to the prediction of building structural damage. The existing damage and loading data will be used as empirical inputs to the analysis.

W73-70180 **501-38-19**
Manned Spacecraft Center, Houston, Tex.
EVALUATION PROGRAM OF IMPROVED AIRCRAFT CABIN MATERIALS
Richard W. Bricker 713-483-3166
(908-44-38)

The objective of this program is to evaluate the effectiveness of new fire-retardant materials for comparison with materials used in current aircraft interiors and to demonstrate the increased evacuation time that can be obtained from the use of better insulation materials and nonflammable emergency passenger evacuation slides. Tests will be conducted using a 737 fuselage to provide the data necessary to fulfill the task objectives; pre-test analyses and subsequent data correlation with data from similar tests but employing more flammable materials will complete the overall task objectives.

W73-70181 **501-38-19**
Ames Research Center, Moffett Field, Calif.
FIRE RETARDATION
Glen Goodwin 415-965-5065
(501-38-12; 501-21-22; 501-17-01)

The objectives are: to reduce the hazards of aircraft crash fires by application of fire retardant materials to modern airframe; to develop and test the necessary designs and concepts which will provide the optimum crash fire protection; to characterize and evaluate the necessary fire-retardant materials which will provide the maximum fire resistance and least smoke evolution when exposed to fire. A study will be made of the practical applicability of Ames-developed fire-retardant polymers and other such materials for application to military and commercial aircraft for fire protection. Various parameters, including fire resistance and smoke evolution of materials, human survivability factors, costs, and weight penalties will be assessed in detail. The best materials such as foams, coatings, window materials and sealants, will be selected for detail testing. Guidelines will be developed for conducting a full-scale fire test of an aircraft.

W73-70182 **501-38-16**
Langley Research Center, Langley Station, Va.
FLIGHT TEST INSTRUMENTATION
R. E. Bower 703-827-3285

An advanced aircraft flight data system under development for several years will be used as the primary means of data collection on several flight test programs this year (CH-54B, Twin Otter, and CH-46) The data system with both PCM and analog capability is compatible with ground-based automatic data processing techniques. An automatic pre-flight checkout system will be designed. Control-position, air-temperature, and airflow-direction sensors for flight research programs will be developed, modified, or adapted to provide customized measurements that conform to safety guidelines and physical and electrical restrictions

W73-70183 **501-38-16**
Flight Research Center, Edwards, Calif.
FLIGHT TEST INSTRUMENTATION
L. D. Webb 805-258-3311

The advanced type research flights being conducted at FRC require the use of new and unproven types of sensors to obtain the desired research measurements. The objective of this program is the design, development and testing of advanced sensors particularly when the work is being done in advance of, or apart from, the vehicle on which it will ultimately be used. Examples of needed sensors are altimeters for use at high speeds and extreme altitudes, miniature pressure transducers capable of withstanding Mach 3 stagnation temperatures, pressure survey rakes suitable for measuring dynamic flows. Special

compensated pitot-static probes, and miniature flow-direction sensors for determining local flow angularities. Whenever possible, off-the-shelf items will be used with flight suitability being determined in FRC labs. Development of new concepts will be sponsored if no available devices suit the needs.

W73-70184 **791-90-03**
Ames Research Center, Moffett Field, Calif.
UNCONVENTIONAL ADVANCED COMMUTER AIRLINE SYSTEMS
J. V. Foster 415-965-5083

The study will examine unconventional technical approaches for aircraft and terminal systems applicable to rapid handling of aircraft and passengers for high-density downtown air-commuter operations. Advanced system concepts for potential implementation in the 1980's time period will be examined. A conceptual commuter airline system will be formulated based on high passenger density, rapid aircraft turn-around, all-weather operation, and completely automated systems. Unconventional techniques will be examined for feasibility as part of the systems. Two principal objectives exist for the study; first, a preliminary evaluation of nonconventional technology applicable to air-commuter systems, and second, exposure of research required to fill technical gaps for an advanced system of the 1980's.

W73-70185 **791-91-03**
Ames Research Center, Moffett Field, Calif.
SYSTEMS ANALYSES OF LONG HAUL HIGH PRODUCTIVITY TRANSPORTS (TST)
L. Roberts 415-965-5066

The objective of this research is to assess the technical and economic feasibility of transport aircraft operating at long ranges over the entire speed spectrum subsonic to supersonic. Emphasis will be on total vehicle performance including with an attempt to identify the most promising technical approaches with regard to vehicle configuration, design specifications and operating characteristics. The study approach will be to perform simplified in-house vehicle analyses with synthesis programs, then contract for more complete studies with aircraft manufacturers. Initial studies would cover a broad cross section of configurations, design speeds, and technical approaches. Later studies would concentrate on the more promising approaches.

W73-70186 **791-91-04**
Ames Research Center, Moffett Field, Calif.
AERONAUTICAL SYSTEM ANALYSIS (ACSYNT)
L. Roberts 415-965-5066
(791-91-03)

The objective of this research is to develop an overall system synthesis capability which can identify the best system characteristics for any air transportation system and the required technology and costs necessary to atttain the desired air transportation system. Mathematical models of the air vehicle elements will be developed and verified by comparison with operational situations.

W73-70187 **791-91-05**
Ames Research Center, Moffett Field, Calif.
IMPROVED AERONAUTICAL SYSTEM ANALYSIS CAPABILITY
D. E. Wilcox 415-965-5887

The objective of this RTOP is the development of an overall systems analysis capability with improved analytical tools and modeling techniques. These tools and methodologies are used in the identification of promising aeronautical systems, and in the definition of technology requirements and costs of such systems. Investigations will be conducted in-house and under contract to assess current systems analysis capabilities and develop improved computer modeling techniques for study of military and civil aviation systems. This will involve the application of advanced mathematical and statistical methods to the development of computer models for: aerodynamic and structural analysis; weight and cost estimation; propulsion system analysis; demand, market, and economics analysis; and aeronautical system synthesis.

W73-70188 **791-91-09**
Ames Research Center, Moffett Field, Calif.
ANALYSIS SUPPORT FOR AERONAUTICAL PROGRAM PLANNING
R. H. Petersen 415-965-5886

The objective of this RTOP is to provide special, short-term studies in support of the aeronautical program planning activities of OAST and to meet other OAST requests for quick response support.

W73-70189 **791-91-10**
Lewis Research Center, Cleveland, Ohio.
ADVANCED AIRBREATHING PROPULSION SYSTEMS ANALYSIS
R. J. Weber 216-433-6273
(501-04-03)

Desirable design characteristics of advanced propulsion systems will be determined for application to various future aircraft and missions. Cycle analyses and weight estimates for a variety of engine designs will be combined with structural and aerodynamic estimates for various airframes. Results will help to identify the potential for accomplishing more demanding missions or developing more economical vehicles and will illuminate the needs for advances in propulsion system technology. The study will be directed at such concepts as non-conventional fuels, nuclear aircraft, hypersonic transports, and airbreathing boosters.

W73-70190 **791-91-51**
Langley Research Center, Langley Station, Va.
LOW-DENSITY SHORT-HAUL TRANSPORTATION SYSTEMS - TRAVELER ACCEPTANCE FACTORS
R. E. Bower 703-827-3285
(501-29-12)

The objective is to identify and examine in detail those factors influencing acceptance and use of aircraft as the preferred mode of travel by the public in the low-density short-haul market. The approach will be to carry out studies, principally by university grant, which will include surveys by questionnaire, measurements aboard airliners, data analysis, and math modeling. Questionnaires will be used to obtain the attitudes of various groups and types of travelers concerning ride quality, safety, convenience, travel time, cost, and other factors deemed significant A data base for deriving a ride-quality model will be generated wherein measurements will be recorded of the environmental factors (e.g., noise level, motion/vibrations in various degrees of freedom, temperature, etc.) and correlated subjective reactions of the passengers during scheduled airline short-haul operations of second- and third-level carriers. From the attitudinal survey analysis and ride-quality model, criteria will be developed suitable for use: to prescribe some of the technical requirements for a traveler-acceptable system; to assess the suitability of specific aircraft and/or operational procedures in meeting these requirements; and to aid in structuring related systems studies, vehicle R and D efforts, and airline demonstration

programs. The criteria will then be used to evaluate the passenger-acceptability of one or two aircraft developed to serve the low-density short-haul market, and to define specific improvements where indicated.

W73-70191 **791-91-53**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
LOW-DENSITY, SHORT-HAUL TRANSPORTATION SYSTEMS; OPERATIONAL SYSTEMS
G. W. Meisenholder 213-354-4058

The long-term major objectives are to: (1) develop Operating Systems Techniques and a uniform methodology for the analysis and optimization of these Operating Systems for Low-Density, Short-Haul Air-Corridor Transportation Systems performing in some specified (demand, scheduled, hybrid) mode, which may or may not be engaged also in cargo transport, (2) conduct operating cost vs Level-of-Service Tradeoff Studies; and (3) determine the transition zone and investigate characteristics of transition from pure demand to scheduled mode. The long-term study will also investigate the sensitivity of the air-fleet and aircraft design to regional market characteristics, proposed operational modes, and air-corridor topology. The short-term objectives are to: (1) develop the overall study program design and modular structures; (2) develop a modular simulation program with parametrized inputs (e.g. payload, number of passengers, passenger origin-destination demand matrices, variable aircraft characteristics, air-corridor topology, cargo demand programs, cost matrices) for use as a general design and analysis tool; and (3) develop a rudimentary operating system (vehicle management scheme) for an existing air-corridor and for use in exercising the simulation program to demonstrate the feasibility of the long range objectives. All pertinent concepts will be clearly defined, delineated and investigated. Systems performance criteria will be developed and analyzed. A practical fleet management scheme for an existing air-corridor will be developed, analyzed and its interactions and implications studied. A digital computer simulation program will be developed as a general analysis tool. Sensitvity studies involving passenger demand distributions will be initiated. ACMD Studies will be used as data basic model.

W73-70192 **791-92-04**
Manned Spacecraft Center, Houston, Tex.
STUDY OF THE EFFECTS OF GOVERNMENT DIRECTED CHANGES ON BASIC COSTS AND SCHEDULE OF SELECTED FLIGHT VEHICLES
J. L. Ryan 713-483-3018
(908-44-35; 975-50-01)

The objectives of this study are: to determine the effects of government directed changes on the basic cost and schedule of selected historical NASA spacecraft and government aircraft acquisition programs, and to analyze the effects of such changes for cost and schedule implications for future NASA advanced aircraft and space programs. The focus of the FY73 studies will be on the first two of the following study elements: Investigations will be conducted to: (1) identify the original (or basic) technical performance characteristics, costs and schedule baseline of select flight vehicles including aircraft and recoverable aircraft type systems (e.g., RPV's); (2) identify discreet changes by the appropriate NASA Level I, II, or III; and (3) analyze the effect of changes for the cost and schedule implications vis-a-vis future NASA advanced aircraft and space programs.

W73-70193 **791-93-01**
Ames Research Center, Moffett Field, Calif.
SHORT-HAUL V/STOL TRANSPORTATION SYSTEM STUDIES
L. Roberts 415-965-5066
(791-93-02; 791-93-03)

The general objectives of this program are to determine the characteristics of advanced STOL systems which satisfy economic viability and environmental constraints. Previous studies which considered only economic viability will be extended to include a variety of noise reduction techniques related to the aircraft and transportation system design. Environmental effects will be evaluated in terms of overall noise reduction, decreased air and ground traffic at CTOL ports, and decreased pollution.

W73-70194 **791-93-02**
Ames Research Center, Moffett Field, Calif.
VTOL TRANSPORT SYSTEMS STUDIES
L. Roberts 415-965-5066
(139-06-02; 130-06-03)

The objectives are: to refine the Avionics Evaluation Program (AEP); to apply the AEP to advanced integrated avionics and airframe systems; and to assess the effect of these advanced technologies on VTOL mission performance. The results of the operational analysis on the various system configurations conducted under FY 1972 RTOP 139-06-03, will be analyzed, and those subsystems which are most significant in satisfying the particular mission requirements will be identified. The sensitivity of mission performance to each of these subsystems will be determined, and higher order models of the critical subsystems will be developed A technological forecast for integrated avionics and other airframe subsystems will be conducted such that the candidate subsystems and components can reflect feasible concepts based upon R and D underway at this time.

W73-70195 **791-93-03**
Ames Research Center, Moffett Field, Calif.
ANALYSIS OF FUTURE CIVIL AIR TRANSPORTATION SYSTEMS AND CONCEPTS
G. C. Kenyon 415-965-5887

The objective of this RTOP is to provide system analyses of future civil air transportation systems and concepts in order to identify promising aeronautical systems, determine optimum characteristics, and define technology requirements and costs associated with such systems. Studies of general aviation aircraft, transport aircraft for regions of low population density, STOL and VTOL transports for short haul applications, advanced subsonic/transonic transport aircraft, and advanced supersonic transports will be conducted. In all cases, total system studies will be carried out considering all of the interactions between aircraft, airports, airways, community impact, and economics (both within the aviation industry and on a national basis).

W73-70196 **791-93-04**
Ames Research Center, Moffett Field, Calif.
ANALYSIS OF FUTURE MILITARY AVIATION SYSTEMS AND CONCEPTS
M. H. Waters 415-965-5887

The objective of this RTOP is to provide system analyses of future military aviation systems and concepts in order to identify promising aeronautical systems, determine optimum characteristics, and define technology requirements and costs associated with such systems. Studies of current and projected tactical aircraft missions will be conducted to evaluate the future requirements of tactical aircraft design. Analysis of the impact of future technologies and advanced weapon systems on the performance and costs of tactical aircraft will be performed.

W73-70197 **791-93-51**
Langley Research Center, Langley Station, Va.
VLF WIDE AREA NAVIGATION FOR LOW-DENSITY SHORT-HAUL TRANSPORTATION
G. B. Graves 703-827-3745

The objective of this work is to investigate VLF navigation techniques and to develop promising approaches for en route and terminal area navigation. Systems such as Omega can provide large geographic coverage with a limited number of ground stations, and are relatively unaffected by altitude or terrain. Characteristics such as these are highly desirable for short-haul, low-density transportation systems, where direct terminal-to-terminal routes at relatively low altitudes are required. The application of VLF navigation to civil aviation will also enhance air safety by reducing pilot work loads and relieving airlane congestion resulting from the current practice of navigating within a network of approximately 1000 VOR stations. Work will be conducted in two areas. The first area consists of the measurement and analysis of errors due to propagation anomalies and atmospheric noise. The second area consists of the development and evaluation of Omega avionics, including both differential and composite Omega configurations.

W73-70198 **791-94-02**
Ames Research Center, Moffett Field, Calif.
LIFT-FAN RESEARCH VEHICLE STUDIES
L. Roberts 415-965-5066
(760-62-01; 760-62-02)

The objectives are: to study lift-fan research vehicle to acquire preliminary design information for a possible V/STOL lift-fan transport research aircraft based on various lift-fan propulsion systems arrangements, to acquire conceptual design information for a V/STOL lift-fan commercial short-haul transport, and to gain a better understanding of potential aerodynamic problems and enable preliminary examination of terminal area flight characteristics. Contracted engineering studies will be initiated (or extended) to provide better technical input to feasibility evaluations of a proposed lift-fan research aircraft. The adequacy of the research aircraft to provide the transport design data required will be determined to some extent by parallel design studies of representative commercial lift-fan transports. Math models of the research and civil transport aircraft will be provided for simulation studies carried out under RTOP 760-62-02. The studies will include relating the commercial aircraft to potential advanced transporation systems and studies to be conducted under ACMD management.

W73-70199 **791-94-04**
Ames Research Center, Moffett Field, Calif.
REMOTELY PILOTED VEHICLES
L Roberts 415-965-5066

Several forms of remotely manned systems have been developed for both space and military functions. Preliminary studies of remotely piloted vehicles for military uses suggest that simple systems can be developed that will perform missions such as battlefield surveillance, reconnaissance and ground attack. Vehicles with higher technology can perform more sophisticated missions involving air-to-air combat, interception and more complex functions. The technology base for these systems has been developing rapidly, and there are indications that the cost of performing remotely-manned functions is decreasing at a rapid rate. The impact of this technology and its rate of development suggest that future aircraft systems could be substantially different from contemporary aircraft. Therefore, there is a need to assess the various aircraft and missions that can use remote piloting technology, and to rapidly assess the critical technology areas involving the vehicles and their missions. A number of in-house synthesis studies are contemplated using computerized design techniques to assess vehicle tradeoffs and sensitivities and to enable selection among alternate vehicle concepts. These studies may require limited wind tunnel and simulator studies of new configurations and critical technical areas where analytical methods do not provide the specific information necessary for creditable planning studies. Contract studies to address critical areas or to add systems analysis depth are required.

W73-70200 **791-94-08**
Lewis Research Center, Cleveland, Ohio.
CTOL QUIET CLEAN ENGINE (MK II)
A. A. Medeiros 216-433-6654
(501-24-01; 765-68-01)

Design studies will be undertaken to identify second generation quiet clean propulsion systems suitable for use in advanced CTOL aircraft in the late 1970 time period. The goal of the studies is to provide untreated engine designs which will be 10 EPNdB lower than the first series of Quiet Engines. The designs will incorporate recent advances in noise and low emission combustor technology. The studies will identify the engine cycle, mechanical arrangements and component designs that will have the best possibility of achieving the goals. Following these studies a demonstration of the noise and emission characteristics of the best engine designs can then be undertaken.

W73-70201 **791-94-60**
Langley Research Center, Langley Station, Va.
SUBSONIC/SONIC CTOL TRANSPORT TECHNOLOGY: SYSTEM ANALYSIS AND DESIGN INTEGRATION (ATT)
W. J. Alford 703-827-3285
(501-15-01; 501-15-03; 501-15-04; 766-73-01)

This RTOP covers the continuation of system and design integration activities. The objective is to define in more depth high subsonic/sonic CTOL transports systems utilizing advanced technologies and reflecting refined inputs from research results, economic studies, alternate missions, and novel concepts. Specifically the approach will address four main categories of work: (1) In-depth studies of the CTOL transport reflecting refined inputs from the following sources: a. Contractural and in-house study results, b High and low speed wind tunnel data, c. Active Control System (ACS) and composite conceptual approaches d. Airline study results; (2). In-depth studies of candidate means of demonstrating technology readiness, reflecting related plans of other agencies, cost, validity of data and the scheduling compatibility of technology readiness and demonstration hardware development; (3). Investigation of the application of the advanced technologies defined to date to reduced runway/range concepts; (4). Investigation of novel and innovative design approaches to reduced and long range commercial transports. These system and design studies will integrate the data as it is generated in complementary program elements under LRC, FRC, LeRC, and ARC RTOPS's covering advanced technology, experimental flight research, propulsion, wind tunnel tests and simulations.

W73-70202 **791-94-61**
Lewis Research Center, Cleveland, Ohio.
CTOL TRANSPORT PROPULSION STUDIES
J. H. Povlny 216-433-6624
(501-15-02)

NASA has inititated an effort to study the application of advanced technology to the improvement of future subsonic

commercial transport aircraft designed for flight speeds up to Mach 0.98. The results of this study are to be resolved in terms of economic factors involving a complex interaction of parameters such as aircraft drag, propulsion efficiency, operating costs, low-speed flight characteristics, propulsion and aircraft noise, and propulsion system exhaust emissions. Detailed analysis of these factors has been completed through in-house and contract studies and documentation is in progress. The studies concentrated on two-spool, fixed-area, turbofan engines Results indicated that the environmental constraints impose compromises to the optimum engine cycle with resulting economic penalties. The studies also identified areas where advanced technology would decrease the noise and exhaust emissions and improve the system economics. The propulsion system studies have been extened to continue in-house and contract studies of combinations of unconventional engine cycles in an attempt to determine an optimum cycle for a quiet and clean propulsion system. Also, contractual studies of controls for fast engine response have been initiated.

Aeronautics Systems and Experimental Programs

W73-70203 **741-86-02**
Ames Research Center, Moffett Field, Calif.
QUESTOL PROJECT SUPPORT - DESIGN AND TECHNOLOGY
L. Roberts 415-965-5066

This RTOP covers Ames support of the Quiet Experimental STOL Transport Aircraft (QUESTOL) program, During the course of the development of the aircraft, several areas of study will be carried out at Ames to adequately support the effort. The planned areas of work are in aerodynamics, performance, stability and control, handling qualities, and augmentor wing and externally blown flap noise. Also planned is simulation of the potential aircraft to establish design criteria prior to proposal evaluation and during design and aircraft development program for the specific aircraft under consideration The simulation effort to provide design criteria prior to final aircraft design will be accomplished with the Ames moving base simulators. Wind tunnel test in the Ames 40- by 80-foot wind tunnel of the externally blown flap concept for the proposed research aircraft will be conducted with large scale models utilizing JT15D turbofan engines to allow a better match of engine fan flow to flap size for the externally blown flap concept. As proposed for the research aircraft, the aircraft will be multiconcept and the wing and empennage can be converted from the externally blown flap configuration to the augmentor wing, or internally blown flap configuration as required with minimal changes.

W73-70204 **741-86-05**
Flight Research Center, Edwards, Calif.
QUESTOL PROJECT SUPPORT - DESIGN AND FLIGHT OPERATIONS
D.A. Kier 805-258-3311

This RTOP covers FRC Support of the Quiet Experimental STOL Transport Research Airplane (QUESTOL) Project. The work will be basically accomplished in-house. A major portion of the work will be a continuation of the activities begun in FY 72. Specifically involved are: QUESTOL contract review including Phase II proposal evaluation and support of the Ames Project Office activities (e.g. Contract Negotiations, Risk Assessment, Simulation, etc.), design and construction of the data acquisition systems, TF-34/EBF noise investigations (in cooperation with the Lewis Research Center); initial flight program planning and flight experiments selection and planning; conducting the flight research operations including program safety, reliability, and quality assurance. New efforts initiated under this RTOP in FY 73 will be the GPAS ride qualities study, a cooperative effort with Ames in simulation, flight experiments selection, and crew training activities.

W73-70205 **741-87-01**
Ames Research Center, Moffett Field, Calif
QUESTOL PROJECT
Leonard Roberts 415-965-5066

In order to provide a technical base for the future design, development, fabrication, and operation of safe, reliable, quiet and economic fan-jet STOL transports, an airplane, designated as the Quiet Experimental STOL (QUESTOL) airplane will be designed, built and flown in a research program to provide a comprehensive set of data for use by designers, civil and military operators, and regulatory agencies concerned with the establishment of STOL transport systems. In order to investigate alternative STOL powered lift concepts, the airplane will be built initially in the externally-blown flap configuration, and will be subsequently converted to the augmentor wing lift concept. The definition, design and manufacture of the QUESTOL airplane will be carried out through a two-phase contractual effort Phase I is a competitive design phase and includes program definition and aircraft design activities. This phase is being conducted by three contractors, McDonnell Douglas Corporation, Lockheed Aircraft Corporation, and Grumman Aerospace Corporation and will be completed in June 1972. Phase II is the fabrication phase and will be carried out by one of the design phase contractors. Two essentially identical aircraft will be fabricated during Phase II. It is expected that the Phase II contract will be awarded in Oct. 1972. The flight research program will be developed in cooperation with other Government agencies and interested industry groups and carried out by NASA as an in-house effort. The project will be managed by Ames Research Center with major elements of the activity being carried out by other OAST centers.

W73-70206 **765-68-01**
Lewis Research Center, Cleveland, Ohio.
CTOL (MK I) QUIET ENGINE
A. A. Medeiros 216-433-6654
(501-24-01)

Preliminary design studies and Lewis in-house research have indicated that a substantial reduction in noise output of engines suitable for subsonic transport aircraft can be achieved. The next step in this program is to demonstrate this technology in an experimental engine. A contract program is providing engine detailed designs; a fan development program; and fabrication, testing and delivery of test engines to Lewis Research Center. Subsequent tests of these engines at Lewis with acoustically treated nacelles will demonstrate minimum installed propulsion system noise levels.

W73-70207 **765-69-01**
Lewis Research Center, Cleveland, Ohio.
QUIET, CLEAN STOL EXPERIMENTAL ENGINE (QCSEE)
Raymond J. Rulis 216-433-6651
(501-24-12)

The objective of this RTOP is to develop and establish the technology required for turbofan engines incorporating advanced noise reduction and emission reduction techniques needed to meet the expected stringent noise and pollution levels of future STOL aircraft. Experimental test engines will be designed and built with acoustic nacelles which would be appropriate for use

on Civil STOL aircraft systems meeting low noise and emission standards.

W73-70208 **765-70-01**
Lewis Research Center, Cleveland, Ohio.
JT3D/JT8D RETROFIT DEMONSTRATION
A. A. Medeiros 216-433-6654

The objectives are: to develop modifications for JT3D and JT8D engines and acoustic nacelles to reduce noise and emissions, and to demonstrate the reduced levels by engine ground tests and flight tests in their respective airplanes. The approaches are to fabricate and test modified JT3D and JT8D engines, develop and fabricate acoustic nacelles for both ground and flight tests, equip 707, 727, 737, DC-8 and DC-9 airplanes with modified power plant installations and conduct flight tests for performance and noise evaluations, and obtain airline consultation services to assure modifications and analyses are compatible with airline requirements.

W73-70209 **766-71-01**
Ames Research Center, Moffett Field, Calif.
C-8A AUGMENTOR WING PROOF OF CONCEPT FLIGHT PROGRAM
L. Roberts 415-965-5066
(766-71-02; 768-83-01; 768-81-03)

An existing C-8A aircraft will be modified to incorporate an autmentor-wing powered high-lift device and jet engines to provide a proof of concept for providing the takeoff and landing performance required for fan jet STOL transport aircraft and to make available an aircraft for carrying out limited longterm flight research on the jet STOL type of aircraft. The modified aircraft is expected to have the capability of takeoff and landing at speeds of 60 to 65 knots required for a STOL balanced field length of 1500 feet. The aircraft will have the performance and control characteristics required to allow flight investigations of takeoff and landing approach profiles and procedures for minimizing noise or approach time. It will also be used to further develop criteria for handling qualities, performance requirements, resolve operating problems, and air traffic operation. The program is a cooperative effort by NASA and the Canadian Government that has been underway since 1965. The program encompasses analytical studies, wind tunnel investigations, ground based simulation studies, design feasibility studies, detail design and modification of aircraft, and flight investigations. The program will provide much needed information for the designers of fan jet STOL aircraft which the NASA short-haul V/STOL transport studies showed to be one of two V/STOL concepts that had the lowest direct operating costs for 500 mile range commercial transports.

W73-70210 **766-71-02**
Ames Research Center, Moffett Field, Calif.
FLIGHT EXPERIMENT PROGRAM - AUGMENTOR WING JET STOL RESEARCH AIRCRAFT
L. Roberts 415-965-5066
(760-61-03)

The primary objective is to perform flight experiments essential to the verification and refinement of jet STOL handling qualities design and certification criteria. These criteria are under development through analysis and ground-based piloted simulation under RTOP 760-61-03. The program will use the Augmentor Wing Jet STOL Research Aircraft (AWJSRA) to verify analysis and simulation. In addition, it will use in-flight simulation with an interim aircraft to provide a wide variation in parameters required to satisfy the generalized objective and to assist in planning the flight program for the AWJSRA. The AWJSRA flight program and the in-flight simulation will encompass basic STOL handling qualities, stability and command augmentation systems, flight director laws, and control integration with the results having application to handling qualities design criteria. Operational characteristics to be considered include flight path control authority, operating margins, maneuver capability, stability limitations, and field length factors. The flight test program for the AWJSRA will start in late FY 73. These flights will be preceded by the in-flight simulation program Handling qualities and controls flight research will proceed through FY 74. Flight director and flight operations experiments will be carried out in conjunction with STOL operating experiments in collaboration with DOT/FAA. These joint experiments will continue through FY 75 and will be concluded by mid FY 76.

W73-70211 **766-76-01**
Flight Research Center, Edwards, Calif.
TRANSONIC AIRCRAFT TECHNOLOGY (TACT)
Weneth D. Painter 805-258-3311
(760-69-01)

The objectives of this effort are to evaluate and flight test a variable sweep supercritical wing which is believed capable of improved aerodynamic efficiency in the transonic region, demonstrate the improved transonic drag rise and lift levels for buffet onset shown in wind-tunnel investigations, identify problem areas in structural and aerodynamic design and flight operations, and establish the desired level of confidence in prediction techniques for future applications.

W73-70212 **766-76-02**
Ames Research Center, Moffett Field, Calif.
F-111 TACT RESEARCH AIRCRAFT
S. L. Treon 415-965-5848
(501-06-02; 501-26-04)

The overall objective of the Transonic Aircraft Technology (TACT) Program is to provide a 'proof-of-concept' research flight demonstration of recent advances in supercritical wing technology applied to a maneuvering fighter configuration with variable sweep capability. Specifically, the effort at the Ames Research Center will be to provide thorough wind tunnel investigations as the basis for prediction of aerodynamic performance, stability, control, buffeting characteristics, and structural loads of the TACT airplane. Correlation of the wind tunnel results with full-scale flight test data is a further major objective.

W73-70213 **766-75-01**
Flight Research Center, Edwards, Calif.
DIGITAL FLY-BY-WIRE SYSTEM FLIGHT EXPERIMENT
C. R. Jarvis 805-258-3311
(501-26-06)

The overall objective of this joint effort with LaRC is to provide the technology required for the implementation of advanced reliable digital fly-by-wire systems in future aircraft. In Phase IA, flight tests will be conducted on the single-channel digital system in an F-8C aircraft to determine the basic system and operational performance. These tests will investigate handling qualities and aircraft response, turbulence and engine noise effects, filter and gain variations, and high angle of attack areas during low speed and cruise flight. In Phase IB, through a cooperative effort with LaRC, a dual-channel digital fly-by-wire system using multi-purpose aircraft computers will be developed and flight tested in the F-8C aircraft. Software development and simulation support for this phase will be provided by LaRC. In Phase II, through cooperation with LaRC, a reliable multichannel fly-by-wire system will be developed and flight tested using information attained from Phase IA and IB

W73-70214 **766-75-02**
Langley Research Center, Langley Station, Va.
DIGITAL FLY-BY-WIRE FLIGHT CONTROL SYSTEM RESEARCH AND DEVELOPMENT
G. B. Graves 703-827-3745
(136-62-03; 766-75-01)

The objective of this effort is to provide a design base for reliable, cost-effective digital fly-by-wire flight control systems for commercial and military aircraft applications. The approach to be followed is as follows: In coordination with FRC, define flight test objectives for the overall fly-by-wire program; participate in the evaluation of flight test results of the single-channel Apollo system being conducted by FRC in the F8-C aircraft, and use these results to assist in the definition of software requirements for an advanced digital fly-by-wire system using multi-purpose computers and strapdown inertial reference; develop and verify the software for this system, and conduct simulations to determine the performance of the advanced system with an F8-C aircraft; together with FRC, plan a follow-on program to develop a cost-effective and reliable multi-channel system for aircraft applications; integrate this work with efforts on reliable electronics being conducted under the Active Controls Technology Program, and initiate research on critical components for the multi-channel system.

W73-70215 **766-74-01**
Langley Research Center, Langley Station, Va.
COMPOSITE MATERIALS APPLICATIONS TO C-130 CENTER WING STRUCTURE
G.W. Brooks 703-827-2042
(501-22-03)

The objective of this program is to obtain longtime flight service performance of filamentary composite materials in the center wing box of C-130 aircraft. The objective will be achieved through a systematic program as follows: 1) Conduct advanced development study to provide design allowables, manufacturing and process methods, and required analysis methods; 2) Perform detailed design; 3) Fabricate three composite-reinforced aluminum alloy wing boxes; 4) Perform ground test on one full-scale box (fatigue and strength); 5) Install wing boxes in two C-130 aircraft; return aircraft to Air Force; 6) Perform periodic monitoring to establish performance of wing boxes. The results of this flight service program will provide meaningful data on the performance of composite materials in a primary structure in the flight environment. Results will also be obtained on design, manufacturing and processing methods, non-destructive evaluation and field inspection procedures heretofore unavailable on large scale composite-reinforced primary aircraft structures. The program will provide confidence needed before commitments are made to future applications in aircraft structures.

W73-70216 **766-72-01**
Flight Research Center, Edwards, Calif.
YF-12 FLIGHT TESTS
G. J. Matranga 805-258-3311
(766-72-02)

The YF-12 type airplanes are the only airplanes in the free world which are capable of sustained Mach 3 flight. Major areas of research include the examination of the hot, flexible structure; dynamic inlet behavior; airframe/propulsion interaction; and general problems related to high speed and high altitude flight. In the structures area, thermocouples and strain gages have been installed in airplane 935. Ground calibrations will allow for the measurement of hot loads in flight. Flight results will be compared with NASTRAN predicted information. Dynamic inlet information obtained in flight will be compared with results from a 1/3 scale inlet model and a full scale inlet operated in the wind tunnel. Airframe/propulsion interaction flight information will be related to data predicted using a 1/12 scale airplane model.

W73-70217 **766-72-02**
Ames Research Center, Moffett Field, Calif.
YF-12 DISCIPLINARY RESEARCH
L. Roberts 415-965-5066

The unique performance capabilities of the YF-12 airplane provides an opportunity to obtain heretofore unavailable flight data. These data are invaluable for the assessment of theoretical and empirical prediction methods, and an evaluation of wind tunnel tests of that airplane or its components. Comprehensive wind tunnel tests will be made in the areas of: (1) the engine-air inlet and internal flow system; (2) the effects on the aircraft aerodynamics produced by the various modes of operation of the propulsion system; and (3) aeroelastic effects on the aircraft stability characteristics. Flight tests will be conducted by the NASA Flight Research Center for correlation with the wind tunnel results, and with predictions based purely on aerodynamic theory.

W73-70218 **766-72-02**
Flight Research Center, Edwards, Calif.
YF-12 DISCIPLINARY RESEARCH
J. D. Watts 805-258-3311

A closely coordinated flight and ground test program utilizing the YF-12 airplane is being carried out in parallel with an extensive wind tunnel and analytical program. The over-all objective is to thoroughly evaluate the state-of-the-art of flight loads measurement, loads predictions including aeroelasticity and thermal effects, and structural analysis for flexible hot-structure aircraft. The major efforts in the program are: flight measurement of wing and fuselage loads and deflections, laboratory determination of temperature effects on loads and deflection measurements, 1/2 scale rigid YF-12 pressure model tests, an 8000 degree-of-freedom NASTRAN structural model of the aircraft, and a FLEXSTAB panelized aerodynamic model of the aircraft. Data from all these sources will be correlated in the final analysis. Propulsion predictability of steady-state supersonic inlet performance, inlet flow dynamics, and interactions of engine, inlet, and aircraft control systems is the major problem to be evaluated on the YF-12 airplane. The effort involves simulations, wind tunnel tests of a 1/12 scale airplane model, a 1/3 scale inlet model, and a full-scale inlet, and flight tests with the YF-12 airplane. Other research includes boundary layer experiments, infrared TV remote temperature measuring system tests, advanced autopilot development and testing, and modal suppression.

W73-70219 **766-72-02**
Langley Research Center, Langley Station, Va.
YF-12 DISCIPLINARY RESEARCH
M. L. Spearman 703-827-3134
(766-72-02; 766-72-02; 766-72-02)

The objectives are. to evaluate analytical techniques for predicting boundary layer transition, heat transfer, and skin friction; to provide the basis for improved design prediction techniques; and to define and provide solutions for unknown problems in flight. The approach will be to conduct pertinent ground-based analyses and wind-tunnel tests on a boundary layer test component (hollow cylinder 10ft long and 1.5 ft in diameter) that will be flight tested on the YF-12 aircraft. These data with those from flight tests on the same component will

be analyzed and correlated. Funding provided by this RTOP will accommodate the design and construction of a model/tunnel adapter for installing the hollow cylinder in the Langley Unitary Plan wind tunnel.

W73-70220 **766-72-02**
Lewis Research Center, Cleveland, Ohio.
PROGRAMS - YF-12 RESEARCH AIRCRAFT
M. O. Dustin 216-433-6754
(501-24-03)

The objectives are: (1) to evaluate the capability of currently available computer simulation techniques to determine dynamic characteristics of a high Mach number aircraft; (2) to investigate advanced concepts for improving inlet stability margins; and (3) to study the existing aircraft control systems and investigate alternate control methods which can both improve the propulsion system performance and minimize propulsion system-airframe interaction.

W73-70221 **766-73-61**
Flight Research Center, Edwards, Calif.
F-8 SUPERCRITICAL FLIGHT EXPERIMENTAL PROGRAM
W. H. Andrews 805-258-3311

The initial phase of the Supercritical Wing Flight Evaluation was completed in May 1971 with 7 flights of the testbed aircraft having been flown. The airplane was then removed from flight status until Aug. 1971 to complete the installation of performance instrumentation. Flight testing was resumed in mid-August and to date 41 flights have been performed. The flight envelope was expanded to an altitude of 51,000 ft, a Mach number of 1.2 and a dynamic pressure of approximately 600 psf. Within these bounds wing pressure distribution and performance data have been recorded and analyzed. In addition, the modified airplane stability, control, and structures characteristics are being documented. Representative results of the program have been published in a Working Paper and an NASA SP report compiled from a series of papers presented during a one-day symposium on Supercritical Wing Technology held at FRC in Feb. 1972. The flight program is continuing with an additional evaluation of performance and wing boundary layer and wake measurements. In June the airplane will be removed from flight status to install fuselage side fairings designed to improve the overall area ruling of the configuration. Return to flight status in July will be to complete the performance evaluation.

W73-70222 **767-77-01**
Langley Research Center, Langley Station, Va.
ROTOR SYSTEMS RESEARCH AIRCRAFT
R. E. Bower 703-827-3285

The basic objective is to develop and bring into operation two versatile flight research aircraft to provide economical rotorcraft research capability in the real and dynamic environment of flight. These research aircraft will provide the research capabilities that cannot be duplicated in groundbase facilities and that have previously been restricted because of the expense of specialized vehicles. The versatility of the Rotor Systems Research Aircraft will provide: (1) economical flight research of a wide variety of promising new rotor concepts, and (2) real-world verification of rotorcraft supporting technology offering potential solutions to existing or anticipated problem areas.

W73-70223 **767-78-01**
Langley Research Center, Langley Station, Va.
TILT-ROTOR RESEARCH AIRCRAFT SUPPORT
R. E. Bower 703-827-3285

Facility support, related technical assistance, consultative services, and additional analytical studies will be provided as required to support the joint NASA/Army Tilt-Rotor Research Aircraft Project. Data available from previously conducted analytical and experimental studies will be prepared for publication.

W73-70224 **767-78-01**
Ames Research Center, Moffett Field, Calif.
V/STOL TILT ROTOR RESEARCH AIRCRAFT PROJECT
L. Roberts 415-965-5066
(760-63-03; 760-63-04)

The objectives are to design, develop and bring into operation two tilt rotor research aircraft to provide flight research vehicles for proof-of-concept of the tilt rotor V/STOL concept and operations flight research for potential military and civil missions. The flight research program will include (1) experimental exploration through flight research of current technology of interest to industry for their consideration for development of useful, quiet, easily maintainable commercial or military V/STOL tilt rotor aircraft, particularly by verifying rotor/pylon/wing dynamic stability and aircraft performance over the entire operational flight envelope, (2) establishment of safe operating envelope and initially assess the handling qualities for use in follow on advanced flight research, (3) investigation of tilt rotor gust sensitivity and load alleviation systems, (4) investigation of tilt rotor disc loading and tip speed on downwash and noise and the impact on hover mode operations, and (5) evaluation of potential benefits of applying tilt rotor capabilities to various Army Air Mobility Missions. This is a joint program with the Army, in accordance with the memorandum of understanding with the Army dated November 1, 1971. The program will be managed through a joint NASA/Army Project Office in accordance with an approved Project Plan for development of two V/STOL Tilt Research Aircraft. Two or more contractors will be selected on or about September 1, 1972 to participate for a three month period in competitive detail design, analysis and program planning studies resulting in a proposal for the development of the two aircraft. These firm proposals will lead---

W73-70225 **768-81-01**
Langley Research Center, Langley Station, Va.
VEHICLE DEPENDENT ASPECTS OF TERMINAL AREA GUIDANCE AND CONTROL
G. B. Graves 703-827-3745
(768-81-02; 768-83-04)

The objective is to determine the aircraft performance and control system characteristics needed for efficient operation in terminal areas with advanced air-traffic management concepts and improved avionics. Emphasis is placed on vehicle dependent aspects such as maneuver capability, speed control, turbulence response, ride quality, flight path control, and the relation of control characteristics to avionic systems. CTOL, STOL, and VTOL aircraft will be considered. Concurrent Langley efforts on terminal area operating practices, handling qualities, control configured vehicles, and avionics such as wide area navigation systems, digital flight control systems, and displays for terminal area and final approach to landing are important considerations in this work. Modeling and simulation capabilities will be used to examine the performance of various classes of aircraft with selected terminal area traffic and airspace constraints, control concepts, avionic systems, and the ground based elements of air-traffic navigation and control systems. Aircraft and airborne systems characteristics will be related to control concepts, safety considerations, traffic density, delays, and economics. Aerodynamic and control simulations will be utilized to evaluate

aircraft performance limitations. Parametric sensitivity and tradeoff studies between aircraft performance characteristics and ground and airborne electronic system capabilities will be made. Analysis and simulation studies will be closely related to the airborne systems technology effort under RTOP 768-81-02.

W73-70226 **768-81-02**
Langley Research Center, Langley Station, Va.
ADVANCED OPERATING SYSTEMS TECHNOLOGY FOR CTOL AIRCRAFT
G. B. Graves 703-827-3745
(768-81-01; 768-83-04)

The objectives of this program are to develop and demonstrate technology which will (1) allow reductions in delays caused by adverse weather, thereby increasing schedule reliability and allowing reconsideration of reserve fuel requirements, (2) allow increases in capacity of present airports, (3) allow for the reduction of noise signature and exposure in airport communities, and (4) improve the safety in both the terminal area and the landing phase of flight. Special attention will be given to avionic systems which take full advantage of advanced terminal area navigation systems and the Microwave Landing System being developed by FAA. The problems of approach and landing in CAT III weather, considering noise alleviation and a required increase in runway acceptance rate with minimum delays, are paramount in the air transport system. The airborne equipment and procedures, available for use with ground facilities, to attack these problems have only been examined in parts and pieces. It is urgent that a coherent program be developed which will directly address the problems of integrating aircraft-pilot-displays and controls in the advanced high-density airport environment. Simulation and flight studies will be conducted at LRC, Wallops, and FAA facilities. The most advanced equipment will be operated in models of present and future airport environments to investigate reliability, digital techniques, automatics, displays, and procedures. Flight modes including terminal area descent, final approach, landing and rollout will be emphasized. The entire program will be actively coordinated with the DOT and the users including the air carriers and airline pilots.

W73-70227 **768-81-03**
Ames Research Center, Moffett Field, Calif.
STOL OPERATING SYSTEMS EXPERIMENTS USING MODILS AND THE CIVIL/MILITARY MICROWAVE LANDING SYSTEM (MLS)
Leonard Roberts 415-965-5066
(768-83-01; 768-81-05)

The objective is to develop a data-base for use by industry and Government in establishing systems concepts, design criteria and operational procedures for STOL aircraft, STOL ports, STOL landing guidance sytems, airborne avionics, flight control systems and air traffic control. The basic approach is to conduct a group of closely related investigations for STOL, encompassing analysis, simulation, flight experiments and supporting studies. Emphasis will be on terminal area navigation, guidance, control and flight management for making steep ascents and descents, tight turns, and slow speed approaches and landings. Flight experiments will be conducted using a versatile integrated avionics system (STOLAND, developed under RTOP 768-83-01) installed in the C8A and modified C8A aircraft, and the following navigation and landing aids: VOR/DME, TACAN, and MODILS (Modular ILS, furnished by the FAA). Finally, the data obtained in simulation of candidate microwave landing systems concepts (MLS), and in flight experiments using MODILS will be checked using a prototype MLS to be furnished by the FAA. Concepts and criteria developed under this RTOP will be used in operational experimental using QUESTOL.

W73-70228 **768-81-04**
Langley Research Center, Langley Station, Va
STOL - AIR TRAFFIC CONTROL INTEGRATION STUDIES
G. B. Graves, Jr. 703-827-3745

This work is concerned with the problems of integrating STOL airplanes and the air traffic control (ATC) system in the terminal area. The objective is to determine: (1) aircraft design and equipment requirements and operating procedures, and (2) airspace requirements and ATC equipment and handling procedures for efficient short-haul operations. Real-time simulation studies are being conducted by linking a STOL airplane simulator at Langley Research Center with the FAA's ATC simulator at Atlantic City. Studies will also be conducted by linking a STOL airplane in flight at Wallops Station with the ATC simulator.

W73-70229 **768-81-05**
Ames Research Center, Moffett Field, Calif.
ADVANCED INTEGRATED AVIONICS CONFIGURATIONS SUITABLE FOR FUTURE LARGE HIGH PERFORMANCE JET V/STOL AIRCRAFT
Leonard Roberts 415-965-5066
(501-23-12)

The objective is in flight investigation of specific current system technologies for a low-cost, highly reliable inertial guidance and navigation concept which can be used as an integrated sensor package, and for use in improving guidance and navigation. This system will make full use of digital computer technology with the system elements regrouped for maximum performance and minimum complexity. It will be a multiple redundant system which fully utilizes an aircraft control computer for navigation, guidance and flight control. The first flight system will be a system which replaces the standard set of inertial sensors with a single redundant strapdown inertial reference unit (SIRU). There are four tasks in this program. Task 1 is the establishment of requirements, development of technology, and identification of deficiencies for rectification. Task 2 is the identification and projection of perfromance and system requirements through computer analysis for an advanced SIR. Task 3 is comprised of a comprehensive simulation, laboratory, and flight test program to confirm and refine the SIRU performance. Task 4 is the development of appropriate aided inertial Kalman filters through simulation studies and flight tests.

W73-70230 **768-81-08**
Ames Research Center, Moffett Field, Calif.
NATIONAL MICROWAVE LANDING SYSTEM FEASIBILITY DEMONSTRATION AND V/STOL OPERATIONAL VALIDATION
H. Lessing 415-965-5428
(768-81-03; 768-83-01; 768-83-00)

The overall objective is to support the user agencies and the FAA in the task of developing a common civil/military approach and landing system called the National Microwave Landing System (MLS). This includes contractor concept evaluation, computer modeling and simulation, and prototype validation. The basic approach is to conduct closely related field investigations and computer simulations to develop realistic criteria for MLS proof-of-concept evaluation and prototype validations. The field investigations will include ground and flight tests with a programmable avionic system referred to as STOLAND. These investigations will emphasize MLS performance for terminal area navigation and approach and landing guidance for Cat. III operations. The three basic tasks in the program are: (1) coordination and facilities support for contractor Brassboard

Feasibility Demonstration; (2) realistic computer simulation using field data leading to performance projections for government and contractor guidance, and (3) prototype MLS configuration K validation for V/STOL applications.

W73-70231 **768-83-01**
Ames Research Center, Moffett Field, Calif.
DEVELOPMENT OF STOL INTEGRATED AVIONICS FOR TERMINAL AREA FLIGHT INVESTIGATIONS IN AN ATC ENVIRONMENT
Leonard Roberts 415-965-5066
(768-82-01; 769-81-07)

The overall objective is to develop navigation, guidance, and control avionics for use in STOL flight experiments and for use in STOL validation flights for the new common-use civil/military Microwave Landing System (MLS). The potential advantages of STOL can be realized only with advanced avionics systems, air traffic control and operational procedures which exploit the capabilities of STOL for making steep ascents and descents, tight turns, and slow speed approaches and landings. Performance and design requirements for a flexible avionics system which will operate in various manual and automatic modes will be defined to satisfy the objectives of STOL flight experiments and of STOL MLS validation flights. In particular, requirements will be based on the use of the developmental scanning beam system, MODILS, to be provided by the FAA for use in the STOL flight experiments. The flexible avionics system referred to as STOLAND, will be designed and developed and then installed in appropriate STOL aircraft and tested in flight. With the exception of MODILS, the flight tests will be conducted using standard instrumentation, tracking, data processing, and navigation aids. The detailed design and development of STOLAND, which will be performed by a contractor, will be supported by relatively complete fixed base and moving base simulations of the aircraft and avionics system at Ames Research Center.

Space Research and Technology Base

W73-70232 **502-01-01**
Ames Research Center, Moffett Field, Calif.
SURFACE PHYSICS AND CHEMISTRY
Glen Goodwin 415-965-5065

This research includes experimental and some theoretical studies of the interaction of atoms and molecules with the surfaces of solid materials. Our efforts are concentrated in three major areas: (a) the characterization of well defined surfaces by advanced analytical techniques with respect to crystallography, chemical composition, binding states, and electrical properties; (b) the interaction of metal vapors with insulator and metallic substrate surfaces to study the kinetics of heterogeneous nucleation and growth, epitaxial and interface phenomena, surface mass transport, and the properties of thin coatings; and (c) the interaction of corrosive gases with metals to study in situ the early stages of the formation of corrosive reaction products and the dependence upon substrate crystallography and substrate defect structure. These investigations are conducted using in situ UHV electron microscopy and LEED/Auger techniques

W73-70233 **502-01-02**
Ames Research Center, Moffett Field, Calif.
PHYSICS AND CHEMISTRY
Glen Goodwin 415-965-5065

The objective of this effort is to exploit the unique capability of the ILLIAC IV computer to determine reliable wave functions for the ground and excited states of atoms, diatomic molecules, and linear polyatomic molecules. The approach will entail a collaborative effort between Ames scientists and Professor B. Crasemann of the University of Oregon. The wave functions determined by this effort will be utilized to calculate reliable values for a large number of atomic and molecular properties such as bond dissociation energies, Auger transition probabilities, and radiation transition probabilities. The data will be of use in a very broad range of applications. Specific examples are as follows: (a) the study of highly ionized atoms in environments such as those existing inside stars or the solar corona, and (b) the study of chemical composition and radiative transport in cool stellar atmospheres or hot bow shock layers of entry probes which contain diatomic molecules as constituents.

W73-70234 **502-01-02**
Langley Research Center, Langley Station, Va.
PHYSICS AND CHEMISTRY OF SOLIDS
C. H. Nelson 703-827-2893

The effects of hazardous conditions encountered by man in space and planetary environments will impose serious constraints on both mission and spacecraft design for any long term manned space mission. Of primary concern is the physical incapacitation and subsequent reduced performance level of astronauts due to mitogenic inhibition of somatic cells, a condition which underlies critical space radiation sickness and other incapacitating malaise. Inhibition and over-stimulation of mitosis by radiation and weightlessness, respectively, can lead to severe homeostasis upset and even death. Research is planned to determine the basic molecular processes involved in the regulation of mitogenesis in somatic cells, and the functional alteration of these processes by adverse elements of space and planetary environments. Following elucidation of these biological interactions, investigations will be concerned with only the physics and chemistry of the processes to establish the correlation and interactions between structural form and function in the systems at the fundamental molecular level. Specific areas to be studied are: The molecular structure of the membrane, the specific ionic partitioning ability of the membrane, the molecular structure and coiling dynamics of the human chromosome and the effects of ionic environments on the physical state of the chromosomal DNA-protein molecules. The information gained from these studies will be used to construct an integrated systems model of the cell which explains the mitotic dynamics in terms of molecular chemical and physical principles. The information gained will pinpoint the key molecular processes underlying mitosis and provide a rational basis for countermeasure development.

W73-70235 **502-01-02**
Lewis Research Center, Cleveland, Ohio.
PHYSICS AND CHEMISTRY OF SOLIDS
Robert A. Lad 216-433-6601

The objective is to obtain an increased understanding of the basic properties of the solid state, both bulk and surface, with particular emphasis on the role of electronic and magnetic properties, atomic structure and chemical reactivity in the determination of physical, chemical and mechanical properties. The research is designed to apply to materials preparation and to the control of physical phenomena in materials of structural and electronic importance in aeronautical and space propulsion systems, energy conversion systems and space communications. Programs in deformation and diffusion in metals and alloys: theoretical and experimental studies of diffusion in alloy systems, reductilizing effects in Mo and W, diffusion effects in dispersion strengthened alloys, hydrogen embrittlement in Ti. Programs in surface phenomena: Oxidative vaporization of metals and oxides,

theoretical calculations of forces at surfaces, hydrogen interactions with Ti surface. Programs in magnetic materials: High coercive force permanent magnets, magnetic and magnetoelastic interactions in rare earth alloys. Programs in chemistry: Preparation of pure metals, thermodynamics and chemical binding in refractory hard metals, ordering in liquid crystals.

W73-70236 **502-01-03**

Langley Research Center, Langley Station, Va.

PROPERTIES OF MATERIALS FOR ELECTRONIC APPLICATION

C. H. Nelson 703-827-2893

Electronic and optical properties of materials are crucial for all solid-state devices. Of interest for these devices are semiconductor surface recombination rates, impurity type, stability to temperature, light and absorbed gases, also the magnetic susceptibilityp, photochemical activity and sublimation energy of crystalline and amorphous insulators. The property studies covered by this RTOP are fundamental to improved solar cells, pollution-gas sensors, light-emitting diodes and diode lasers, optically pumped maser amplifiers, and catalysis. Solar cells could have improved efficiency by using GaAs with reduced surface recombination rate and, for high temperature power production, by employing P-N junctions in either GaAs or Cds. High-temperature transistors, blue and green light-emitting diodes and diode lasers require improved doping and characterization of wide band gap semiconductors such as, GaAs, CdS and ZnSe. As an outgrowth from studies of organic photochromics, paramagnetic organic solids have recently been discovered and they suggest potential application as mm wavelength tunable maser amplifiers. Calculations on LiH in the gas and solid phase provides basic information on microscopic and thermodynamic properties of solids.

W73-70237 **502-01-03**

Marshall Space Flight Center, Huntsville, Ala.

PROPERTIES OF MATERIALS FOR ELECTRONIC APPLICATIONS

E. W. Urban 205-453-5134

(114-03-03)

A wide variety of superconductinq devices have been proposed for space applications, including magnets and instrumentation. All are limited in utility by excessively low operating temperature requirements; magnets are additionally restricted by magnetic-thermal instabilities. It is important to seek techniques for increasing superconducting transition temperatures, to investigate new superconducting instrumentation concepts, and to improve the stability of magnetic materials. Theoretical and experimental studies are being made of the properties and preparation of known and new superconductors to determine those parameters which govern transition temperatures and magnetic field properties, with an ultimate goal of being able to specify the characteristics of and to produce materials of greater utility in space; also studies are made to enhance the capabilities of superconducting quantum instrumentation for space experiments and technological applications. It has been recognized for some time that valuable improvements in semiconductor electronics for space as well as commercial application is possible by improving the surface characteristics of the materials used in their construction. The importance of surface effects are recognized not only due to their importance played in the quantum-mechanical transitions, but also the contributions from surface areas become more significant with microminiaturization as for instance in thin film circuits, solar cells, etc. In situ studies of surfaces characterized on atomic scale are proposed in order to obtain a better insight of certain atomic interactions occurring at and on the surface and their role played in charge carrier, mobility and recombination.

W73-70238 **502-01-04**

Lewis Research Center, Cleveland, Ohio

INTERDISCIPLINARY MATERIALS LABORATORIES

Robert A. Lad 216-433-6601

The objectives are: to obtain new understanding of the relationships between electronic, atomic, molecular and microscopic structures of solids and their useful mechanical, structural electronic and chemical properties; to employ the expertise existent in universities to obtain knowledge in these areas; and to aid in determining the best directions to follow in improving existing materials and obtaining new materials. Research is conducted at the University of Washington (ceramics), RPI (physical metallurgy) and Rice University (solid state physics and chemistry). These programs are interdisciplinary in character and involve participation in several departments at each school. Research topics include interatomic forces in solids, corrosion, diffusion, polymer rheology, composites, computer memory materials, hydrogen embrittlement, superconductivity, grain boundary mobility in ceramics, dispersion strengthening, electromigration, crystal growth and others. The research is chosen to be of NASA-wide interest and utility. The results are disseminated in summary reports, journal publications and topical conferences.

W73-70239 **502-01-05**

Jet Propulsion Lab., Calif Inst. of Tech., Pasadena.

NON-METALLIC SUPERCONDUCTORS

John W. Lucas 213-354-4530

(501-01-22)

The primary objective is to ascertain the feasibility of synthesizing a high temperature superconductor. The achievement of the objective requires understanding and investigations of new theories and new systems leading to superconductors of relatively high transition temperatures. The general approach involves a theoretical and experimental study of a two-dimensional model. This is achieved by incorporation of molecular layers of metals into either layered structures of semiconductors (e.g., molybdenum disulfide) or incorporation of polarizable molecules into metallic layered compounds (e.g., niobium diselenide, tantalum disulfide). Monodimensional systems (e.g., DNA) will also be investigated by a similar approach.

W73-70240 **502-01-06**

Lewis Research Center, Cleveland, Ohio.

RELATIONSHIP OF ATOMIC STRUCTURES WITH MATERIAL PROPERTIES

W. D. Klopp 216-433-4000

(501-01-06)

The objective of this program is to elucidate the relations between atomic and microstructural properties and mechanical properties for refractory and nickel-base alloys in order to guide the development of these materials for advanced space applications. To achieve this objective, the coarsening behavior of strengthening HfC precipitates in Ta and Mo alloys is being studied. Solution softening is being studied in dilute refractory metal alloys to improve low temperature ductility. The microstructure of irradiated tungsten is being investigated. Diffusional weakening in thoria-strengthened nichrome is under evaluation.

W73-70241 **502-21-20**

Lewis Research Center, Cleveland, Ohio.

ADVANCED MATERIALS FOR SPACE

W. D. Klopp 216-433-4000

The primary objectives of these programs are to characterize the suitability of present materials, and to develop new materials for advanced space systems including APR, thermionics, and re-entry vehicle heat shields. The major objectives of the program are: (1) To evaluate and develop refractory material systems with superior mechanical properties such as long time vacuum and irradiation creep resistance for heat pipe, advanced power reactor (APR) and thermionic applications; (2) To conclude the process and material development of Ni-Cr-ThO2, coated columbium, and coated tantalum systems for metallic re-entry vehicle heat shields; and (3) To explore the feasibility of developing ceramic fiber systems with suitable high temperature stability for advanced reusable surface insulation heat shield concepts.

W73-70242 **502-21-20**

Langley Research Center, Langley Station, Va.

ADVANCED MATERIALS FOR SPACE

G. W. Brooks 703-827-2042

The objectives of the research are: (1) to develop and characterize new and improved carbon and graphite materials for use as high-temperature load carrying structure such as heat shields and leading edges of advanced spacecraft; (2) to develop and investigate coatings and infiltrated oxidation inhibitors to enhance oxidation resistance at high temperature; and (3) to develop the mass spectroscopic instrumentation and techniques required to support current and projected materials research programs. Raw materials and manufacturing processes will be varied systematically to produce carbons and graphites with desirable combinations of properties. The resulting materials will be analyzed and characterized to correlate their physical, mechanical, and microstructural properties to their behavior under load and temperature. New binders and improved forming procedures will be developed as required. Efforts will be made to improve the oxidation resistance of experimental and commercial graphites and carbon-carbon materials by impregnation with inhibitors and protective oxide formers and by the application of diffusion, slurry, and plasma sprayed coatings. Material and coating performance will be evaluated in static environments and in supersonic arc-heated airstreams. Mass spectrometric methods will be developed for monitoring the processing of polymeric and other ablative materials. Nonchemical techniques will be developed for measurement of submicrogram quantities of elements in metals. Direct measurement will be made of diffusion coefficients in solids without resorting to chemical or radioactive tracer analysis.

W73-70243 **502-21-27**

Marshall Space Flight Center, Huntsville, Ala.

SPACE STATION THERMAL CONTROL

D. W. Gates 205-453-3102

As a continuation of work in the thermal-control coatings field, our efforts will be directed toward methods of improving NASA's capabilities of controlling spacecraft temperatures. Effort will be directed toward improvement of the white paints and their reliability for extended mission requirements. While maintaining the 0.9E required in the present thermal designs for space station, the DA must be a minimum to obtain the required total life or the least EVA required to restore the thermal-control surfaces. This is being done by improving both binders and pigments, and protection of the coating after application, to its eventual mission requirement. Backup knowledge for these development efforts will include laboratory studies of coatings, measurement design parameter data and long life-times of coatings and their substrates at cryogenic temperatures. Maximum effort will be toward reducing the present best white paint, composed of Zn2TiO4 pigment in an OI-650 glass resin binder, to a NASA specification coating.

W73-70244 **502-21-27**

Langley Research Center, Langley Station, Va.

THERMAL CONTROL

G W. Brooks 703-827-2042

An experimental program is in progress to define, study, and solve the problems associated with utilization of second-surface mirror coatings for passive thermal control of spacecraft. The development of the technology necessary to economically utilize second-surface mirror coatings on large spacecraft surfaces will be emphasized. Experimental aromatic-heterocyclic polymers will be evaluated to provide improved radiation stability for the second-surface mirror coatings. The approach shall include: (1) understanding the principles of second-surface mirrors, determining the materials to be employed, and developing complete coating systems and procedures for their application to spacecraft, and (2) the continued use of the Space Environmental Effects System facility to evaluate the radiation stability of thermal control coatings.

W73-70245 **502-21-27**

Goddard Space Flight Center, Greenbelt, Md.

SPACE VEHICLE THERMAL CONTROL - HEAT PIPES, VACUUM DEPOSITED COATINGS

S. Ollendoft 301-982-6966

The objectives of this task are to improve the art of spacecraft temperature control by the development of more reliable heat pipes, and to increase cost effectiveness of heat pipe technology. The approaches which are being considered are: (1) to develop very reliable high performance heat pipes with moderate heat transfer capacity for ambient temperatures, (2) to formulate standard procedures and processes for fabricating and testing heat pipes, and (3) to establish heat pipe performance in the zero-g environment via sounding rockets and orbiting experiments. For the coating technology, the approach is to develop stable thin films via vacuum deposited coatings. The work proposed under this RTOP is not being undertaken by any other NASA center.

W73-70246 **502-21-27**

Ames Research Center, Moffett Field, Calif.

THERMAL CONTROL

John V. Foster 415-965-5083

The objectives are: to develop a fundamental understanding of heat pipe phenomena; to develop into useful components different types of heat pipes, each capable of performing an unique thermal control function; to provide basic heat pipe design data and computer routines, not available from other sources, as design aids for the thermal engineer; and to establish and participate in flight tests of advanced heat pipes to establish their practicability. The Ames Research Center shall act as a means of extrapolating basic understanding into practical missions. Specific approaches will include the investigation of: (1) the interaction between noncondensing gas and the working fluid in gas-loaded pipes; (2) vapor modulation effects on pipe temperature; (3) materials compatibility and life testing; (4) arterial dynamics; (5) transient performance; (6) wick hydrodynamics; and (7) electrohydrodynamic wicking. Development will be continued on variable conductance, feedback-controlled, one-way, thermal accumulator, and high performance/fixed conductance heat pipes. The Ames Heat Pipe Experiment on OAO-C and the Advanced Thermal Control Flight Experiment on ATS-F will remain a part of this program.

W73-70247 **502-21-27**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
THERMAL CONTROL
John W. Lucas 213-354-4530

The objective is to provide the technology necessary to insure that adequate temperature control of the spacecraft planned for the new missions now being considered can be accomplished. These missions, traveling in toward the sun, outward away from the sun to the outer planets, and in earth orbit pose some new and severe thermal problems. New power/propulsion techniques such as solar electric propulsion and nuclear power create new and different thermal problems. The technology for these missions will be provided by a program of research in four broad areas: (1) Definition of thermal control requirements and identification of necessary advances. (2) Development of advanced analytical and design techniques which will allow better prediction of spacecraft heat transfer. (3) Development of selected temperature control devices which can be used for more effective spacecraft temperature control design. These devices will typically be aimed at controlling or modifying the flow of heat between various parts of the spacecraft, between the spacecraft and space, or to measure some particular heat transfer parameter. (4) Improvements in the technology of materials selection, utilization and performance of temperature control insulations, devices, and coating systems. In all areas, informal contacts with workers at other NASA centers will be utilized to insure minimal duplication of effort and to facilitate information exchange. For this fiscal year, primary emphasis of this RTOP is upon the practical application of heat pipes to spacecraft thermal control and participation in the NASA coatings program. Studies will be aimed at understanding hydrogen generation in water-stainless steel heat pipes and at developing standardized heat pipe cleaning procedures.

W73-70248 **502-21-28**
Marshall Space Flight Center, Huntsville, Ala.
OPTICAL CONTAMINATION OF SPACECRAFT
Hoyt M. Weathers 205-453-3040
(975-72-39; 114-03-07)

The induced environment around spacecraft, both manned and unmanned, does exist and has seriously degraded the results of several measurements and experiments. The contamination can originate from many sources, including material outgassing, particulates and debris, vents of several kinds, attitude thruster firings, leakage, and even from within experiments. A program for the study, control, monitoring, and abatement of contamination has been established within the Space Sciences Laboratory as the key activity in the overall MSFC program in this area. This program is vital to the determination of the degradation of the optical properties of astronomical instruments, thermal control surfaces, and other critical optical surfaces to be used on Skylab, HEAO, Space Station, Space Shuttle, RAM, Sortie Can, and LST. In order to continue the optical contamination effects work at MSFC and to provide the research which is basic to a better understanding of these effects, it is essential that the tasks defined in this RTOP be continued.

W73-70249 **502-21-28**
Lewis Research Center, Cleveland, Ohio.
OPTICAL CONTAMINATION OF SPACECRAFT
H. Mark 216-433-6201

The objective of this work is to determine the effects of releasing gases from a space vehicle or from a neighboring vehicle in such a way as to contaminate a critical surface and affect the operation of the vehicle or any of its optical instruments or components. Determination of the effects on space vehicle surfaces of firing chemical rockets for maneuvering or docking in the vicinity of another space vehicle will be included. Critical low temperature instrument surfaces on which condensates will most probably appear will be studied. Effects for higher temperature surfaces on which undesirable reactions could occur will be included. The effects of additional environmental features will be considered and some effort will also be directed towards application of plume vehicle interactions for refurbishment of contaminated surfaces. In addition spectral data will be obtained to help identify the contaminant as well as to provide the possibility of correcting measurements made by optical instruments under these conditions.

W73-70250 **502-21-28**
Goddard Space Flight Center, Greenbelt, Md.
OPTICAL CONTAMINATION OF SPACECRAFT
R. Kruger 301-982-5034
(502-21-28)

The purposes of this RTOP are to define the contamination environment of unmanned spacecraft, develop monitoring techniques, and develop information so that degradation hazards may be reduced. The approaches are to: Study correlation of in-chamber effects with space phenomena to develop predictive testing techniques and thereby increase spacecraft reliability; Investigate the characteristics of the contaminant fluxes and their effects on the sensitive surface; Conduct outgassing studies in space simulation chambers, investigating the fluxes which originate from either the chamber equipment or the spacecraft; Measure flux directional properties and character using pressure gages, residual gas analyzers, quartz crystal microbalances, etc.; Study the effects of such fluxes in space and determine ways to lesson their detrimental effects; Devise flight experiments to measure the self-generated environment of unmanned spacecraft in orbit and monitor them so that, if degrading occurs, corrective action may be taken.

W73-70251 **502-21-29**
Marshall Space Flight Center, Huntsville, Ala.
METEOROIDS (SPACE STATION)
K. S. Clifton 205-453-0942
(114-03-46)

Low light level television systems will be used in ground-based observations of meteors in order to define the mass distribution of the near-Earth meteoroid environment. Specifically, data will be recorded to determine the slope of the mass-flux curve in the mass range between that defined photographically and that measured by the Pegasus satellites, a region of critical importance to long-term orbiting spacecraft. In addition, the temporal and other variations in meteor influx rates will also be investigated. With the use of video processors, filters, and spectral gratings meteor parameters such as luminosity, color, and spectra will also be examined. Furthermore, two station observations can allow the calculation of meteor heights, velocities, and orbital parameters. The meteoroid simulation program is conducted using light gas and plasma accelerators. At the present time they are utilized in support of four objectives: (1) To verify and support an accurate theoretical model of the hypervelocity impact phenomena; (2) To define damage to such structures as Skylab bumper and hull, MDA instrumentation cables, proposed lunar tug fuel tanks, solar cells, IU panels, etc., from hypervelocity impact; (3) To simulate meteor phenomena in support of the groundbased work; and (4) To increase the acceleration velocity of projectiles.

W73-70252 **502-21-29**
Langley Research Center, Langley Station, Va.
METEORS AND METEOROID STUDIES

C. H. Nelson 703-827-2893

The broad objective is to provide on a continuous basis to the designers of future spacecraft sufficient knowledge of the meteoroid environment, and the effects of the meteoroid environment on space operations to insure proper mission planning and implementation. Models of the meteoroid environment in the solar system will be generated and periodically updated as new data are obtained. Particular attention will be given to the meteoroid environment in the Asteroid Belt and in space near major planets such as Mars, Jupiter and Saturn which are currently planned as targets for flight investigations. The effects of meteoroid impacts on spacecraft will be studied both analytically and experimentally. The Langley Research Center will serve as the lead Center for all OAST meteoroid research. The talents and resources of other Centers will also be utilized. All available meteoroid data from flight experiments, meteor observations, zodiacal light measurements, asteroid observations, etc., will be used to generate the environment models. Laboratory particle accelerators will be used to investigate impact damage. Meteoroid damage predictions will be made for most major NASA spacecraft and the flight performance of these spacecraft will be observed to generate feedback into the environment models for updating or simply improving confidence levels. Man-made debris particular in earth orbit will also be considered and feed into spacecraft damage prediction models.

W73-70253 **502-21-30**

Goddard Space Flight Center, Greenbelt, Md.

ENVIRONMENTAL DESIGN CRITERIA

A. Mills Scott 301-982-4246

The objectives are to develop and publish: (1) NASA design criteria monographs describing terrestrial, extraterrestrial, and space system environments and (2) GSFC environmental test specifications. For this task, we assess data from three sources: space and terrestrial research, space system operational performance, and environmental test experience. The objective, which is to improve design and performance of space systems, is carried out in three complementary ways: (1) Development of some 30 NASA Design Criteria Monographs, each of which presents an engineering description or model of an environment which can affect the design of space systems and the planning of space missions. As Lead Center, GSFC initiates, coordinates, and reviews efforts of participating NASA Centers, contributing scientists, engineers, and contractors. (2) Formulation of GSFC general specifications for testing spacecraft and sounding rocket payloads. Revisions are made in response to new environmental knowledge or when NASA adopts new launch vehicles. (3) The Past Experience and Performance (PEP) effort compares actual spacecraft operational results with prior environmental tests. The object is to improve the test program and attain maximum reliability in future spacecraft.

W73-70254 **502-21-30**

Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.

ENVIRONMENTAL DESIGN CRITERIA

John W. Lucas 213-354-4530

The objective of this work is to prepare space vehicle environmental design criteria for interplanetary and planetary environments. The effort during FY'73 is directed toward completing the first draft of a Space Vehicle Design Criteria Document for the interplanetary charged particle environment and initiating an cometary environmental design criteria document. Together with knowledgeable scientists, engineers, and designers important environmental parameters will be identified Based on the current state-of-the-art knowledge of the specified environment, engineering descriptions, and/or models will be developed and space vehicle design criteria for the important parameters established. An environmental design criteria document will be composed, edited, and written in the established style. The documents are to pass through the regular review cycle with the final draft sent to GSFC for publication. This task is in direct support of the Space Vehicle Design Criteria Program. The resulting documents provide space vehicle design criteria for potential space missions to major and minor solar system objects.

W73-70255 **502-21-30**

Marshall Space Flight Center, Huntsville, Ala.

ENVIRONMENTAL DESIGN CRITERIA

William W. Vaughan 205-453-3106

To meet the scientists, engineers, and designers requirement for documents, such as guidelines and monograms of environment parameters, the following work has been undertaken to develop space and terrestrial environment criteria, ground wind, inflight, lunar surface, surface extremes, earth orbital, planetary, and others which are required. These models or monographs are being put together by knowledgeable scientists based on data obtained in the past, as well as data presently being recorded. These documents are necessary in the overall design, development, and operational requirements of present and future space vehicle and systems. Due to the changing requirements of NASA projects and increase in data records, it is necessary to maintain a continuous effort to analyze these data and potential engineering applications. This permits the development of timely guideline and monographs for environmental criteria. This work was covered during FY 72 under code 114-03-55 with the same title of this RTOP.

W73-70256 **502-21-32**

Langley Research Center, Langley Station, Va.

RADIATION SHIELDING AND DOSIMETRY

C. H. Nelson 703-827-2893

The objectives are: to experimentally obtain data on the production of nucleons and heavy ions from elemental materials under high-energy proton and alpha particle bombardment and improve biological dose calculations for manned space missions; to develop a real-time REM dosimeter for extended manned space missions and theoretically estimate eye damage from heavy cosmic ions using fractional cell lethality and Katz cell inactivation model; to make a critical analysis of current active dosimetry methods of monitoring dose to internal organs; to develop models for the interaction of heavy ions with heavy nuclei for heavy ion shielding studies; and to continue effort to determine the damaging effects of space radiation on various types of photographic film proposed for space experiments.

W73-70257 **502-31-50**

Langley Research Center, Langley Station, Va.

EXTERNAL INSULATION

G. W. Brooks 703-827-2042

(502-37-02)

The properties of ceramic materials will be evaluated to establish their suitability for use as surface insulation thermal protection systems. Methods for improving the thermal and mechanical properties of current low-density materials will be investigated. Low-density rigidized fibrous materials such as silica, mullite, zirconia, and alumina will be subjected to cyclic heating. Thermal and mechanical stability will be determined through mechanical tests and microscopic examination. Improvements in properties will be pursued by varying processing methods and materials. Coatings required to seal fibrous materials against excessive moisture absorption and to provide suitable surface emittance properties will be evaluated in combination

with the various fiber systems. The structural behavior of the coating, fiber, substrate system will be studied analytically and through structural tests of representative panels. A more flexible form of surface insulation will be developed for areas of entry vehicles where the temperature is less than 800 K Approaches to be followed include multidimensional fibrous reinforcement and impregnation with high temperature silicone resins. Such materials could be made waterproof without resorting to glazed ceramic coatings and also offer a potential for lower cost than current rigidized fibrous systems.

W73-70258 **502-31-50**
Ames Research Center, Moffett Field, Calif.
SPACE SHUTTLE: EXTERNAL INSULATION
Glen Goodwin 415-965-5065
(502-37-02)

The objective of this project is to determine: (1) the material property changes of the ingredients of this class of materials as they are processed and subsequently exposed to the shuttle ascent and entry environment; and (2) how these changes relate to the thermal performance and reliability of this class of thermal protection material. Silica, mullite and other material systems will be studied in their current status to provide a baseline for assessing the effects of future improvements on their performance and reliability. This will be accomplished by assessing the chemical and morphological states of the material ingredients before and after processing into the insulation itself. The coating will likewise be studied. After cyclic exposure to simulated entry environments, changes in the materials will be assessed, related to the thermal and mechanical performance of the materials and recommendations will be made for improving the material composition, processing and coating to achieve higher performance and greater reliability.

W73-70259 **502-31-50**
Lewis Research Center, Cleveland, Ohio.
SHUTTLE EXTERNAL INSULATION
R. W. Hall 216-433-4000

This research and development effort is related to the general class of materials that might be used in the reusable surface insulation (RSI) concept for the Space Shuttle and advanced thermal protection systems. The objectives of this work may be briefly summarized as follows: (1) To fully characterize the RSI materials; (2) To improve the mechanical behavior of RSI bodies; (3) To improve the surface character of RSI bodies; (4) To optimize currently used fibers and to seek new and improved fiber compositions. The first three objectives will be pursued by obtaining currently used RSI materials from NASA contractors for in-house studies. Materials characterization will be made at several stages of processing. Improvements in mechanical properties and surface characteristics will be sought by the introduction of other selected materials intended to bring about the desired improvements. These materials will be compatible with, but completely independent of, the fabrication processing steps. Optimized and improved fibers will be sought by contractual efforts.

W73-70260 **502-31-51**
Lewis Research Center, Cleveland, Ohio.
BEARINGS, LUBRICANTS AND SEALS FOR SHUTTLE
R. L. Johnson 216-433-4000
(502-01-07; 501-24-10)

Materials and lubricants selection, development, design, theory, analysis and experimentation of bearings and seals will be performed under extreme conditions associated with (a) engine and (b) vehicle components subject to lubrication, friction, wear and hydraulics problems. Components must function in cryogenics, after exposure to vacuum, and in air at extreme temperatures. Rolling element bearings and face type seals for hydrogen pumps of shuttle engines will be operated under conditions simulating problem areas. Vehicle frame control bearings, hydraulic fluids, and seals for actuation systems of flight control surfaces will be studied. Minimum weight, efficiency and extended life are essential.

W73-70261 **502-31-52**
Lewis Research Center, Cleveland, Ohio.
COMPOSITES FOR SHUTTLE
R. W. Hall 216-433-4000
(501-21-23)

The principal objectives are to establish the characteristics of and to obtain design information for certain advanced fiber/polymer composites that are applicable to Space Shuttle tankage. The high strength to weight ratios and the high modulus to weight ratios of these systems offer considerable promise for reducing the structural weight of the Shuttle system and thus increasing the payload. A new high strength, high modulus organic fiber will be further investigated as a filament winding material in addition to a polyimide/glass fiber system for increased temperature capability. Adhesive systems will be investigated to provide better bond strength over a wider temperature range. A LOX compatible nonburning F-W matrix resin will be developed. Acoustic emission techniques will be developed to characterize flawed areas. Impermeable polymeric films will be evaluated for composite vessel liners. F-W graphite composite vessels will be subjected to low-cycle and sustained loading tests.

W73-70262 **502-31-53**
Ames Research Center, Moffett Field, Calif.
HIGH TEMPERATURE MATERIALS FOR SPACE SHUTTLE
Glen Goodwin 415-965-5065
(502-37-02)

This program will encompass a number of work areas dealing with the effects of the entry environment on candidate thermal protection and skin materials for space shuttle, with a common goal of evaluating the oxidation susceptibility and resulting effect on the mechanical and optical properties of these materials. Oxidation experiments will be run in high-temperature environmental chambers with atomic oxygen generators to provide reactive species appropriate for shuttle thermal-environmental conditions. Mechanical property experiments will be run which incorporate environmental simulation, tensile tests, and appropriate metallurgical, chemical and physical property measurements.

W73-70263 **502-22-01**
Langley Research Center, Langley Station, Va.
STRUCTURAL DESIGN STUDIES
G. W. Brooks 703-827-2042

The objective is to conduct system design studies where the application of advanced structural concepts, materials, methods, and processes could provide technical breakthroughs and cost reductions for current and projected systems. Specific objectives are to (a) assess the impact of advanced structural technology on mission requirements and economics; (b) evaluate advanced structural design concepts and the effects of varying key structural parameters on system weight, performance, and cost; (c) make results available to NASA programs, contractors, and non-aerospace users in the form of reports; and (d) continue the development of soundly conceived structural design criteria to provide a uniform basis for formulating requirements for flightworthy aerospace structure. The program is managed

by the Structural Systems Office of the Structures Division using a prime contractor to apply short term support from recognized authorities in industry and the academic community. The SSO will identify tasks and assign multidisciplinary teams to derive specific information from systems studies and criteria development. Planning and direction will be coordinated with in-house expertise and designated contacts at other centers, and results applied to aeronautical space, and non-aerospace systems.

W73-70264 **502-22-02**
Lewis Research Center, Cleveland, Ohio.
COMPOSITE TANK TECHNOLOGY
R. H. Johns 216-433-4000

Composite propellant tanks and pressure vessels have a high potential for weight savings in launch vehicle applications. In addition, they have an added safety advantage if a burst condition is reached as there is no fragmentation or flying shrapnel. The liner may be a load-carrying part of the structure or simply an impervious sealing medium. A wide variety of metals are available for the liners. In addition, many filament and resin combinations can be considered. They offer a variety of properties which can be tailored to particular applications. Applications vary from small, high-pressure gaseous pressure vessels to large, low pressure cryogenic propellant tanks. Strain compatibility between liner and overwrap, reinforcements around openings, liner buckling and pressure vessel efficiency are some of the problems which need study. Also, environment, load history and manufacturing technology will be studied.

W73-70265 **502-22-03**
Lewis Research Center, Cleveland, Ohio.
FRACTURE CONTROL TECHNOLOGY
R. H. Johns 216-433-6380

Work conducted under this RTOP will provide methods, data, materials and other applied technology for the design and fabrication of reliable, low cost, efficient aircraft and aerospace vehicles. Specific tasks will be directed to characterization of a new cryoworked steel and to extension of current methods of analysis for surface and embedded flaws. Both complex crack-part geometry stress intensity solutions, and analysis of surface and embedded flaws, which experience large plastic deformations in the crack tip region, will be pursued. Analytical models and basic crack growth data for validation of the models will be developed for subcritical crack growth conditions. Environmental degradation of crack growth resistance caused by gaseous hydrogen and other typical degrading environments will be included. The effects of loading profile, loading sequence, and material creep sensitivity will also be investigated. Effective correlation and generalization of basic crack growth data which will permit improved design accuracy with a minimum amount of empirical testing is the objective of these tasks.

W73-70266 **502-22-04**
Goddard Space Flight Center, Greenbelt, Md.
SPACECRAFT LAUNCH DYNAMICS
J. P. Young 301-982-4964

The overall objective of this effort is to improve spacecraft and component structural dynamic test specifications (acceleration, vibration, shock, and acoustic noise) and test techniques so as to provide a better balance between conservatism in severity, risks associated with insufficient testing, and economy. Program objectives will be met by performing a series of research tasks in the areas of development of an improved component test specification; expanded treatment of the protoflight program concept and combined environment testing in the general test specification; further study of factors that can determine the recommended use of acoustic testing; and an investigation of alternatives to the use of a uniform test factor.

W73-70267 **502-22-05**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
ADVANCED CONCEPTS FOR SPACECRAFT ANTENNA STRUCTURES
John W. Lucas 213-354-4530
(502-23-12)

Outer planet and planetary orbit missions in the 1975-1985 period will require substantially increased communication capabilities. JPL studies indicate that optimum telecommunication design for these missions is realized with antennas having much higher gain than those now used on Mariner spacecraft; however, the assumed gain vs. weight used in these studies has not been verified, nor is the technology sufficiently well developed. The principal objective of this five-year effort is to fulfill the need to develop and make available the knowledge required by flight project to be able to utilize new large antennas. A number of furlable antenna configurations have been considered from 15 to 100 feet in diameter for operating radio frequencies up to X-band. The technical approach is to demonstrate feasibility on small scale development models and to design and fabricate larger models such as 14-15-foot diameter furlable conical antennas. The technology will then be investigated for extrapolation to larger sizes. Criteria which will continue to be considered include: weight (goal is 0.25 lb/ft squared), surface accuracy in the operating environment, reliability of deployment, long life, avoidance of adverse interaction between structure and the attitude control subsystem, and amenability to preflight verification by analysis and tests. This effort will be coordinated with "Microwave Deep Space Communications and Tracking," RTOP Code 115-21-20. Another objective of this task is to perform investigations in selected areas of structures, dynamics, and materials relevant to future flight projects. The results of these investigations will be applicable to entire structures of spacecraft carrying large antennas. Increasing reliability and performance and decreasing cost application to projects is anticipated as the work is completed.

W73-70268 **502-22-06**
Goddard Space Flight Center, Greenbelt, Md.
STOP (STRUCTURAL-THERMAL-OPTICAL-PROGRAM)

This RTOP is intended to advance analytical capabilities where the thermal distortions of structural components result in degradation of functional performance. For example, the degradation in the performance of a space telescope because of varying thermal loads in orbit. These loads result in the deformation of the structure supporting the optical elements and also distortions in the structural components themselves. Applications exist in areas such as the Large Space Telescope, Small Astronomy Satellite, RF Antennas, and any complex system where alignments are critical. The approach is to utilize the NASTRAN program for the structural analysis of complex systems and to apply the same technology of the finite element method to thermal analysis; thus a unified thermostructural model is feasible. Subsequently, it enables the structural analysis to use the temperature output directly. The structural results can then be used as an input, through an interface computer program which is being developed under STOP, to ray trace programs for optical or RF performance analysis.

W73-70269 **502-32-01**
Langley Research Center, Langley Station, Va.

SPACE SHUTTLE STRUCTURAL DESIGN TECHNOLOGY
G W. Brooks 703-827-2042

The objectives are: to develop the criteria, analytical tools, and insight concerning efficient structure/TPS arrangements required to support design decisions for the Space Shuttle; to evaluate primary structure concepts embodying the application of advanced material systems such as composites or new arrangements conventional materials toward shuttle structural components with significant potential for minimizing mass; to determine material and structural allowables for confident design of such advanced components; to demonstrate their readiness for Phase C baseline commitment or later application for mass reduction and payload growth; and to define and evaluate feasible approaches to design of secondary structures such as window systems including material specifications and seal requirements.

W73-70270 **502-32-02**
Ames Research Center, Moffett Field, Calif.
SPACE SHUTTLE DYNAMICS AND AEROELASTICITY
C. F. Coe 415-965-5880
(501-22-05; 502-37-01)

Wind tunnel test support and analysis will be provided to investigate several dynamic and aeroelastic problems that must be confronted in the development of a space shuttle vehicle. The primary emphasis will be on transonic buffet (including aeroelastic effects), aerodynamic noise inputs and response, and flutter. A cold-jet plume simulation capability will be developed so that static and dynamic loads can be measured in the presence of an exhaust plume. Elasticity scaled models will be tested in wind tunnels as needed to investigate buffeting and flutter, and pressure fluctuations will be measured in regions of high intensity turbulence to evaluate aerodynamic noise inputs. Full-scale thermal protection system panels will be tested to study the response of panels to high intensity aero-acoustic noise generated by shock waves and separated flows. An existing computer program (FLEXSTAB) will be used in conjunction with experimental tests to evaluate aeroelastic effects on loads and stability and control of launch configurations

W73-70271 **502-32-02**
Langley Research Center, Langley Station, Va.
SHUTTLE DYNAMICS AND AEROELASTICITY
G W. Brooks 703-827-2042

The objective of this research is to develop the structural dynamics, aeroelasticity, loads, hydroelasticity, and vibro-acoustics technology for space shuttle vehicles. The technology under development is directly applicable to specific problems such as vehicle dynamic behavior and control; flutter, buffet and ground winds; booster recovery and landing loads; liquid-structure interaction and suppression; pogo; engine and aero-noise environments and the integrity of systems within the shuttle noise and thermal environment. Both analytical and experimental approaches are required to determine critical loading conditions, vehicle dynamic responses, stability boundaries, and control requirements. Dynamic models and wind tunnels are being used extensively for this in-house and contract effort. The results will influence the shuttle design and lead to lighter weight and more reliability in the flight system.

W73-70272 **502-32-03**
Lewis Research Center, Cleveland, Ohio.
SHUTTLE COMPOSITE TANK TECHNOLOGY
R. W. Hall 216-433-4000
(502-22-02; 502-31-52)

The work conducted under this RTOP will provide the technology for application of filament wound composites to Space Shuttle vehicle tankage. Applications for this technology will include large, low-pressure, load-carrying liquid propellant tanks; nonintegral (nonload carrying) liquid tanks, and small, high-pressure gas storage vessels. Filaments of glass, boron, graphite, and high modulus polymer which offer significant weight or cost savings, while maintaining or improving the reliability attainable with conventional metal vessels, will be evaluated. The development of the advanced concepts for filament-wound pressure vessels already in progress will be continued. In FY 1973 additional activities will be specifically directed toward Space Shuttle system component design and development.

W73-70273 **502-32-04**
Lewis Research Center, Cleveland, Ohio.
SHUTTLE FRACTURE CONTROL METHODS
R. W. Hall 216-433-4000
(502-22-03)

The work conducted under this RTOP will provide technology required for establishing effective fracture control design and operational methods for the Space Shuttle vehicle structures. Technology benefits for commercial aircraft, other space vehicle, and space station applications will also result. Specific areas of current work include: (1) development of fracture data on materials using flaw geometries and loading conditions of specific interest to the Space Shuttle vehicle structures, (2) development of analytical evaluation of crack tip stress intensity for specific Space Shuttle vehicle flaw geometries and loading conditions, and (3) definition of fracture control design approaches specifically suited to the Space Shuttle vehicle structures. FY 1973 efforts will continue in these areas, with increased emphasis on the effects of environment on flaw propagation and the integration of NDT with proof test procedures to provide improved detection of tight defects

W73-70274 **502-04-01**
Lewis Research Center, Cleveland, Ohio.
ION THRUSTER RESEARCH
P. D. Reader 216-433-4000
(502-24-03; 758-57-04)

The broad objective of the work described herein is to provide the basic research needed to increase in an orderly and meaningful manner the knowledge of the behavior of electrostatic thrusters and their interaction with the spacecraft to be employed in communication and scientific missions. By conducting pertinent experimental and analytic studies, the overall program is directed at obtaining a more thorough understanding of the basic physical processes (1) occurring in and external to electrostatic thrusters and (2) interacting with the spacecraft or its intended mission Major programs are directed at searching for basic understanding of thruster and spacecraft interactions to permit refinement of the designs of a given thruster and spacecraft to enable the combined system to experience no significant degradation in mission performance. Specifically, the basic research goals are to investigate the surface deposition of materials from thruster component erosion, the electromagnetic and magnetostatic interactions affecting the thruster/spacecraft interface, problems of ground simulation of thruster-spacecraft interactions in space, thruster/space environment phenomena and theoretical and experimental thruster diagnostics.

W73-70275 **502-04-02**
Lewis Research Center, Cleveland, Ohio.
ADVANCED PLASMA THRUSTER AND LASER RESEARCH
G. R. Seikel 216-433-4000.

The objective is to investigate plasma thruster and laser concepts that show promise for applications of interest to NASA. Investigations are aimed at both understanding the physics of the processes and demonstrating the feasibility of high performance systems. Investigations will also attempt to define possible new applications which could be of interest. Analytical and experimental studies which include extensive diagnostics will be made. Thruster investigations will emphasize demonstrating endurance for low power thrusters and improving performance by minimizing energy losses. Laser investigations will explore novel lasers and attempt to demonstrate their feasibility in MW quasi-steady experiments. Research will include investigations of various laser applications including the transmission of power to drive thrusters, information transmission, and remote measurements.

W73-70276 **502-04-05**
Langley Research Center, Langley Station, Va.
QUASI-STEADY PLASMA PROPULSION RESEARCH
C. H. Nelson 703-827-2893

The long-range objective of this research is to develop plasma thrusters for prime propulsion, which have the potential advantages over the ion engine of higher thrust per unit area, variable specific impulse with little loss in efficiency and simplicity in design. So far the efficiency of plasma thrusters is not sufficiently high to compete for prime propulsion missions of specific impulses approximately 3000 sec. However, plasma thrusters for high specific impulse (approximately 2000 to 2500 sec) lower thrust auxiliary propulsion missions (e.g. north-south stationkeeping) are becoming competitive. Recent prime plasma propulsion research has concentrated on quasi-steady operation, with approximately millisec current pulses, of the MPD arc and generally the use of gas propellants. The auxiliary propulsion thrusters have been of similar design; however, short (approximately mu sec) current pulses were used and ablation of solids for gas propellant production. The efficiency of the quasi-steady gas propellant thrusters has been limited by critical values, whereas, for the short pulse, ablative solid thrusters, the efficiency was not subject to this critical limit. The operation of the quasi-steady MPD arc thruster has been studied, however, in much greater detail and is better understood. An effort will be made to improve the operation of the prime propulsion thruster by making use of some of the experiences of the more efficient high specific impulse auxiliary propulsion thruster. Changes in propellant, propellant feed geometry and pulse duration will be used together with extensive diagnostics. The ultimate purpose of this research is to decide if a prime plasma propulsion device can be made competitive with the ion engine and if this is not the case to improve the operation of the high specific impulse auxiliary plasma thruster.

W73-70277 **502-04-14**
National Aeronautics and Space Administration, Washington, D.C
PHYSICAL PROCESSES IN PLASMA PROPULSION
J. P. Mullin 202-755-2380

Plasma thrusters offer promise for future electric propulsion application with simpler systems than presently available. Development of such systems has been handicapped by a lack of understanding of the physical processes involved in efficient plasma acceleration. The proposed research is aimed at increasing understanding of the pulsed and steady flow phenomenon experienced in such devices. The research also seeks to better understand hollow cathode operation. Such cathodes are basic components of ion thrusters and improved knowledge will provide some insight into scaling laws and operation on a variety of propellants. In addition research aimed at increased understanding of high powered gas-dynamic lasers is being carried out.

W73-70278 **502-04-20**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
SPACECRAFT LIQUID PROPULSION RESEARCH
P. Meeks 213-354-2546
(502-24-26)

The chemical-physical processes that are the essence of liquid propellant rocket engines are being characterized. These processes include ignition, combustion and decomposition, the fluid dynamics and chemistry of nozzle flows, compatibility of chamber walls with reaction products, and plume effects on spacecraft components/structure. The feasibility of applying chemical propulsion technology to a teleoperator/robot capable of propelling itself and functioning in space, planetary atmospheres, and/or on extraterrestrial surfaces will be demonstrated. The mixing effectiveness of various liquid/liquid, gas/liquid, and gas/gas propellant injection systems are being evaluated experimentally and the mechanisms that control mixing are being correlated with injector dimensions and operating conditions. An on-line high-speed mass-spectrometer in combination with a molecular beam probe, is being used to relate engine conditions (compositions) and injector variables and bound the relevance of non-reactive data and predictions of analytical/computer models. The origin of solids deposited from fluorinated oxidizer/amine propellants is sought. The margin of stability for engines utilizing space storable propellants is being determined and modified as required to give a high confidence level for a successful mission (proposed). A combustion model (Distributed Energy Release) in conjunction with a 2-dimensional non-linear combustion instability model (COMB and THDL) is being used to predict stability margins. Densities and pressures within the exhaust plume of a small rocket nozzle are being determined. These properties are being mapped by an electron beam fluorescence technique and the use of quartz crystal microbalances. Studies of novel and advanced concepts and energy sources which can yield a large increase in propulsion capability will be conducted.

W73-70279 **502-04-25**
Lewis Research Center, Cleveland, Ohio.
LIQUID ROCKET RESEARCH
R. J. Priem 216-433-6259

The objectives of this work are: to provide basic analytical and experimental data for chemical propulsion systems; to improve performance, reliability and cost effectiveness; and to establish new and novel concepts for propulsion which provide large increases in performance. These objectives will be attained through theoretical studies to delineate the important design parameters required to achieve engineering improvements, experimental studies to demonstrate the validity of specific theoretical approaches and design parameters, and exploratory studies to investigate new techniques or theoretical approaches that will provide further engineering improvements in liquid rocket engines. Areas in which this effort will be applied are the following: (1) Combustion (2) Fluid flow, cooling and heat transfer (3) Thermodynamic, transport and kinetic data (4) Contamination of spacecraft surfaces (5) Instrumentation (6) Application of lasers for propulsion and (7) Mission and system analysis.

W73-70280 **502-04-35**
Lewis Research Center, Cleveland, Ohio.
RESEARCH IN ATOMIC AND METALLIC HYDROGEN
James C. Laurence 216-433-4000

Hydrogen is the lightest, simplest, and most prevalent of

all the elements. Its low mass and availability are sufficient reason for its selection as a propellant and a fuel. In the more energetic forms, metallic hydrogen, if metastable, and atomic hydrogen, is storable, could provide energy-to-mass ratios exceeding those of any chemical reaction and thus would be a means of energy storage as well as being superior and non-polluting fuels The energy available from either metallic or atomic hydrogen is nearly the same and results from release of the 4 eV binding energy. In addition, metallic hydrogen is theorized to be a high temperature superconductor. The objective of the Lewis program is to produce atomic and metallic hydrogen using approaches and equipment not available when previous studies were made. Dissociation of the hydrogen molecule and short-term manipulation of the atomic species without recombination are feasible, as is perhaps monatomic layer collection on appropriate surfaces. These processes have not, however, been developed enough to produce significant quantities or concentrations of atomic hydrogen. Using the latest capabilities and techniques in dissociation of gases and the very high magnetic field strength and very low cryogenic temperature facilities available at Lewis, collection of significant quantities---

W73-70281 **502-04-36**
Langley Research Center, Langley Station, Va.
PROPAGATION STUDIES USING EXTENDED WAVELENGTH TUNING OF CO AND HF LASERS
C. H Nelson 703-827-2893
(503-10-01)

The objective of this research is to study propagation of CO and HF laser wavelengths through the atmosphere by performing laboratory studies of absorption of CO and HF laser wavelengths by atmospheric constituents (i.e., H2O, CO2). The CO laser radiates discrete wavelengths between 4.4 and 5.8 microns; the HF laser radiates discrete wavelengths between 2.65 and 3.00 microns. These lasers are important since they have demonstrated high efficiency and output power and are therefore suitable for a variety of NASA and DOD related applications. Furthermore, their wide wavelength coverage brings some of the emission wavelengths in spectral regions where the transmission through the atmosphere could be higher than that of the CO2 laser (10.6 microns). To perform this study, it is necessary to develop low power CO and HF lasers radiating over a wide wavelength range. In our laboratory, several subsonic low power CO and HF lasers have been constructed for propagation studies, but the wavelength coverage is limited (i.e., 5.2 to 5.8 microns for CO, 2.7 to 3.0 microns for HF). These wavelength ranges lie within totally absorbing regions of the atmosphere (e.g., subsonic CO emits within the 6.3 microns absorption band of H2O; subsonic HF emits within the 2.7 microns aborption band of H2O). Analytical studies recently performed at LaRC for HF and at AFCRL for CO show the presence of transmission windows (greater than or equal to 80 percent) at the edges of the known absorption bands of H2O at sea level under high resolution. These studies imply that by extending wavelength coverage of CO less than 5.0 microns and that of HF greater than 2.8 micron, the transmissivity of the atmosphere would be greater than 80 percent for select lines of the---

W73-70282 **502-04-45**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
SOLID PROPELLANT RESEARCH
Paul J. Meeks 213-354-2546
(758-56-47; 502-24-46)

The long range objectives of this program are to (1) solve problems in the field of ignition, combustion, and combustion instability of solid propellants relevant to current and future motor technology development programs, (2) develop a general model for the prediction of the network polymer macrostructure of practical propellant systems from measureable characteristics of starting ingredients and their formulated properties, and (3) develop an omnibus theory of propellant viscoelastic behavior, by which a knowledge of basic molecular parameters will permit the prediction of propellant material response in a generalized stress-time-temperature field; and to integrate this theory with a comprehensive stress analysis program to create, together with the propellant development activities, a reliable motor-oriented technology base. During this fiscal year the objectives are to (1) study parametrically the variation in L^*-instability characteristics with oxidizer particle size and the convective flow contribution to acoustic instability, (2) expand the current polymer macrostructure model to include the more complex urethane reaction system and determine which of two theories is more general, and (3) seek more definite knowledge of finite deformation, rupture as a function of molecular parameters and in a macroscopic context, and binder-filler interactions.

W73-70283 **502-24-21**
Marshall Space Flight Center, Huntsville, Ala.
LAUNCH VEHICLE PROPULSION TECHNOLOGY
J. L. Lombardo 205-453-3800
(113-31-12)

The effort outlined in this plan is directed at integrating recent results into the JANNAF's formulation of a General Engine Performance Prediction Methodology, conducting additional tests to investigate transonic flow phenomena based on inhomogeneous mass concentration in altitude compensating nozzles, demonstrating the technology for operating low speed, separately driven inducers with saturated propellants, obtaining flow field properties of hydrogen-oxygen rocket exhaust plumes using optical techniques, and formulating a small perturbation theory for unsteady cavitating flow past pump inducer sections. This work will be accomplished using available test data where possible. Additional tests will be conducted to provide data where necessary. The existing JANNAF engine performance prediction methodology must be extended to include two phase flow, mixing across stream tube boundaries, droplet evaporation and combustion downstream of the nozzle throat, and solid propellant combustion. This effort requires the generation of analytical models and modification of existing computer programs. Therefore, the FY 73 resources are to be applied to extending the JANNAF Rocket Engine Performance Evaluation Methodology. This RTOP is a continuation of FY 72 RTOP 113-31-21.

W73-70284 **502-24-22**
Manned Spacecraft Center, Houston, Tex.
ADVANCED PROPULSION TECHNOLOGY
R. C. Kahl 713-483-4671

The ability to predict rocket engine performance will be advanced through a combined analytical and experimental approach which includes: a) Experimental evaluation of engine and nozzle performance effects caused by striated propellant injection, and b) JANNAF performance computer program improvements. Nozzle performance degradations caused by striated propellant injection, mixture ratio, and mass flow variation will be experimentally investigated to provide accurate data which will be used to calibrate the JANNAF performance models. The two dimensional kinetic (TDK) thrust chamber performance prediction program that forms part of the JANNAF performance evaluation methodology will be modified to allow for calculations through strong shocks and for multi-phase flow, including unvaporized propellant and solid particles.

W73-70285 **502-24-24**
Lewis Research Center, Cleveland, Ohio.
ADVANCED LIQUID ROCKET COMPONENT TECHNOLOGY
H. W. Douglass 216-433-6915

The objective of this program is to provide improvements in the technology of liquid rocket components and subsystems, including (1) turbomachinery, (2) feed systems, (3) thrust chambers, and (4) associated instrumentation. These programs will be pursued largely for applications utilizing high energy propellants. In turbomachinery, the major efforts will be devoted to investigation of axial flow pumps, inducer design, cavitation in cryogenic propellants, turbopump stability, and POGO suppression. In the area of propellant feed systems, efforts will be devoted to propellant flow controllers, a hot gas powered ejector pump, and improvements in valve design. Effort on regeneratively cooled thrust chambers will investigate improved materials, fabrication techniques, and NDT inspection procedures. Research will also be continued to improve the accuracy of flow measurement techniques in cryogenic fluids. Design Criteria Monographs will be generated and distributed.

W73-70286 **502-24-26**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
ADVANCED SPACECRAFT ENGINE COMPONENTS
P. Meeks 213-354-2546
(502-04-20; 757-53-30)

The objective of this plan is to develop the feed system component and rocket engine technology required to support advanced propulsion systems that will be used for planetary missions. The work includes the development of components, rocket engines, and establishing criteria and technologies required for the integration into advanced chemical propulsion systems for long duration missions. The current work is directed toward space storable propellants for unmanned spacecraft which include FLOX, IF2, OF2, MMH, N2H4, B2H6, and N2H4 mixtures. The implications of simulant or processing fluids are being considered. Tasks involve investigations of materials and propellants, components, and rocket engines. Major emphasis is being given to understanding the effects of ten year flight environmental and operational conditions. Of critical concern is the lack of suitable verification methods for assuring satisfactory material propellant compatibility relative to these multi-year mission requirements.

W73-70287 **502-24-31**
Lewis Research Center, Cleveland, Ohio.
ADVANCED LIQUID ROCKET SYSTEMS TECHNOLOGY
E. W. Conrad 216-433-6874
(909-74-03)

Analytical and experimental studies are being made to provide the technology required for near-earth space propulsion systems using hydrogen-oxygen propellants, and for deep space missions using both cryogenic and space storable propellants. The scope includes problems posed by such potential applications as the space tug, OOS, OMS, and planetary orbiters. The major areas of technical concern are the main rocket engine, fluid management, thermal management, and auxiliary propulsion, which in turn are strongly influenced by the overall system configuration. Basic configuration models have been evolved through several NASA, Air Force, and European contracts as well as in-house studies, and provide a rational basis for propulsion, thermal and fluid system activities. In the main propulsion area, the initial emphasis is on the technology of critical engine components. Engine system problems will be studied with emphasis on the start transients and off-design operating conditions. Auxiliary propulsion requirements for docking, propellant settling and attitude control will be established. Work will be done on the problems of long-term storage of cryogenic propellants in both near-earth orbit and deep space, storage during boost and orbit hold in the cargo bay, and inspection techniques to assure adequacy for reuse. The fluid management area is concerned with optimum tank pressurization, propellant line (and engine) preconditioning, accurate outage control, zero gravity venting, propellant acquisition and gaging, and provision for propellant transfer.

W73-70288 **502-24-34**
National Aeronautics and Space Administration, Washington, D.C.
TECHNOLOGY IDENTIFICATION
W. Cohen 202-755-2400

The objective of this work is to obtain necessary data for long range program planning, which includes selection of fruitful new research directions, evaluation of cost effectiveness of components and systems, estimates of costs of programs, allocation of resources, justification of new starts. In general the programs will include technology identification, preliminary analysis, and feasibility studies.

W73-70289 **502-24-41**
Langley Research Center, Langley Station, Va.
ADVANCED PYROTECHNIC/ROCKET SYSTEMS TECHNOLOGY
C. H. Nelson 703-827-2893

The overall objective is to develop and demonstrate technology for pyrotechnic and related rocket systems that is needed to meet aerospace flight program requirements. Pyrotechnic systems work will include continued studies to validate accelerated aging techniques developed with prior year funding, evaluation of electrostatic insensitive pyrotechnic composition for single and dual bridgewire devices, development of measurement techniques to quantatively define the reduction in pyrotechnic shock achieved in the program directed to the minimization of this induced environment, and the program to increase the understanding of pyrotechnic performance mechanisms and their monitoring and evaluation will continue. Three modest ongoing efforts in related solid rocket system technology will be concluded during FY 73 or FY 74. In the first of these, improved non-destructive test techniques will include the demonstration of a laser holographic interferometry method in both inert subscale and live full scale fiber glass case, solid rockets. The second of these involves a contracted effort to characterize improved strength molded reinforced composites for rocket motor components. The third effort is a limited in-house investigation of gas phase reactions occurring above the surface of a double-base solid propellant.

W73-70290 **502-24-46**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
ADVANCED SOLID PROPULSION AND PYROTECHNIC CONCEPTS
Paul J. Meeks 213-354-2546
(758-56-47; 502-04-45)

The objectives are: to conduct research, and to develop advanced technology in the disciplines of solid propellants and pyrotechnics, and to test propellants, motors and critical components toward the goal of improved propulsion systems for NASA spacecraft and upper stages. Specific objectives in (1) 'Propulsion and Motor Technology' are: (A) Develop technology leading to and including demonstration firing of a new high mass-fraction Conesphere Motor design concept. Development

activities will include case fabrication, structural integrity, scaling, and staging. (B) Develop and demonstrate an advanced propulsion concept that will be effective in dense planetary atmospheres. Two concepts are under consideration, liquid jet and explosive charge. (C) Develop a rational designer-usable stress analysis, combining latest methods, data, and failure criteria. (D) Reassess current stop-restart techniques with the aim of identifying the most promising for advanced development. Specific objectives in (II) 'Propellant Binders and Formulating' are: (A) Perfect the new concept for occluding aluminum powder in ammonium perchlorate crystals, and determine effects on low-pressure combustion efficiency and two-phase flow losses. (B) Prepare and characterize new polymers as potential propellant binders. (C) Applying continuing development from Network Polymer Formation studies, advance the art of propellant formulating for the purposes of improving the results and reducing the cost of this activity. Use the advanced formulating methods for evaluating new binder polymers. (D) Develop propellants to meet specific requirements, including the Conesphere Motor and an improved low-acceleration motor demonstration. Additionally, (III) complete the study of radiation effects on propellant and pyrotechnic materials, and (IV) develop technology toward the development of laser pyrotechnic ignition systems.

W73-70291 **502-24-03**
Lewis Research Center, Cleveland, Ohio.
ADVANCED BOMBARDMENT THRUSTER TECHNOLOGY
P. D. Reader 216-433-4000
(502-04-01; 758-57-04)

The broad objective of the work described herein is to provide the technology programs necessary to ensure orderly and meaningful advances in the state-of-the art of electrostatic thrusters. The overall program is directed at applying the knowledge gained from ion thruster research programs to the design, fabrication, and testing of new thruster components; integration of promising new components into thrusters sized for widest possible applications and evaluation thruster performance. A major program is directed at producing mercury electron-bombardment ion thrusters for high efficiency application. Interactions of multi-thruster clusters are also being investigated. Pertinent information from experimental and analytical studies and demonstrated components will be integrated into a specific thruster system design. This design will cover the widest possible range of currently foreseen mission types. Thruster system interactions and integration problems will be investigated to the extent necessary to clearly define interface problem areas.

W73-70292 **502-24-10**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
SOLAR POWERED ELECTRIC PROPULSION SYSTEMS AND INTEGRATION TECHNOLOGY
A. Briglio, Jr. 213-354-6137
(758-57-11; 502-25-56)

The broad objective is to provide a continuing technology and integration base to focus the solar-electric propulsion (SEP) subsystem development effort. To provide this technology and integration base in a timely and effective form to support the thrust subsystem (TSS) work, supporting subsystems trade studies must be performed based upon mission, vehicle, and operations support studies. In addition, the technology areas impacted by the thrust subsystem design will require definition, evaluation and functional descriptions. In FY'72, the design concept of an attachable module was defined. It was found that this approach provided many of the multi-mission aspects of an electric propulsion stage and some of the performance advantages of a completely integrated spacecraft. Early in FY'73, the thrust subsystem design point selection will be completed in the form of a preliminary subsystem functional description. Throughout the fiscal year, work will be underway on the preparation of the functional descriptions of the supporting subsystems, leading towards completion of these documents in FY'74. Thrust subsystem performance interfaces will also be studied in FY'73, in support of an updating of the TSS Preliminary Functional Description under RTOP 758-57-11 and selection of the TSS design point at the end of March 1973 (RTOP 758-57-11). This design point will take into consideration the requirements of the three different vehicle approaches which have been studied; the solar-electric attachable module, the stage, and the integrated spacecraft. Appropriate inputs (e.g., thermal control and configuration requirements) will be provided to the power conditioning development efforts at JPL and LeRC. Major efforts in FY'73 are divided into three categories: 1) thrust subsystem element evaluation; 2) thrust subsystem support interfaces; and 3) SEP mission software development and thrust subsystem performance interfaces.

W73-70293 **502-24-12**
Ames Research Center, Moffett Field, Calif.
PIONEER SOLAR ELECTRIC PROPULSION SPACECRAFT
J. V. Foster 415-965-5083

The technical feasibility and cost effectiveness of a spinning, electric propulsion spacecraft using Pioneer components was demonstrated under Contract Number NAS2-6287. Three spacecraft configurations (2-, 3-, and 5-kw) were developed. These systems appeared, not only to provide excellent science mission capability, but could also serve as a highly desirable technology flight test for the electric propulsion subsystem. The study did not restrict the spacecraft configuration nor include evaluation of inbound missions. In addition, since it was an initial feasibility study, with primary emphasis on missions, spacecraft hardware problems were identified but not evaluated in detail. The objectives of this extension are to concentrate on the hardware aspects of adapting the Pioneer spacecraft for use with solar electric propulsion. The principal objective will be to minimize spacecraft modifications while adding the electric propulsion elements. In addition, the interaction of the electric propulsion elements with the scientific instruments and spacecraft will be studied. The expected results will include the definition of a Basic Pioneer Solar Electric Propulsion Spacecraft, and evaluation of its capabilities, modifications required for specific missions, and an evaluation of the interaction of the electric propulsion elements with the spacecraft and instruments. The approach will be to start with the baseline Pioneer F/G configuration (excluding RTG's) and add solar electric propulsion with minimum modifications to form a basic solar electric spacecraft.

W73-70294 **502-24-13**
Marshall Space Flight Center, Huntsville, Ala.
FEASIBILITY STUDY OF A SOLAR ELECTRIC PROPULSION STAGE (SEPS) FOR GEOSYNCHRONOUS MISSIONS
C. H. Guttman 205-453-3190
(680-40-05)

The objective of this RTOP is to continue the Phase A study activity for utilizing a Solar Electric Propulsion Stage (SEPS) in conjunction with the Tug/Shuttle or chemical stage /Shuttle for performing geosynchronous delivery and retrieval missions. This is a continuation of Exhibit C, NAS8-27360, that will accomplish the objectives of this RTOP. A secondary objective of this RTOP is to investigate all of the environmental effects that will impact the SEPS, evaluate and understand these effects, and recommend future activities to offset future problem areas. A third objective of this RTOP is to initiate design of a peak

power tracker for the SEPS. The Phase A study has been completed and the activity is presently in study phase A-1. The FY '73 funding is for tasks in study phase A-2. This is a continuation of RTOP 113-26-24, (FY'72)

W73-70295 **502-24-18**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
PULSED PLASMA ATTITUDE CONTROL SYSTEM TECHNOLOGY FOR PLANETARY MISSIONS
A. Briglio, Jr. 213-354-6137

The objectives of this program are: (a) continue to assess the application of pulsed plasma thrusters for programmed maneuvers, and attitude control torquer applications for long-duration planetary planetary missions; (b) perform extended single-axis control system hardware simulations with the LES-6 and other available pulsed plasma thrusters, and continue support to other NASA centers (GSFC, LaRC) pulsed plasma thruster developments and applications; and (c) continue development of high-energy, high total impulse thrusters.

W73-70296 **502-34-33**
Lewis Research Center, Cleveland, Ohio.
SPACE SHUTTLE AUXILIARY PROPULSION
J. W. Gregory 216-433-6860

The objective of this program is to provide improvements in the technology of engine components for the Auxiliary Propulsion System of the Space Shuttle The major portion of this work will be devoted to advancements in the thruster assembly, including the injector, thrust chamber, igniter, and valves. The operating conditions for the experimental work are selected to fit the particular requirements of the Space Shuttle. This includes operation with hydrogen/oxygen propellants at thrust levels in the range from 1000-2000 pounds, chamber pressures from 100-500 psia, and appropriate ranges of propellant inlet pressures and temperatures. Complete thruster assemblies will be fabricated and tested to provide an evaluation of overall performance (both pulsing and steady-state), thruster life (high cycle fatigue), and operating characteristics for typical duty cycles. Evaluation of thruster component technology will be extended to low propellant inlet temperatures, down to liquid conditions. Unique problem areas of ignition, injection, pulse mode operation, and stability with liquid or near-liquid propellants will be investigated. Other programs relating to the supply and regulation of the propellants fed to the attitude control engines as well as more basic programs to evaluate critical problem areas in combustion, valves, and ignition devices are included.

W73-70297 **502-05-50**
Lewis Research Center, Cleveland, Ohio.
SOLAR CELL BASIC RESEARCH
Daniel T. Bernatowicz 216-433-4000
(502-25-52)

The objective of this work is to raise the efficiency of silicon solar cells so that cost benefits might be realized on space and terrestrial applications. The approach will be multifold: (1) To increase the current by improving the surface of the cell, the diffused region profile and the diffusion length in low resistivity silicon; (2) To improve the output power by decreasing the excess dark forward current; (3) To increase the open-circuit voltage by using 0.1 ohm-cm material and identifying the losses in these cells; (4) To increase understanding of the solar cell through improved formulation of the diffusion equations and modeling of other current less mechanisms.

W73-70298 **502-05-51**
Lewis Research Center, Cleveland, Ohio.
SOLID ELECTROLYTE RESEARCH
Harvey J. Schwartz 216-433-4000
(502-25-53)

The key to the development of a true high energy density battery for space power and terrestrial electric transportation vehicle applications lies in finding a suitable separator which can keep the reactive electrode materials apart while allowing transfer of ions necessary for the cell reaction. An ideal separator would be a chemically stable solid material which allows free passage of only those ions which are required for the electrochemical reactions. A basic research program will be continued to identify and evaluate potential solid ionic conductors. Candidate materials will be synthesized in pure form and evaluated. Emphasis will be on alkali metal and halide ion conductors in keeping with the long range goal of developing a 150 watt-hour per pound secondary battery.

W73-70299 **502-05-54**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
PLANETARY SOLAR POWER RESEARCH
A. Briglio, Jr. 213-354-6137
(502-25-56)

The objectives of the solar cell junction research are to separate the damage in the space charge region due to proton and electron irradiation from the damage in the base region and to further study the recombination term (second exponential) in the current-voltage characteristics in silicon solar cells. The distinction will be made by irradiating with low energy protons, which cause damage only at a very shallow depth, and irradiating with 1 MeV electrons, which will damage all parts of the cell. Spectral response and dark and light current-voltage curves taken before and after irradiation will give the required data to analyze lifetime degradation in both base and junction regions, and hence, to determine which and to what amount each part contributes to loss of current, voltage, fill factor, and efficiency. The objective of the inversion layer solar cell is to determine the feasibility of forming a depletion layer barrier by induced inversion rather than by impurity diffusion and hence possibly increase the short wave length response. A contract is being let to investigate several means of forming an inversion layer in lightly doped P-type silicon wafers and to form contacts to the device. Spectral response and electrical characteristics including efficiency will be measured as devices are made.

W73-70300 **502-05-55**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
ELECTROCHEMICAL ENERGY STORAGE RESEARCH
A. Briglio, Jr. 213-354-6137
(502-25-57)

The primary objective of this task is to improve battery performance for spacecraft and terrestrial uses through a continuing research and development effort. One element of this task, and the major activity for FY'73, is the investigation of the effects of pulse charging on battery performance. Most batteries exhibit performance problems due to capacity decline, gassing, or dendrite formation. Preliminary experiments and the electrochemical literature indicate that pulse charging will improve battery performance in these areas. The development of more rapid and efficient methods of charging, as well as delaying the onset of certain debilitating changes, will provide direct support to both long and short-term missions and terrestrial applications. The immediate objectives are: (1) to determine the effects of pulse charging on degradative changes in alkaline cells; (2) to develop pulse charging procedures to extend the life of spacecraft batteries; (3) to define the interfaces imposed by integration of pulse charging systems on spacecraft. The

elements of this task will be accomplished by: (1) the determination of the effects of pulse charging techniques on the gassing behavior of sealed nickel-cadmium cells; (2) the determination of the effects of pulse charging on the formation and propagation of dendritic growths on zinc and cadmium electrodes; (3) the development of optimum pulse charging techniques for extending the useful lives of spacecraft batteries.

W73-70301 **502-25-52**
Lewis Research Center, Cleveland, Ohio.
SOLAR CELL TECHNOLOGY
D. T. Bernatowicz 216-433-4000
(502-05-50)

Research and development will be conducted to improve the performance and reduce the cost of silicon solar cells and modules. Results of this program can produce significant reduction in cost of space power and can make solar cells more practical for wider terrestrial applications. The investigations will be in four areas: 1. Novel Cells a. Improved single-crystal wafer cells. These include field-effect cells and epijunction cells as well as more conventional cells made with improved junctions, surface treatments, and lower resistivity material. b. New concepts with potential of great reductions in cost. Deposited polycrystalline and multisphere cells will be investigated. 2. FEP-covered Modules. Development of large modules with conventional cells will continue until they are shown flight-ready. Development will also be started to incorporate wrap-around cells. 3. Flight Experiments. FEP-covered cells and modules will be flown to demonstrate their space worthiness. 4. Terrestrial Applications. Especially attractive terrestrial applications for solar cells will be searched out and demonstration units will be built.

W73-70302 **502-25-53**
Lewis Research Center, Cleveland, Ohio.
HIGH ENERGY CELLS
Harvey J. Schwartz 216-433-6910
(502-05-51)

The broad spectrum of space mission power requirements already known and anticipated dictate development of a variety of electrochemical power sources to meet these needs. Because of the similarity in energy source requirements, most of this same technology development will be directly applicable to terrestrial electric vehicle applications. Major emphasis will be placed on technology leading to an advanced H2-O2 fuel cell system; on improved silver-zinc batteries for 5 year operation in synchronous orbit; new approaches to nickel-cadmium and silver-cadmium battery construction for long-life in low-altitude orbit; and on the application of solid ionic conductors to a 150 watt-hour per pound secondary battery.

W73-70303 **502-25-56**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
PLANETARY SOLAR POWER TECHNOLOGY
A. Briglio, Jr. 213-354-6137
(502-05-54)

The JPL FY 73 Program for planetary solar arrays and solar cell technology development has the following major objectives. 1. Completion of the 100-W/Kg solar array feasibility study. 2. Continuation of the solar array dynamic integration program. 3. Completion of the first phase of the thick-film silicon growth technique investigation. 4. Initiation of a program to develop high-efficiency 4-mil silicon solar cells. 5. Development of a solar cell and module fabrication techniques to improve performance and reduce cost. 6. Continue the program to develop electrical design information for deep-space application. 7. Continue the program to develop the materials property data and analytical modeling techniques to permit design of solar arrays for long-life mission. 8. Initiate a program to develop reliable non-destructive testing techniques to evaluate solderless solar cell modules. 9. Publish a revised edition of the solar cell radiation handbook. 10. Investigate the silane process to determine its feasibility as a method of producing superior silicon solar cell materials. 11. Complete the state-of-the-art Ga As cell evaluation program. This work will be accomplished through combined in-house and contracted efforts with industry and universities. Special consideration in the approach to meeting these objectives will be given to the mission requirements of the solar-electric propulsion effort.

W73-70304 **502-25-57**
Jet Propulsion Lab., Calif Inst. of Tech., Pasadena.
DEEP SPACE BATTERIES
A. Briglio, Jr. 213-354-6137
(502-05-55)

This RTOP is directed toward providing the technologies for various planetary missions, (1) The development of reliable batteries for long-life (3 to 12 year) planetary missions; (2) the definition and resolution of the interfaces consequent from the integration of long-life battery systems in spacecraft; and (3) the continued investigations and development of batteries, which are required in order to improve the performance of battery systems for selected short term (less than 3 years) space missions, and (4) the definition and development of battery technology for planetary entry probes. The objectives have been defined from realizations that the technologies for batteries and interfaces required for long-life missions, such as Jupiter orbiter, Jupiter entry probe, and outer planet missions, are not available and that improvements in battery electrical performance and reliability should be obtained for short-life missions, such as those to Mars, Venus, Mercury, and comets. The elements of this task will be accomplished by: (1) the development of suitable and reliable components, designs, and fabrication techniques; (2) the investigations of the effects of particular environmental conditions on batteries, (3) the securing and evaluation of data from characterization tests of the components, batteries, and battery systems, and (4) the establishment of the controls, technology levels, and procedures required for flight technology readiness. The subtasks titled Development of Nongassing Batteries, and Mission-Dependent Battery Developments and Evaluations are structured to achieve the program objectives.

W73-70305 **502-25-58**
Goddard Space Flight Center, Greenbelt, Md.
BATTERY QUALITY CONTROL AND TESTS
Thomas J. Hennigan 301-982-5547

The objectives are to: A. Advance battery material development, B. Increase the usable energy density of nickel cadmium cells, C. Improve cell and cell component characterization methods and cell fabrication process control, D. Develop analytical methods for cell component analysis, E. Maintain a NASA test facility to perform battery life tests and investigate methods of accelerated testing, F. Investigate thermal properties of sealed cells.

W73-70306 **502-25-59**
Langley Research Center, Langley Station, Va.
THERMAL ANALYSIS AND DESIGN OF THERMAL CONTROL HARDWARE FOR 200 AH NICAD BATTERY
C. H. Nelson 703-827-3745

The objective of this RTOP is to develop the thermal control technology required to build 200 AH batteries for space

use. Experimental 200 AH NiCad cells are being developed on contract No. NAS1-10982 by Heliotek at the present time. Preliminary thermal studies of these cells have indicated that thermal control of large batteries will be a major factor in their design. Heat pipes, or similar devices will be investigated. Since these batteries will be assembled, repaired and serviced while in orbit, special emphasis will be placed on ease of handling. This will be accomplished by modularization of cell and thermal control device into one basic, easily handled and assembled unit.

W73-70307 **502-25-70**

Lewis Research Center, Cleveland, Ohio.

POWER PROCESSING & DISTRIBUTION: COMPONENTS, CIRCUITS, AND SYSTEM TECHNOLOGY

P. A. Thollot 216-433-6228

The objectives of this program are to advance the state-of-the-art and establish the technology required to improve spacecraft power processing & distribution systems. This includes improvement in electrical component and/or device characteristics, electrical circuit performance, and the general optimization of power processing and distribution systems including utilization of integral solar array power regulation and conditioning. In addition to general technology this program has as an objective directed technology for specific applications. Included in this category are: power processing concepts with efficiencies in excess of 90% and power densities of about 2.5 Kg/Kw for ion thrusters; single and multi-module power conditioning units meeting typical space station-base & shuttle requirements; and components and devices such as solid state switches which will meet the space shuttle requirement for remotely controlled circuit breakers. Space station-base & shuttle flight programs and satellites for survey, scientific and communication purposes. Contract and in-house studies, experimental investigations, and hardware fabrication as required to establish the technology of new components, circuits and power processing and distribution systems for manned and unmanned spacecraft.

W73-70308 **502-25-72**

Goddard Space Flight Center, Greenbelt, Md.

POWER PROCESSING FOR EARTH ORBITAL SPACE SCIENCE AND APPLICATIONS SATELLITES

Fred C. Yagerhofer 301-982-4886

Power conditioning developments are investigating techniques to improve power conversion efficiencies and reliability, and also transfer electrical power from an oriented platform such as a solar array or antenna, to a spinning spacecraft. Investigations of synchronous rectifiers, thick and thin film integrated circuits, and the utilization of ferromagnetic air core or ceramic transformers so as to reduce weight and size by increasing the operating frequency of the power conditioning subsystem are proposed.

W73-70309 **502-25-73**

Marshall Space Flight Center, Huntsville, Ala

MULTI-KW DC DISTRIBUTION SYSTEM - EVALUATION AND DEMONSTRATION

J. G. Felch 205-453-4631

(113-60-21)

An in-house and contract program is proposed, oriented to demonstrate the major advantages disclosed by the current study (RTOP 113-60-21) for DC power distribution in excess of 100 volts. A technology test facility for electric power processing, distribution and control will be developed at MSFC This facility will provide for both component and subsystem level dynamic performance demonstration test and evaluation of Multikilowatt DC Distribution System for 28 to 120 VDC, utilizing dynamic source and load simulators.

W73-70310 **502-25-74**

Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.

POWER SYSTEMS AND CIRCUITS DEVELOPMENT FOR PLANETARY SPACECRAFT

Anthony Briglio, Jr. 213-354-6137

This RTOP provides for the development of power processing and distribution and related power system configuration and integration technology for future planetary spacecraft. It develops the necessary capability, techniques and hardware required to produce high-reliability, long-life power systems for RTG-powered outer-planet missions and for advanced photovoltaic powered missions. It also initiates studies to establish power system requirements and identify potential problem areas for nuclear thermionic powered missions. Existing power processing and distribution system technology cannot meet the stringent requirements for many future missions which require extremely long life, low specific weight and immunity from single piece part failure. The fault-tolerance capability presently being developed may have to be further developed to a capability for completely autonomous operation. The work to be done includes: (1) Further development and test of high-quality breadboard power processing and distribution equipment for an RTG-powered outer-planet spacecraft. Effort will be concentrated upon improving previously developed designs and upon obtaining a test history with them. (2) The development of new technology circuit configurations and techniques to improve the performance, reliability and life times of photovoltaic/battery power processing and distribution systems. These developments are necessary to insure that technology is available to meet the requirements of advanced solar powered missions, particularly where an electric thruster is included on the spacecraft. (3) Initial studies to identify power system requirements and potential problem areas for nuclear thermionic powered missions. This will be a preliminary effort to determine what needs to be done to prepare for such a mission.

W73-70311 **502-35-60**

Lewis Research Center, Cleveland, Ohio.

SPACE SHUTTLE H-O APU (WAS FLIGHT CONTROL POWER UNIT)

Donald G. Beremand 216-433-6844

APU's are required on the Shuttle to provide hydraulic power for aerodynamic control-surface actuation and electric power for general vehicle use. Parametric studies were performed and preliminary APU designs were generated under two parallel contracts. A Reference System was then synthesized by Lewis Research Center combining the best features of both. Primary technology requirements were identified to be system dynamic controls in the propellant feed and conditioning subsystem, and hydrogen pump development. Detail analysis, design, fabrication and test of a 400 HP test APU supplied with high-pressure liquid or gaseous propellants are being conducted under Contract NAS3-15708 by AiResearch. This effort includes development of a system computer model to permit ready evaluation of system modifications and parametric changes as required for final application. Two units will be delivered in August of 1974. The liquid hydrogen pump requirement will be pursued initially through evaluation tests of a flight type unit adapted from existing facility type pump technology. In-house effort will be used to provide conceptual designs of liquid H2-O2 supply for the APU.

W73-70312 **502-35-62**

Lewis Research Center, Cleveland, Ohio.

TERRESTRIAL APPLICATIONS OF SOLAR ENERGY

R. L Thomas 216-433-6632

The Terrestrial-Applications of Solar-Energy program is to develop the technology and systems for non-polluting, non-depleting energy sources. The energy sources available are solar--heat and sunlight--and solar derived including the winds, sun warmed ocean layers, and fuel from burning of plants etc. The output of the systems would be energy in the form of electrical power, mechanical shaft power, as fuel such as hydrogen. The initial program consists of evaluating all presently proposed systems and recommending technology and system development plans for the most promising candidates. These systems include space heating/cooling of homes, generation of electrical power (from systems for individual residences to large utility systems of 1000 HWe or more), and production of fuels.

W73-70313 **502-35-64**

Lewis Research Center, Cleveland, Ohio.

ADVANCED H-O POWER SYSTEM TECHNOLOGY

D. G. Beremand 216-433-6844

This activity is directed toward the continued investigation and advancement of Hydrogen-Oxygen Turbine engine technology. This work is in support of advanced H-O Space Power Systems (such as advanced Shuttle APU's) as well as the widening interest in non-polluting H-O ground power systems. Engine applications, designs and technology requirements will be evaluated and an experimental program undertaken appropriate to these technology needs Potential areas of investigation include Stoichometric H-O) engines with water-injection-cooled combustors, utilization of water-cooled turbines, and materials development for hydrogen turbines. The H-O APU will be employed as a test bed for in-house testing of advanced concepts.

W73-70314 **502-07-01**

Ames Research Center, Moffett Field, Calif.

GAS DYNAMICS RESEARCH

Glen Goodwin 415-965-5065

(502-27-01; 502-27-02)

The objectives are to acquire a basic understanding of the characteristics of high energy fluid flows and related aerothermodynamic phenomena, so as to be able to identify and understand potential problems relevant to long lead time NASA mission requirements: To investigate both theoretically and experimentally the kinetic rate processes that occur in high temperature gases; To obtain theoretical predictions of the particulate and continuum dynamics of high-enthalpy gases subjected to force fields and energy sources; To develop computer codes that numerically simulate the complete three-dimensional flow field including viscous effects about entry vehicles. A three-dimensional treatment of coupled vibration-rotation transitions in diatomic gases has been worked out, and a similar approach for pure rotational excitation is being developed. These studies will be extended to include triatomic molecules and the effects of anharmonicity and more precise interaction potentials than the simple exponential models used so far. High speed computers using finite difference, Monte Carlo, and other computer simulation techniques will be applied to solve the equations for the time dependent particulate and continuum dynamics of multi-species gas. The Illiac will be used to obtain more accurate atomic and molecular wave functions to permit a reliable means for estimating optical transition strengths and ultimately the radiative transfer through high temperature gases. The computer codes developed that simulate three-dimensional flow fields including viscous effects will be checked experimentally.

W73-70315 **502-07-01**

Langley Research Center, Langley Station, Va.

GAS DYNAMICS RESEARCH

C. H. Nelson 703-827-2893

(502-27-01; 502-27-02)

The objective of this research is to acquire a basic understanding of the characteristics of high energy fluid flows and related aerothermodynamic phenomena. The intent is to undertake research to identify and understand potential problems relevant to long lead time NASA mission requirements. The objective will be pursued using analytical and experimental methods and will be conducted principally in-house with some contract support. This work will encompass the following topics: (a) Various mathematical models for spectral absorption coefficients will be developed and evaluated for use in flow field calculations. (b) A survey and tabulation of "best available" absorption coefficient data will be performed on contract (c) Analytical study of the dependence of flow field and surface transfer parameters on transport properties, the diffusion model, and surface catalyticity. (d) Shock tube measurements of precursor ionization and election density profiles, very high-temperature phenomena (30,000-40,000 K) in xenon and krypton, and reaction rates for species characteristic of planetary entry probe shock and ablation layers.

W73-70316 **502-27-02**

Ames Research Center, Moffett Field, Calif.

EARTH ORBITAL REENTRY TECHNOLOGY: THERMAL PROTECTION SYSTEMS

Glen Goodwin 415-965-5065

(502-31-50)

New reusable concepts for thermal protection of advanced earth orbital spacecraft wil be studied. The goal is to provide lower weight and cost than current systems and to provide greater cross-range capability. The objective will be accomplished in-house, both analytically and experimentally. Immediate attention will be given to a study of the application of RSI to the shuttle orbiter for cross-ranges up to 3000 nautical miles, and to identify optimum characteristics that RSI should possess. In addition, the following aspects will be investigated: TPS inspectability, structure inspectability, fail-safe characteristics, and optical and catalytic properties of RSI materials.

W73-70317 **502-27-02**

Langley Research Center, Langley Station, Va.

EARTH-ORBITAL REENTRY TECHNOLOGY

C. H. Nelson 703-827-2893

(502-07-01; 502-37-01)

The objective is to develop the aerodynamic and heat protection technology required for design of advanced earth-orbital spacecraft for the late 1980's. The intent is to undertake research to identify promising new concepts which offer, significant advantages over current spacecraft design in areas of performance; stability and control; handling qualities; control systems; and in light-weight, low-cost thermal protection system capability. The objective will be carried out in-house using analytical and experimental methods to examine all phases of atmospheric flight from launch to reentry and landing. Fully reusable orbiter and launch vehicles concepts will be studied to identify configurations and subsystems which might provide advantages in cost, weight, structural design, control system effectiveness, and stability anc control.

W73-70318 **502-27-01**

Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.

PLANETARY ENTRY TECHNOLOGY

Rob R. McDonald 213-354-6186
(186-68-59)

The principal objective of this RTOP is to provide the knowledge required by the designer of an atmospheric entry probe heat shield and structure. The knowledge required for heat shield design is primarily concerned with aerodynamic heat transfer and material response, while the knowledge required for structural design is concerned with aerodynamic loads, inertial forces, and material strength. If by investigating the environmental factors affecting the probe design we can place reasonable bounds on heat transfer, loads, and inertial forces, then excessive heat shield and structure are eliminated. Many research tasks must be completed before the project phase of a Jupiter, Saturn, Uranus, or Neptune atmospheric entry probe may be initiated. The many tasks planned for this RTOP over the next several years are outlined and briefly defined. These tasks nominally fall in one of three categories as to whether it reduces the prediction uncertainties (1) in the aerothermodynamic environment experienced by a probe, (2) in the action of the aerothermodynamic environment on the probe, or (3) in the ablation and thermomechanical response of the probe.

W73-70319 **502-27-01**
Langley Research Center, Langley Station, Va.
PLANETARY ENTRY TECHNOLOGY
C. H. Nelson 703-827-2893
(502-07-01)

The objective of this work is to develop the aerothermodynamic and ablative heat protection technology required to design spacecraft for reentry into the Earth atmosphere and for entry into the atmospheres of Mars, Venus and the outer planets. The intent is to develop a sound base of technology relevant to long leadtime NASA planetary exploration mission requirements. The objective will be pursued using analytical and experimental methods and will be conducted primarily in-house with contract support as justified. This work will encompass the following topics: (a) Studies to. (1) define Earth and other planetary entry vehicle heating and aerodynamic environments and (2) minimize radiative and convective heating rates and optimize aerodynamic performance by choice of trajectory, vehicle shape, heat shield material, etc. (b) Evaluation of heat shield concept and new and available heat shield materials in simulated Earth or planetary entry environments. (c) Development of aerothermodynamic technology required for upgrading of existing facilities or design of new facilities considered appropriate to development of planetary entry aerothermodynamic behavior.

W73-70320 **502-27-01**
Ames Research Center, Moffett Field, Calif.
PLANETARY ENTRY TECHNOLOGY
Glen Goodwin 415-965-5065
(502-07-01; 186-68-51)

The objectives are to develop the aerothermodynamic and ablative heat-protection technology required to design spacecraft for entry into Venus and the outer planets, and to evaluate heat shield design concepts for future space-exploration vehicles capable of entering atmospheres at speeds to 60 km/sec. The work includes aerothermodynamic studies; to define the heating environments to be encountered; to minimize the heating rates and total heat loads by proper choice of trajectory, vehicle shape, and heat shield material; to evaluate available materials in simulated environments including a number of different atmospheric compositions and combined convective and radiative and convective heating loads; to develop new materials tailored to provide maximum heat protection in given environments. Shock tube measurements of radiative emission, radiative cooling, and ionization equilibration time will be performed for hydrogen and hydrogen-helium mixtures at speeds and pressures duplicating the conditions for entry into the outer planets. Heat shield materials capable of the severe entry conditions of the outer planets will be tested in arc jets and their performance evaluated. Realistic computations of the in-depth material response, the entry environment, and the alteration of the environment in the vicinity of the heat shield due to ablation will be made to provide a basic understanding of heat shield performance. Proof of concept for reflecting heat shields has been demonstrated for teflon and boron nitride. Development of more efficient reflecting heat shields will continue.

W73-70321 **502-37-01**
Langley Research Center, Langley Station, Va.
SPACE SHUTTLE AEROTHERMODYNAMICS, CONFIGURATIONS, AND OPERATIONAL ANALYSIS STUDIES
C. H. Nelson 703-827-2893

This RTOP addresses those configuration aerothermodynamic and operational flight mechanics technologies of greatest current concern to NASA in those areas where Langley expertise can be most effectively applied. The RTOP supports the shuttle program by (1) providing time in Langley ground-based facilities for direct OSMF/contractor requested support; (2) continuing to perform independent in-house orbiter design studies; (3) giving full technical support to the Subscale Orbiter program, should it materialize; (4) examining pivotal issues on the ascent configurations such as defining launch vehicle control requirements and developing the technology base needed to analyze abort and normal staging maneuvers; (5) defining operational maneuvers and procedures permitting accomplishment of mission goals with minimum cost and risk; and (6) maintaining a strong basic aerothermodynamic supporting technology program. In addition, Langley will perform independent evaluations and assessments of the contractor's configurations as required. The program represented by this RTOP is coordinated with other NASA Centers through the Aerothermodynamics/Configurations Working Group. The Program Office at MSC looks to LRC for major support in certain critical areas - this effort is coordinated with MSC through weekly conference calls.

W73-70322 **502-37-01**
Ames Research Center, Moffett Field, Calif.
SPACE SHUTTLE: CONFIGURATIONS AND AEROTHERMODYNAMICS
Glen Goodwin 415-965-5065

To evaluate the aerodynamic performance, stability and control, heating and sonic boom overpressures of the space shuttle orbiter and launch configuration, and to pinpoint and find the solution to aerothermodynamic problems of these vehicles in support of the Phase C/D studies. Accordingly, models resulting from contractor and in-house studies will be tested in subsonic, transonic, supersonic and hypersonic facilities of the Ames Research Center. Shadowgraph and oil-flow photographs, flow field pressure surveys, heat transfer and static and dynamic aerodynamic data will be obtained. The wind-tunnel and trajectory data will be used to evaluate the space shuttle characteristics relative to existing airplanes and entry vehicles such as lifting bodies. The effects of realistic gaps, joints, and surface conditions on boundary-layer transition and heat transfer will be determined. Numerical methods and computer programs will be developed for calculating the three-dimensional inviscid and viscous real gas flow around space shuttle orbiter configurations at angle of attack and for calculating the thermochemical response of the upper mesosphere to shuttle launch (except for effects of rocket exhaust) and entry. Near-field pressure signatures of proposed shuttle configurations will be obtained in appropriate ground-based test facilities and trajectory constraints required to limit sonic boom overpressures will be determined.

W73-70323 **502-37-02**
Ames Research Center, Moffett Field, Calif.
SPACE SHUTTLE: THERMAL PROTECTION SYSTEMS
Glen Goodwin 415-965-5065
(502-31-50; 502-31-53; 502-27-02)

Candidate materials for use in space shuttle thermal protection systems will be evaluated to determine performance and to identify failure modes. Samples of candidate materials (metallic and non-metallic) will be tested in arc-jet facilities capable of duplicating a number of full-scale flight conditions. Heat shield materials to be investigated include the nickel, cobalt and columbium alloys, reuseable surface insulators and carbonaceous and polymeric materials. Emphasis will be on the evaluation of materials that require little or no refurbishment. Performance evaluation will include determination of the emittance of the surface and its catalytic behavior regarding surface recombination of dissociated boundary layer species. In order to accomplish these objectives considerable improvements in arc-jet operation will be made. This will include use of the 2' x 9' supersonic duct, increasing the total power and flexibility of the D.C. power supply and increasing the level of enthalpy of the arc jet streams.

W73-70324 **502-37-02**
Langley Research Center, Langley Station, Va.
SPACE SHUTTLE THERMAL PROTECTION SYSTEMS
G. W. Brooks 703-827-2042
(502-31-50)

The objective of this program is to investigate thermal protection systems for the space shuttle in order to assess the adequacy of existing technology and to identify and implement programs required to establish a firm technology base. The work will be accomplished primarily by contract work supported by in-house studies and testing. Three basic classes of heat shields are being investigated: low-cost ablators, reusable surface insulators, and metallic radiators. Parametric studies will be made to provide rational and up-to-date estimates of the weight and cost of heat shields. Large-scale models will be designed, fabricated and tested to validate analytical results and prototype designs. Results of these studies will serve as a basis for selection and design of shuttle thermal protection systems.

W73-70325 **502-03-11**
Goddard Space Flight Center, Greenbelt, Md.
LASER PHYSICS
H. H. Plotkin 301-982-6171
(115-22-08; 160-79-61)

This RTOP is to continue at GSFC the program initiated and monitored by NASA Headquarters, Office of Aeronautics and Space Technology in prior fiscal years. The overall objective is to perform fundamental theoretical and experimental research in the physics of quantum electronics, lasers, masers, and related devices, and in the areas of their application which are particularly related to NASA's interests. The work is performed under grants to four universities, and the requirements and resulting information are coordinated and disseminated among all relevant Centers and elements of NASA. Subjects to be investigated in FY73 will include study of new laser molecules and excitation processes, means for stabilizing lasers, production and transmission properties of ultrashort pulses, infrared mixers and rectifiers, theory of high pressure and high power lasers, and laser spectroscopy of astronomical sources. The results are required in on-going NASA programs and to advance technology needed for optical space communication, earth observations, astrophysics, power generation and transfer, navigation, and materials studies.

W73-70326 **502-03-12**
National Aeronautics and Space Administration, Washington, D.C.
OPTICAL COMMUNICATION RESEARCH
J. K. Meson 202-755-2450
(502-03-11)

This program of research is directed towards providing NASA with fundamental tools and methods of optical communication at earth orbital and interplanetary distances for missions in the 1970-1985 time period. The future requirements for high data rate communication may well be satisfied by optical communication systems using laser technology. This program will advance optical technology by means of two grants for research in laser transmitters, modulators, receivers and optimal communication techniques, and will complement related research and development at NASA field Centers.

W73-70327 **502-03-31**
Ames Research Center, Moffett Field, Calif.
ARTIFICIAL INTELLIGENCE
H P. Klein 415-965-5094
(115-02-02; 115-04-20; 115-23-10)

The objectives of this RTOP are: (1) to improve greatly our ability to manage large amounts of data; (2) to utilize effectively information obtained from a variety of sensory systems; (3) to develop methods to reduce the costs and improve credibility of information processing results. In the near term, the principal goals are the development of: (1) a model of meaningful memory; (2) problem-solving strategies; and (3) question-answering approaches The primary technical approach is the creation of a model for representing information and knowledge. This model will be programmed on a digital computer and will test memory as it affects perception, question-answering and learning. Since an effective method of representation is essential for a successful robot, the results of this study will feed in directly to the ongoing robot project. Current grants and contracts will augment this research and will be redirected, where feasible, to the development of an integrated program. The initial approach is to develop the model based on certain facts of human information processing. However, the model will be self-sustaining as a component in a machine system.

W73-70328 **502-03-32**
Jet Propulsion Lab., Calif. Inst of Tech., Pasadena.
ARTIFICIAL INTELLIGENCE FOR INTEGRATED ROBOT SYSTEMS
R. V. Powell 213-354-6586
(970-83-20; 503-24-01; 502-23-46; 502-33-93; 186-68-55)

The long-range objective of this RTOP is to make a significant contribution to NASA strength in robotics, so that when missions to planetary bodies require adaptive, semiautonomous machines, the necessary conceptual tools and approaches will be available and demonstrable. This goal will be approached through research on how machines should be structured to perform meaningful scientific and operational tasks in a complex, perceptually rich, dynamic environment. The primary short-term objective is to design, construct, and put into operation, by January 1975, an integrated "breadboard" robot system that can be used in subsequent research as a tool for developing, testing, and displaying concepts of robot system design and operation, and of machine intelligence. This work will ensure that the program is sharply focused on problems germane to the long-range interests of NASA and its planetary program. The robot breadboard for January 1975 will be designed for

functions typical of a roving vehicle on the surface of Mars. The primary tasks will be to provide the necessary sensory and motor capabilities, and to integrate these into a well-coordinated system by means of suitably structured software. The performance requirements are that the rover shall be able to move from where it is to a designated location, and to pick up a designated rock from the ground; each of these tasks is to be done safely and without human assistance once the initiating command has been given. To accomplish the tasks, the rover must be able to recognize an irregular object from its surroundings, to plan a path to its objective around obstacles, to pick out a target with its sensors, determine its distance, and recognize it from somewhat different perspectives. Many of these capabilities will require advances beyond the present state of the art, particularly in the area of perception.

W73-70329 **502-03-33**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
STUDY TO GENERATE A NASA SOFTWARE RESEARCH PLAN
R. V. Powell 213-354-6586

The basic objective of this study is to develop a plan for software research within NASA. This plan will identify important software problems and the activities needed to solve them. It will detail work units, their priorities, and recommended funding levels. The study will assess NASA software scope and the state-of-the-art as ingredients to the plan. The study will be approached through several survey techniques and will emphasize quantitative measures of potential pay off from proposed research activities. The study will involve major NASA centers to gather and verify facts about their software activity, to identify and define problems, and to generate research recommendations. Other government agencies, universities, and industry will also be surveyed as required. An important element of the study will be a software conference/workshop to speed factfinding and to initiate inter-center discussions of software generation technology problems.

W73-70330 **502-03-51**
Langley Research Center, Langley Station, Va.
ELECTRONIC MATERIALS AND PROCESSES
G. B. Graves 703-827-3745

Research in selected areas of electronic materials and processes will be conducted. Analytical studies and laboratory investigations of materials with potential application in new electronic devices to meet future aerospace mission requirements will be emphasized. Research contracts will be used to further develop these materials in a form suitable for device development. Current efforts on electronic materials include research on organic materials and layered ferroelectric materials with controllable indices of refraction for application as the storage medium in optical mass memory systems under development by NASA for earth resources satellites and space station/base. New materials and processing techniques will be investigated for the development of a high resolution, modular, two color, monolithic array of light-emitting diodes and an x-ray addressed liquid crystal matrix device for application in aircraft and spacecraft display systems.

W73-70331 **502-03-52**
Langley Research Center, Langley Station, Va.
ELECTRONIC DEVICES AND COMPONENTS
G. B. Graves 703-827-3745

Research programs leading to the development of electronic components and devices from new materials and processes will be conducted. The primary objective is to investigate those technologies which can provide increased performance in spacecraft and aircraft data handling systems with new electronic devices and components that have improved reliability. Theoretical and experimental research will be conducted in-house to demonstrate feasibility of device and component concepts. Also, research contracts will be implemented to further develop and refine new electronic devices and components. Areas of research which are being currently emphasized are: the investigation of Epitaxial Garnet Films for Bubble Domains for Application in High Density Memories; the Development of Charge Couple Devices for Shift Registers and Photo-imaging Applications; the Development of Improved Complementary MOS Integrated Circuits; and the Development of Solid State Photosensor Arrays for Planetary Imaging and Spectrometry.

W73-70332 **502-03-53**
Langley Research Center, Langley Station, Va.
SOLID STATE SENSORS AND PROCESSING TECHNIQUES
G. B. Graves 703-827-3745
(502-01-03; 502-33-86; 502-03-51)

The objective is to develop an advanced solid state sensor and component technology leading to improved devices for aerospace vehicle and earth observation applications. This will be accomplished through research of new solid state materials and processing techniques and the subsequent development and application of these new concepts to prototype devices. Emphasis will be placed on the exploitation of solid state characteristics and processing techniques which provide advantages over existing technology, e.g., size, reliability, sensitivity, efficiency, bandwidth, and high temperature operation. Specific technology areas to be investigated include: metal alloy and semiconductor strain gages with improved gage factor and high temperature characteristics; radiation and ion implantation doped, semiconductor, infrared detectors and imagers with increased detectivity and extended long wavelength response; calibration techniques and high spatial resolution ion detector for mass spectrometry; ion implantation doping of II-VI and III-V compound semiconductors with improved electro-optical and high temperature properties, and diagnostic techniques for assessing new material properties, processing techniques and prototype device performance

W73-70333 **502-23-41**
Langley Research Center, Langley Station, Va.
EARTH-ORIENTED ATTITUDE REFERENCE
G. B. Graves 703-827-3745

The overall objective of this work is to develop technology and sensors for pointing and navigation of earth-oriented, orbital spacecraft. An IR horizon sensor head, with an indicated accuracy of 0.015 deg to 0.03 deg, will be developed to the level of a flight prototype model. Laboratory equipment and techniques to calibrate and evaluate the sensor will be developed. A combining-logic module to combine four IR horizon sensor heads into an operational attitude determination system will be designed and breadboarded. Analytical error studies of the 4-sensor configuration indicate a local-vertical measurement accuracy of 0.005 deg to 0.008 deg (1 deg) is achievable. This work will provide an improved horizon sensor for application in pointing and navigation of earth orbital vehicles, including shuttle sortie pallets, shuttle launched research and applications modules, and advanced applications satellites.

W73-70334 **502-23-42**
Marshall Space Flight Center, Huntsville, Ala.
INERTIAL COMPONENTS

B. F. Walls 205-453-0793
(115-17-05; 125-17-14)

Develop and evaluate a three-axis strapdown inertial navigation system using operational laser gyros with minimal weight, size, and cost. Continue the laser gyro development work in order to increase the tube life and decrease the electromagnetic sensitivity. Determine the environmental capabilities, and the necessary improvements required to make the gyro meet spaceborne and airborne specifications. Continue evaluation of the three-axis laser gyro configuration, and investigate the feasibility of flight testing this configuration in conjunction with NASAs fly-by-wire or automated VTOL avionics program.

W73-70335 **502-23-43**
Goddard Space Flight Center, Greenbelt, Md.
ADVANCED COMPONENTS FOR PRECISION CONTROL SYSTEMS
H. E. Evans 301-982-5194

This task covers research, design and evaluation of cost effective advanced control and stabilization components and related control circuitry for precision pointing applications and long duration missions. Components and control systems for both earth orbital and interplanetary applications are included. For precise pointing systems, prototype components and control systems will be developed to extend bandwidth and eliminate hardware limit cycling by using unique designs that minimize pertubating forces due to friction, wear, thermal effects and transmissability. The ultimate objective of this work is a system pointing accuracy of 0.01 second of arc and an operating life of ten years. Component technology advancements include the technical breakthroughs in the areas of electronic commutation and magnetic suspension techniques. These concepts are integrated into cost effective precision component designs such as long life bearings (magnetic, hydrodynamic), isolation systems, and advanced motors and actuators. Speed and position control systems compatible with these new concepts form part of this work. Results of this work directly supports unmanned earth orbital and planetary missions and the manned Space Station and Shuttle programs.

W73-70336 **502-23-44**
Langley Research Center, Langley Station, Va.
ADVANCED SPACECRAFT AND EXPERIMENT CONTROL SYSTEMS
G. B. Graves 703-827-3745
(909-71-08; 909-74-35; 502-23-41)

Technology will be developed to permit the design of cost-effective spacecraft and experiment control systems for earth orbital missions. Simulations will be made of new and existing control concepts for earth orbital vehicle/missions in order to determine required system and component performance. Effective system configuration, low-cost system integration, multipurpose operation, and component standardization will be used to reduce system and component costs while achieving required performance. Control software and hardware needs will be defined and development efforts undertaken. Critical hardware elements will be carried through prototype development to establish feasibility. This effort is directly coordinated with GSFC, MSC, MSFC, and JPL GSFC developed components will be integrated into Langley control actuator hardware.

W73-70337 **502-23-45**
Manned Spacecraft Center, Houston, Tex.
EOS/SPACE STATION/FLEXIBLE SPACECRAFT SIMULATION PROGRAM
C. F. Lively, Jr. 713-483-3256

The objective of this task is to complete the development of a digital computer program which simulates the motion of a controlled, multibodies flexible spacecraft subjected to environmental disturbances and prescribed forces and torques. The total motion of the flexible spacecraft will be represented as a superposition of linear elastic deformations upon arbitrary, nominal large displacements of the structure where it is modeled as a system of interconnected rigid bodies. The simulation will provide for orbital dynamics, rigid body dynamics, flexible body dynamics, environmental disturbances, control systems, and their interactions. Versatility in the modeling of vehicle characteristics is achieved by treating the system of interconnected bodies as a general topological tree and includes the capability to model various candidate control system design concepts.

W73-70338 **502-23-46**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
EXTENDED LIFE ATTITUDE CONTROL SYSTEM (ELACS) FOR UNMANNED PLANETARY VEHICLES
Robert V. Powell 213-354-6586
(186-68-54)

The long range objective of "Extended Life Attitude Control System" (ELACS) is to develop and demonstrate a spacecraft control concept that is applicable to a wide range of unmanned, planetary missions, such as outer planet flybys and orbiters, atmosphere probes, landers, sample and return, and combat or asteroid rendezvous. In combination, these missions demand improvements in technology for longer life, improved accuracy, lower weight, less power, and greater cost effectiveness. It is also the goal of ELACS, to produce technology advancements that can be utilized by other space programs. The approach depends upon the concept of a programmable processor capable of being programmed to meet the requirements of the different individual missions and vehicles The processor must be hybrid in order to interface with both analog and digital inputs and outputs. It is designated "Hybrid Programmable Attitude Control Electronics" (HYPACE). New technology advances must be made to assure that there will sensors, actuators, and reaction devices to provide the inputs and outputs demanded by the processor, to accomplish a particular mission. Analytical formulations are required for control laws, system integration, and dynamic analysis. Increased autonomy is a necessity due to communication distances. This, together with the long life requirements, demands that reliability be improved at both the device and system level. But, since absolute reliability is impossible to achieve, failure tolerant designs must be incorporated at both the device and system level. The culmination of these activities will be a demonstration of breadboard hardware, as a complete system, on a gas bearing spacecraft simulator.

W73-70339 **502-23-31**
Marshall Space Flight Center, Huntsville, Ala.
OPTICAL MASS MEMORY
Earl J. Reinbolt 205-453-3770
(115-23-40)

The long range objective of this RTOP is to design, develop and demonstrate a new optical mass memory technology having read-write capability, 10 to the 12th power bit capacity and power, speed, size and weight characteristics compatible with anticipated requirements for in-flight space use in the late 1970's. During FY '73 the following efforts will be pursued: 1. An existing breadboard, used in conjunction with computer simulation programs, allows evaluation of alternative optical systems, storage media, and other characteristic "subsystems" or subtechniques will be refined. A program is in use currently. The interfacing of the breadboard with an existing computer

system is planned for '73. 2. Investigations of "page composer" techniques and materials will be continued. 3. Investigations of storage materials, particularly thermoplastics, lithium niobate and photopolymers will be continued. 4. Investigation of the optical systems and techniques will be continued. 5. A design improvement is underway to update the present holographic memory breadboard system to 10 to the 8th power bits. A demonstration of the system updated to 10 to the 6th power bits, using improved techniques, components and materials is expected late in FY '73. 6. Iron-doped lithium niobate is showing promise as a storage material, and for use in the page composer is expected to be completed in FY '73 will be evaluated, using the breadboard.

W73-70340 **502-23-32**
Goddard Space Flight Center, Greenbelt, Md.
AUTOMATED DATA HANDLING TECHNIQUES AND COMPONENTS
D. H. Schaefer 301-982-5184

Operational Earth Resource missions will sense a very large number of images in many spectral regions. It has been estimated that sensors may be receiving inputs at a total rate equivalent to 10 to the 12th power bits per second. In order to effectively utilize this avalanche of information, data reduction on-board the spacecraft must be performed. The focus of this RTOP is to develop methods of on-board analysis of data generated in Earth Resource missions The development of these methods should also assist other NASA missions including missions around planets other than the Earth. Three tasks will be undertaken. The first is the development of "parallel" image processing systems. Such systems process all points of an image simultaneously. Technologies capable of performing such processing include coherent optical techniques, non-coherent optical techniques, advanced large scale integration techniques and techniques involving electron optics. The emphasis will be to develop automatic image processing systems that can accept an image directly as an input and, in a parallel manner, process this image to obtain desired information. Such systems may well combine several types of parallel image processing techniques into a single piece of hardware.

W73-70341 **502-23-33**
Manned Spacecraft Center, Houston, Tex.
CENTRAL MULTIPROCESSOR AND MAN/MACHINE TECHNIQUES
E. A. Dalke 713-483-4065
(115-25-02; 908-51-33; 115-23-40; 977-41-33)

The objective of this development is the laboratory prototype demonstration of an advanced information management system employing the Shuttle and candidate payloads as the baseline configuration The scope of this demonstration will encompass multiprocessing and redundancy back-up, high order language, crew interfacing, payloads and vehicle system data acquisition and control interfaces, onboard information handling and ground support operation. This will utilize the fault tolerant onboard multicomputer/multiprocessor system being defined and implemented as part of this RTOP during FY-72. This activity will provide a long-term RTOP effort to design and implement a fault tolerant system tailored to representative automated payloads, sortie cans and advanced orbiting vehicle operational processing. A laboratory prototype system will initially be implemented using the most advanced available aerospace computers (to be acquired with FY-72 funds) and multipurpose display (FY-71 RTOP), a new multicomputer interconnect/data bus system (FY-73 non-RTOP funds) & a new data acquisition and control system and peripherals (FY-74 RTOP funds) as the basic development system. The final phases will involve the laboratory demonstration of overall system concept to evaluate the new technology developed & including a projected crew station environment utilizing advanced software techniques for information acquisition and handling.

W73-70342 **502-23-11**
Goddard Space Flight Center, Greenbelt, Md.
MICROWAVE NEAR EARTH COMMUNICATIONS AND TRACKING
V. R. Simas 301-982-4654

The objective of the work under this RTOP is to achieve technological advances in communication and tracking systems in order to satisfy the demanding communication requirements for future space flight projects, such as Space Shuttle, Earth Observation Satellite (EOS) Program and TDRS. The capability and performance requirements on the communication links for these advanced projects are characterized by high data rates (100-MHz bandwidth), simultaneous multi-link operation, and reliable long life operation. The attainment of these parameters will require technological advances in both Spacecraft and Ground Terminal techniques and hardware. (1) High power (10 watt) efficient solid-state signal sources at Ku-band will be developed. This will circumvent the liabilities associated with vacuum tube TWTS, namely limited life, size and weight, and high voltages. (2) In succeeding generations of spacecraft programs, the antenna requirements are envisioned to continue to increase. The demand for wider bandwidths will drive the operating frequency higher and will require large antenna areas with attendant narrow beams resulting in pointing difficulties. Simultaneous multiple beams will probably be required for some spacecraft which will compound the antenna problem. Phased arrays may be the only type of antenna capable of meeting future requirements. Continuing growth of microwave solid-state circuitry makes the realization of spacecraft phased arrays feasible. Reflect arrays have power and weight advantages compared to other phased array techniques, thus, this area is being pursued first.

W73-70343 **502-23-12**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
MICROWAVE TECHNIQUES AND COMPONENTS
R. V. Powell 213-354-6586
(502-22-05; 502-33-92)

This RTOP develops microwave techniques, components, and subsystem technology for planetary communication and tracking applications in the 1977-1987 decade. Missions flown during that period require new subsystem capability, in order to provide useful data at reasonable risk, cost, and lead time. The goal is to develop microwave techniques and components for all the communication and tracking functions of a wide variety of possible missions, especially missions operating in new and partially unknown environments hostile to communication. For this reason, the technology devised here is to permit maximum commonality from mission to mission, so as to reduce mission lead times and provide flexibility in mission mix planning. During FY'73, techniques and components will be sought which increase data rates in severely data rate limited situations. Components for the Venus-Mercury '73 S/X Experiment will be delivered to the project. Spacecraft absorption concepts compatible with the multimission approach will be designed to permit the pointing of high gain spacecraft antennas to Earth, or of entry probe and relay bus antennas to each other. A hybird analog/digital implementation of the lowest frequency spacecraft transponder tracking loop will be demonstrated. Microminiature spacecraft radio technology will be assessed for spacecraft and probe use to increase reliability and reduce fabrication costs. A 4.3m unfurlable spacecraft X-band antenna will be demonstrated. Lens

antennas will be evaluated for planetary entry and relay use. Analytic and experimental techniques will be developed for coping with signal attenuation through dense planetary atmospheres. Work on antenna breakdown in Earth's atmosphere will be extended to cover absorption. Conceptural antenna designs for planetary entry will be conceived so that pointing problems can be assessed and crude data rate estimates made for various planets.

W73-70344 **502-23-13**
Ames Research Center, Moffett Field, Calif.
CODING FOR SPACE COMMUNICATION
J V. Foster 415-965-5083

The objective is to develop error detection/correction coding techniques applicable to telemetry links with requirements for data rates greater than 15 Mbps. Develop proof-of-concept hardware to determine extent equipment performance departs from theoretical predictions. Investigate the feasibility of extending the performance to greater than 50 Mbps. For low data rate deep space telemetry, study the requirements for mechanizing the recent developments in concatenated codes which show promise of providing additional system gain. Complete the development of prototype decoding, encoding, and channel simulation equipment being assembled for the high data rate telemetry coding system. Evaluate the system performance, including maximum data rates and gains. Investigate availability of circuit components for extending system rates to greater than 50 Mbps. Perform a design study for implementation of a concatenated block and convolutional/Viterbi decoding system for potential application to deep space telemetry.

W73-70345 **502-23-14**
Goddard Space Flight Center, Greenbelt, Md.
TECHNOLOGY FORECASTING FOR SPACE COMMUNICATIONS
Ford Kalil 301-982-2357

The Networks Directorate interfaces with all space programs and provides recommendations to new programs regarding telecommunications and related systems for the most efficient ulitization of existing and projected ground networks capabilities with minimum augmentation. These recommendations must especially consider the spacecraft systems whose implementations could be impractical or more costly than augmenting the ground systems. The Networks Directorate recommendations must consider the overall telecommunications system from the viewpoint of both the spacecraft and the ground. Hence, the purpose of this RTOP is to: (1) Provide the Networks Directorate with current and projected state of the art performance for parameters, components, and systems used in space electronics, in particular space telecommunications and integrally related systems; and (2) Provide cost-effectiveness evaluations for different component and system configurations based on a broad range of mission profiles. Provide continuous computerized review of technology and techniques used in space electronics with emphasis on telecommunications and related systems, subsystems, and components. Evaluate the present state of the art and provide meaningful technology forecasts in several areas such as: power sources, modulators, detectors, data processing components, antennas, and optical apertures, acquisition, and tracking/ pointing, prime power (power supplies), weight and thermal factors, lifetime, efficiencies, optimizations and cost effectiveness of practical configurations related to various actual and projected mission requirements.

W73-70346 **502-23-15**
Goddard Space Flight Center, Greenbelt, Md.
OPTICAL COMMUNICATIONS AND TRACKING
Walter J. Carrion 301-982-4942

Program conducts studies and develops technology of components, systems, and operational techniques for spacecraft communication and tracking with lasers. Optical technology is directed toward satisfying NASA's needs for precision tracking and high data rate communication in the 1975 to 1985 era. Using latest developments from continuously changing state-of-the-art, proof-of-concept models of laser transmitters, receivers, modulators, and telescopes, are designed and constructed. Performance of components and systems is measured in laboratory and field stations under conditions in which effects of environmental perturbations such as atmospheric propagation, acoustic vibration, and solar radiation background can be studied, leading to theoretical systems analysis and selection of optimum components and parameters. Prototype tracking and communication terminals are developed and employed in experiments with satellite equipment such as passive reflectors, laser detectors, and radiating sources; in order to prove concepts and provide baseline data for specific application designs. GSFC emphasis is on development and evaluation of complete operational systems needed for space laser applications. Fundamental research in devices, component operation, control systems, and environmental properties are performed when necessary for direct support of system development, test, and analysis.

W73-70347 **502-23-16**
Marshall Space Flight Center, Huntsville, Ala.
AIRBORNE VISIBLE LASER OPTICAL COMMUNICATIONS (AVLOC)
Joseph L. Randall 205-453-3770
(115-22-05; 975-75-49; 755-43-11)

The purpose of the experiment is to establish a two-way laser communications link with one end of the link located at the MSFC Madkin Mountain Optical Tracking Station, while the other end will be packaged in the belly of an RB-57F aircraft orbiting over Madkin Mountain at 50,000-70,000 feet. Initial acquisition of the corresponding laser beams (blue-green argon laser beam uplink, red helium-neon laser beam downlink) and continuous, closed loop tracking of the same is required within the experimental procedure. The optional communication modes will include a 30-megabit psuedo-random coded data link. The objectives of the experiment are: (1) Evaluation of optical acquisition and tracking techniques, as well as optical communications systems performance in an aerospace environment, and (2) determining turbulence effects on laser beams propagating vertically through the atmosphere. The Ground Station and the airborne equipment are being completed in FY '72. The FY '73 effort will consist of completion of the Flight Experiment Program and analysis of the data.

W73-70348 **502-23-21**
Marshall Space Flight Center, Huntsville, Ala.
LARGE TELESCOPE TECHNOLOGY
Joseph L. Randall 205-453-3770
(115-22-09)

The objective of this effort is to establish the basis for a flight demonstration of a three-meter, diffraction-limited optical telescope. During fiscal year 1973 the following efforts will be pursued: 1. Studies, using a 0.5 meter segmented mirror system and a 0.5 meter deformable mirror system will be continued to prove primary mirror figure control techniques and systems 2. The studies above will be enlarged to incorporate testing of the 58-actuator mirror developed by the Langley Research Center. 3. Efforts to improve automation of the control systems to maintain optical figure will be continued. 4. The structural and thermal characteristics of a mechanically-actuated and a

thermally-actuated mirror will be investigated analytically and through simulation studies.

W73-70349 **502-23-51**
Marshall Space Flight Center, Huntsville, Ala.
DESIGN, PROCESSING AND TESTING OF LSI ARRAYS
D. L. Anderson 205-453-3770
(115-25-02)

The overall objective of this effort is to develop technology and automated techniques for the design, processing and testing of large scale integrated circuit arrays having predictable, long operating lifetime. This program includes two major tasks (1) the investigation and development of automated techniques for the design, processing and testing of large scale integrated circuit arrays, and (2) the development and evaluation of new technologies which offer improved performance and reliability for microelectronic devices. Automation of design and testing is well advanced, so the major effort in this area will be in automating wafer processing. New technology development will be directed at improved performance and long life. The work performed under this program will be closely coordinated with, and complement, the work being conducted on predictable long-life microelectronics at the Jet Propulsion Laboratory and Langley Research Center.

W73-70350 **502-23-52**
Marshall Space Flight Center, Huntsville, Ala.
SCREENING AND RELIABILITY TESTING OF MICROCIRCUITS AND ELECTRONIC DEVICES
L. C. Hamiter 205-453-3986

To develop approaches for assessing and assuring predictable long operating life of microcircuits and other electronic devices used in aerospace applications. These activities will be directed toward two major task areas: a. Studies will be conducted to identify long life failure mechanisms that can be eliminated through device redesign, improved process technology, or better application restraints. Complementing these studies will be programs to implement the recommended corrective actions. b. Techniques will be developed for predicting and assuring long life operation of microelectronic devices. This will include new and improved criteria and procedures for qualification, screening and testing along with new approaches to understanding device physics of failure. These tasks will be closely coordinated with the Predictable Long Life Microelectronics Program at JPL. Much of the effort will be performed in-house utilizing the capability of the recently established LSI Laboratory.

W73-70351 **502-23-53**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
PREDICTABLE LONG-LIFE COMPONENT TECHNOLOGY
R. V. Powell 213-254-6586

This effort is to provide a major segment of the technology necessary to achieve long-lifetime microelectronic devices of predictable life characteristics. The JPL objective is a meaningful part of the more encompassing NASA goal to attain predictable long-lifetime microelectronic devices. The more-focused JPL near-term objectives are contained in Block 15, Operating Plan. A series of Inter-Center planning meetings and reviews (Langley, Marshall and JPL) has resulted in the following: Identification of the tasks to be accomplished in order to achieve the predictable long-lifetime goal. Establishment of priority criteria. Application of the priority criteria to the list of tasks to be accomplished. A preliminary assignment of task areas to individual NASA Centers has been made.

W73-70352 **502-23-54**
Goddard Space Flight Center, Greenbelt, Md.
ASTRONOMICAL SENSORS AND IMAGING SYSTEMS FOR LARGE SPACE TELESCOPES
Lawrence Dunkelman 301-982-4988
(188-78-57; 188-78-58; 502-33-94)

The purpose of this effort is to develop high performance optical image recording system(s) for advanced astronomical space telescopes. As a corollary effort it is planned to develop holographic reflecting gratings. These gratings are desired because the low scattering properties present information of higher fidelity. In order to realize the observational potential of the Large Space Telescope, current technology must be modified, extended, and improved to provide the full range of detectors required. Emphasis is placed on electro-optical detection techniques in order to provide high quantum detectivity, desired spectral response and the capability of electronic readout. Other characteristics such as resolution, format, magnification, and image control must be matched to space telescope instrumentation requirements which are being developed simultaneously. These techniques in conjunction with real-time image processing are used to enhance the system performance and increase the design capability of the space telescopes. Also it is planned to develop, through light interference phenomena, spaceflight qualified reflecting diffraction gratings that exhibit optical/mechanical properties which in the 20 to 1100A spectral region are superior to mechanically ruled diffraction gratings. Spectral information is to be isolated by the development and applications of diffraction gratings produced by holographic techniques. Stigmatic imaging, dispersion and effective working focal ratio are some of the characteristics which must be matched to a detection system. A most important characteristic of holographic gratings is the low level of scattered radiation which would permit photometric analysis of dim objects. Another important characteristic is the elimination of "ghosts" (cont.)---

W73-70353 **502-23-55**
National Aeronautics and Space Administration, Washington, D.C.
ELECTRONIC DEVICE AND SYSTEMS SUPPORT
C. E. Pontious 202-755-2440

The objective of this program is to provide effective coordination of NASA sponsored research and development efforts on electronic devices and systems with similar work supported by the DOD and other government agencies. Through associate membership on the Advisory Group on Electron Devices and its constituent Working Groups, NASA program managers receive expert advice on the feasibility, currency and soundness of planned R&D procurement activities, long range R&D requirements, complementary work in other government agencies, and forecasts of new technical developments.

W73-70354 **502-23-56**
Langley Research Center, Langley Station, Va.
LASERS FOR REMOTE SENSING
G. B. Graves 703-827-3745
(160-44-64; 502-03-53)

The basic objective of this research is to develop laser technology which relates to NASA research programs and requirements in remote sensing of earth and planetary environments; optical ranging and altimetry; and optical data processing and storage techniques. Technology areas to be investigated are: (1) an airborne hydrographic lidar system for measurement of ocean depth, fertility, and turbidity; (2) continuously tunable infrared diode lasers for high resolution absorption and emission spectroscopy of low concentration atmospheric constituents; (3) lasers and laser systems for use

in relating laser scattering, absorption, and fluorescence measurements to constituent distributions in the atmosphere and bodies of water; (4) diode lasers with visible emission and improved performance for use in spectroscopic instrumentation, optical ranging, and optical data processing systems where small size, coherence, efficiency, and reliability are primary constraints. This work will be accomplished through a combination of in-house, grant, and contract effort.

W73-70355 **502-33-81**
Ames Research Center, Moffett Field, Calif.
SYSTEMS CONCEPTS FOR NAVIGATION, GUIDANCE AND CONTROL DURING APPROACH AND LANDING.
Leonard Roberts 415-965-5066
(909-72-48)

The objective is to develop a technology base to aid the establishment of design criteria for shuttle approach and landing navigation guidance and control systems. The program includes analysis, limited flight simulation and flight tests. In FY 72, analysis and simulation continued in-house and flight tests of radio ground ranging navigation aids were conducted using the CV-340 aircraft. In FY 73, limited analysis and simulation will continue but the emphasis will shift to flight evaluation of a shuttle system concept. Analysis and simulation for FY 73 includes: a. Limited examination of the automatic/manual control system interface. b. Examination of the performance of the blended INS-ILS/VORTAC system concept. An advanced airborne digital avionics system has been installed in a NASA CV-990 aircraft. The flight program for FY 73 is a 50-hour test program using this CV-990 to investigate automatic and piloted landing system concept (INS-ILS/VORTAC) performance to confirm navigation, guidance and control system performance obtained from analyses and simulation. These flight tests will duplicate as nearly as possible the shuttle trajectory and performance from about 40,000 feet to touchdown.

W73-70356 **502-33-82**
Flight Research Center, Edwards, Calif.
A VEHICLE STATUS AND MONITORING SYSTEM
J. E. Love 805-258-3311

The objective is a state-of-the-art system designed for monitoring and continuous inflight recording of parameters which determine the operational status of a vehicle will be flight tested in a high performance jet aircraft. After each flight, a quick analysis is performed by computer processing of the digitized magnetic flight tape. Operational discrepancies are detected and identified when sensed quantitied exceed predetermined thresholds as inserted into the computer for analysis. The tape also serves as a history of operation from which predictions of malfunction or failure can be made from long-term (several hundred hours of flight) parametric trend analysis. The flight experience and data accumulated will provide basic information for system requirements for the Space Shuttle vehicle to achieve short turnaround time by automatic system testing, fault location, and checkout. The objective is also to demonstrate the ability to refly the engine-inlet system based upon data from the last flight with little or no formal ground preflight of that system.

W73-70357 **502-33-83**
Langley Research Center, Langley Station, Va.
SPACE SHUTTLE: ANTENNA TECHNIQUES AND MATERIALS
G. B. Graves 703-827-3745

Critical antenna technology will be developed to meet the requirements imposed by structural design considerations, thermal conditions, and the overall reentry environment of the Space Shuttle. The reuse capability of RSI (Reusable Surface Insulation) and antenna window materials will be determined by measuring the dielectric properties of these materials after repeated thermal cycling. Antenna designs will be developed which use these materials in layers to reduce antenna temperatures. Analytical techniques, with experimental verification, will be used to determine optimum antenna locations and the effects of RSI and antenna window materials on antenna performance.

W73-70358 **502-33-84**
Langley Research Center, Langley Station, Va.
HIGH TEMPERATURE SENSORS
G. B. Graves 703-827-3745

The objective of this work is to develop measurement techniques and instrumentation to determine the effect of the reentry environment on structures used in the Space Shuttle. Specific efforts will be made to develop heat transfer sensors, wire strain gage measurement methods with extended upper temperature performance, and dynamic displacement instrumentation for analyzing the performance of candidate panel designs under both vibration and thermal loads. This work is essential to the development of efficient load bearing structures which meet the aerodynamic requirements and can withstand repeated high temperature exposure without imposing severe weight penalties on the vehicle.

W73-70359 **502-33-85**
Manned Spacecraft Center, Houston, Tex.
SPACE SHUTTLE INSTRUMENTATION/SENSORS
A. J. Farkas 713-483-2848
(125-24-20)

The object of this program is to develop the technology, to design, to fabricate and/or modify, and to test and evaluate Space Shuttle Instrumentation for use in zero g. The object of this task is to develop the technology, to design, to fabricate, and to test a feasibility model of a zero g sensor using nuclear techniques which can be adapted to a variety of measurement requirements. The approach will be to increase the accuracy of the present gauging system and to increase the response time of the system to provide for continuous readout of quantity for quantity management. A reduction in source strength will be sought to reduce system weight by using a more sensitive detector material or by optimizing the present detector material's performance. The system interface electronics, source strength, detector/source matrix, and tank geometries will be investigated to define a computer model which will allow optimization of these parameters for different density fluids. The objective of this RTOP is to develop a measurement system for determining the energy available from and the general "health" of chargeable batteries. The measurement system, by making charge and discharge current measurements along with cell voltage, temperature, etc., will provide a direct rather than ground computer calculated measurement of battery charge and "health". The battery status measurement system design will incorporate the technology being advanced by Chrysler Corporation for ground based systems.

W73-70360 **502-33-86**
Marshall Space Flight Center, Huntsville, Ala.
SHUTTLE SENSORS AND INSTRUMENTATION
W. T. Escue 205-453-4626
(115-24-05; 502-33-85; 501-23-33)

The technology being conducted in the areas of air data sensors, zero "g" quantity, gas analysis and propellant utilization/loading sensors is an extension of work being conducted

under RTOP 115-24-05. FY-73 technology will continue in respect to the final space shuttle configuration requirements. Acoustic emission techniques will be pursued for application to on-board incipient failure detection and monitoring of: (1) stress corrosion, (2) crack propagation, (3) structural integrity, (4) hydraulic, propellant, and hydraulic leaks, and (5) peak acceleration and pressure measurements.

W73-70361 **502-33-87**
Langley Research Center, Langley Station, Va.
MANNED SPACE SHUTTLE: MICROWAVE AMPLIFIERS FOR SPACE SHUTTLE VEHICLE
G. B. Graves 703-827-3745

Highly efficient and reliable microwave power amplifiers for the communication subsystem of the Space Shuttle vehicle will be developed at C-band frequencies utilizing presently available techniques and basic tube designs. These tubes will be compatible with the vehicle transmitters used in conjunction with the Intelsat IV satellite relay communications system. The tubes will have a nominal power output of 100 watts and can be used for power outputs in the 20 to 100 watt range. The engineering models resulting from this effort will be suitable for specific system design and would form the basis for subsequent qualification and life test programs

W73-70362 **502-33-88**
Goddard Space Flight Center, Greenbelt, Md.
SPACE SHUTTLE LOW NOISE RECEIVER
P. H. Dalle Mura 301-982-5036

The space shuttle communications through synchronous satellites will require increased antenna sizes or more sensitive receiving systems. Since re-entry is a factor, it is obvious that the latter area of concern should be developed. It is the objective of this RTOP to develop comprehensive space qualified paramp technology at S-band, C-band, and Ku-band. The paramp developments will employ hybrid microwave integrated circuits to achieve an advanced degree of miniaturization. All-solid-state components will be utilized both to enhance size and weight reductions and to significantly improve operational reliability. The paramps will be thoroughly tested for suitability of operation in a space environment. The C-band paramp will have a noise figure less than 2 db and thereby significantly reduce the size requirement of the antenna. The development effort will be primarily contractual with some effort performed in-house. This unit will be completely developed from breadboard stage through a space qualified design. The S-band paramp will have a noise figure of 1.5 db and a bandwidth of 100 MHz. The complete development will carry through to a space qualified design. The Ku-band paramp will have a noise figure of 1.8 db and a bandwidth of 500 MHz. It will employ high cutoff chip varactors to achieve this exceptional performance. A space qualified design will be produced at the conclusion of the program.

W73-70363 **502-33-91**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
GUIDANCE AND NAVIGATION FOR UNMANNED PLANETARY VEHICLES
R. V. Powell 213-354-6586
(502-23-46; 502-23-12)

The objective of the deep space navigation is the delivery of the spacecraft to the target with an accuracy resulting in the achievement of mission objectives. Future candidate missions in the late 1970's - 1980's may have their objectives seriously compromised by delivery accuracy capability limited to the improvements expected from extensions of present capability. New concepts and measurement data types now becoming available can help satisfy the anticipated demands. The JPL R&T program for navigation system analysis and development is directed toward the achievement of greater future mission potential through capabilities available from new technology. Long range goals for this RTOP are to develop navigation unique technology to meet future mission requirements and to demonstrate new concept/technology feasibility. During FY'73 this RTOP focuses on the navigation functional subsystems of measurement, orbit determination and maneuver strategy, and tasks at the overall systems level. The spacecraft based optical navigation measurement data type being developed under this RTOP will greatly improve future mission approach and orbit phase navigation. Orbit determination filter development will provide accurate and reliable processing of the various anticipated data types even in the presence of unmodeled and random forces acting on the spacecraft. Computational techniques will be developed for optimum multiple and terminal maneuver calculations which will be required to minimize on-board propellant requirements on the complex future missions. At the systems level, requirements analysis and subsystem tradeoffs will aid in ordering sub-system goals and priorities. Tradeoffs will also be performed between on-board and ground based performance requirements.

W73-70364 **502-33-92**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
DEEP SPACE MICROWAVE COMMUNICATION AND TRACKING
R. V. Powell 213-354-6586
(502-23-12)

This RTOP develops the communication and tracking systems technology necessary for defining and performing the planetary/interplanetary missions of the 1977-1987 decade. These missions require new capability, and new kinds of capability, in order to provide useful data at reasonable cost. The goal is to develop communication systems for navigation, spacecraft command, and data return for planetary entry probes, outer planet orbiters, asteroid rendezvous, and similar new classes of missions. This discipline is to provide maximum commonality and reliability by the multiple-mission approach, and in addition permit planning flexibility by providing variable capability that can be incorporated with minimum hardware changes. Techniques for microwave link analysis and design are developed, so that proper communication and tracking strategy can be determined early in mission planning. During FY'73, this effort will concentrate on adapting the dual frequency transponder concept to cover the new classes of missions considered, which require more precise radio navigation and antenna pointing and rely more heavily on ranging. The feasibility of the S/X-band system will be extended to allow precise radio navigation at the edge of the Solar system and in planetary environments. Techniques will be developed for enhancing expected data return subject to minimum requirements, so that advantage can be taken of non-worst case conditions in new propagation media such as occur in Venus and Jupiter entry. Theory of the optimum use of relay links in planetary entry, landers, rovers, and sample return will be initiated, so that tradeoffs can be made between probe and relay bus complexity. These tradeoffs involve acquisition, sampling, data storage, modulation, detection, and coding. Interplex modulation will be evaluated from the results of the Venus-Mercury '73 mission. Three channel Interplex will be evaluated in which ranging is the third channel

W73-70365 **502-33-93**
Jet Propulsion Lab., Calif. Inst of Tech., Pasadena.
ADVANCED DIGITAL DATA SYSTEMS FOR DEEP SPACE
Robert V. Powell 213-354-6586
(502-03-32)

The goal of this work is to develop concepts and technology for integrated spacecraft data systems which perform the functions of control and automatic maintenance, acquisition and processing of engineering and scientific data, and spacecraft timing and sequencing. Work is presently focused on self-adaptive data systems intended for long-life missions to outer planets or for the control of semiautonomous planetary rovers; however, the results will benefit any NASA mission for which adaptability, unattended fault-free operation, and long lifetime are required. Major problems are to provide reliability to guarantee critical functions for 10-20 year lifetime and to provide for automatic adaptation to unexpected changes in environment or partial spacecraft failure. Minimization of size, weight, and power for increasingly complex data systems is also essential. For FY 73 the technical plan calls for continuation or completion of work now in progress and for some new tasks arising directly from results of previous work. Activities will include (1) continued development of fault-tolerant computer techniques and their extension to make the entire spacecraft fault tolerant, (2) research into principles and techniques of spacecraft measurement source encoding, (3) further development of high density memory devices using charge storage technology and magneto-optic recording on thin manganese-bismuth films, and (4) development of cellular logic as a basic architecture for data systems and investigations into optimization and fault diagnosis of digital logic.

W73-70366 **502-33-94**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
ADVANCED IMAGING SYSTEMS TECHNOLOGY
R. V. Powell 213-354-6586

The long term objective of this RTOP is the development of imaging system enabling technology to meet the anticipated requirements of future planetary imaging missions. The general approach includes the study of future missions as a source for the postulation of future imaging requirements, the study of current and projected imaging technology as a means of establishing a state-of-the-art baseline, and the implementation of specific technology development tasks to provide the desired enabling technology. Current enabling technology development on silicon vidicons, of interest for outer planet type missions because of their sensitivity, red response, and potentially long life, will phase out with a report on the slow scan capability of these devices. Coincidentally, effort on solid state sensors will increase, investigating the obstacles to application of these devices in imaging systems. Given the desirable characteristics of these devices (size, reliability, scan versatility, geometric fidelity, magnetic cleanliness) and the long development history, it is obvious that there are major problems to application. Both a systems application attack and a technology development attack are included in the search for solutions

W73-70367 **502-28-04**
Lewis Research Center, Cleveland, Ohio.
SAFETY RESEARCH
Paul M. Ordin 216-433-6941
(770-14-02)

The objectives are to obtain a better understanding of the hazards and improve the safety of NASA and contractor operations associated with oxidizer and related cryogenic propellants for flight, R&D facilities and ground service equipment. Standards/criteria recognizing the threat of failures of the oxidizer systems are to be prepared. Initiation of system failures induced by chemical and physical properties of the oxidizer, oxidizer environment and contaminants will be investigated. A firmer base for risk management techniques related to spacecraft systems will be provided by ASRDI, by conducting or having conducted for it, investigations of combustion, fire propagation, fire detection systems, and shrapnel formation caused by possible explosions.

W73-70368 **502-28-33**
National Aeronautics and Space Administration, Washington, D.C.
DETECTION OF HEAT SOURCES AND SMALL FIRES BY AIRBORNE THERMAL INFRARED LINE SCANNERS
T. B. Kerr 202-755-2420

Radioisotope-fueled nuclear heat sources present a potential hazard from direct radiation and/or fuel release after return from orbit. The location and recovery of these sources following land impact could be simplified if it is possible to use the heat generated by the radioisotope fuel as a location aid. The Forest Fire Research Laboratory of the Forest Service is using infrared detectors to locate small forest fires. This task will utilize existing technology to determine feasibility of using the same type of equipment in parallel with nuclear detectors for locating nuclear sources.

W73-70369 **502-28-34**
Langley Research Center, Langley Station, Va
RECOVERY AIDS FOR AEROSPACE NUCLEAR SYSTEMS
G. B. Graves 703-827-3745

This RTOP covers the technology development for underwater sound generators and detection devices that will permit accurate location of nuclear electrical power systems in salt water. One of the critical requirements of the sensor is that it be integrated into an RTG system design and remain in close proximity to the radioisotope fuel cell. It must, therefore, perform normally after long periods of exposure to high temperature (400-600 C). Unique power sources such as the direct application of chemical energy, salt water activated batteries, and solid state batteries will be investigated. Candidate location aid designs will be carefully assessed to assure reliable operation after vehicle reentry and free-fall water impact.

W73-70370 **502-28-31**
Ames Research Center, Moffett Field, Calif.
NUCLEAR FLIGHT SAFETY RESEARCH AND ANALYSIS
Glen Goodwin 415-965-5065
(503-35-03)

The objectives of this RTOP are: (1) To conduct research that will permit accurate and authoritative predictions of reentry conditions for nuclear space power systems, (2) to conduct research leading to the ultimate development of nuclear space power system intact reentry and ground impact vehicles, and (3) to participate in and provide support for the joint DOD/AEC/NASA nuclear flight safety review and evaluations. Time-to-melt and heating-rate experiments will be performed on thermally scaled models at appropriate arc jet test conditions. Candidate configurations will be tested in shock tunnels and wind tunnels. Results will be applicable to radio-isotope power systems that are candidates for manned and unmanned space operations.

W73-70371 **502-19-20**
National Aeronautics and Space Administration, Washington, D.C.
SAFETY DOCUMENTATION AND TRAINING
J. C. Loria 202-755-2420

The objective of this work is to improve safety by providing the necessary documentation and training to inform and motivate personnel. A clear definition of safety responsibilities will be sought which will differentiate the policy function from operational responsibilities. This RTOP covers contract activities to assist in

the delineation and documentation of policy and operational procedures and training to expedite the implementation of safety policy and procedures.

W73-70372 **502-11-11**
Ames Research Center, Moffett Field, Calif.
POWER CONVERSION OF COHERENT LIGHT
Glen Goodwin 415-965-5065

The objective is to conduct a study and development program in efficient conversion of high-intensity coherent light into electrical power for use in laser power transfer systems. Layered surface materials will be developed that will selectively absorb laser radiation as a nearly perfect black body and reradiate over a broad band spectrum as a nearly perfect reflector. This will permit the laser energy to be almost totally absorbed by a high-temperature device with very little radiation loss. Collector temperatures on the order of 800 K will be attempted. Interference stacks of alternating layers of various materials will be investigated, such as An, SiN, Si and SiO2 layered in stainless steel or Mo, CeO2, and MgF2 also layered on stainless substrate. In addition, the surface potentials and conduction band structure of solids will be investigated by quantum methods, with the ultimate purpose of answering the question whether coherent radiation can be used more effectively to activate a thermoelectric converter than convention broad band radiation.

W73-70373 **790-90-01**
Ames Research Center, Moffett Field, Calif.
ADVANCED CONCEPTS DEVELOPMENT
H. Hornby 415-965-5894
(110-06-01)

The objective of this RTOP is to provide the capability and facilities for generation, discussion, and preliminary feasibility analyses of innovative ideas relating to man's future involvement in space activities. The work will be accomplished through: (a) identification from all available sources of innovative ideas relating to space and space-related activities, and (b) preliminary feasibility analyses to determine whether additional study and/or research on the ideas is warranted.

W73-70374 **790-90-04**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
ADVANCED CONCEPTS AND FUTURES PLANNING
R. V. Powell 213-354-6586

A survey of present and possible missions requiring cooling below 4K will be made to establish the need of more extensive use of helium. A survey of helium technology will be made. Mission cooling requirements will be compared to the state of technology to determine where additional development will make some missions practical and will improve the effectiveness of planned and future missions. Cryogenic vendors will be consulted. Preliminary designs of liquid Hel, liquid Hell, and solid HE cooling systems for selected missions will be performed. Particular attention will be given to refrigerator (electromechanical) vs. solid-cooler effectiveness. Assessments of future trends in industry-developed cryogenic technology will be made. A final report will be prepared which will contain the results of mission survey, cryogenic technology, cooling system design, and recommendations for further study and/or development.

W73-70375 **790-91-01**
Ames Research Center, Moffett Field, Calif.
ANALYSIS SUPPORT TO OAST MANAGEMENT
B. L. Swenson 415-965-5890
(110-06-02; 118-06-02)

The objective of this work is to provide the OAST with a quick-response analysis capability for support of current Headquarters program management. Such analysis will also provide technical requirements information to augment planning of the OAST program for FY 1975 and later. This analysis will give consideration to the objectives of OAST Discipline and Program Elements and the objectives of the other elements of the agency in order to aid in the definition of goals for technology emphasis in the OAST. Particular activities identified under this RTOP include support to Entry Technology Office in the establishment of its program plans through 1978 and support to Lewis Research Center in their studies of orbiting solar power stations and nuclear waste disposal.

W73-70376 **790-91-02**
Langley Research Center, Langley Station, Va.
ANALYSES, ADVANCED CONCEPTS, PLANNING AND SYSTEM SYNTHESIS FOR THE SPACE PROGRAM
C. H. Nelson 703-827-2893

The objective of this work is four fold: (a) To define space program models for relation of the OAST Space Technology Program to the future mission goals of the agency. (b) To provide technical requirements information to augment planning of the OAST program for FY 1975 and beyond. (c) To provide the OAST with a quick-response analysis capability for support of Headquarters program management. (d) To provide a base for the discussion, generation and coordination of intuitive and speculative thinking for the future in space. The approaches to be taken to achieve these objectives are: (a) To develop long-range mission models for space operations in Earth orbit, at the Moon and for exploration of the solar system including extrapolations which consider technical achievements and/or increased funding levels. (b) To assign personnel responsibilities for special analytical tasks in the areas of planetary exploration and earth orbital operations to support special tasks for the Associate Administration of OAST and his staff. (c) To assign personnel to interface with the OAST Vertical Cut Managers for OSS and OMSF to provide planning inputs for the analytical capabilities of he LRC. (d) To assign a spokesman for Advanced Concepts and Futures, Planning at the LRC who will interact with spokesmen at other centers to promote speculative thinking for future space missions.

W73-70377 **790-91-41**
Ames Research Center, Moffett Field, Calif.
SPACE EXPLORATION - MISSION AND SYSTEMS ANALYSIS
B. L. Swenson 415-965-5890
(110-06-02, 118-06-02)

The objective of this work is to define the mission and spacecraft requirements to accomplish recognized scientific goals of exploration within the solar system. These studies will be aimed at determining mission strategies and the associated vehicle requirements to accomplish these goals with minimum cost and maximum scientific benefit. In this regard, examinations will be made of the benefits and cost of the use of advanced and evolving technologies, subsystems, and vehicles.

W73-70378 **790-91-42**
Langley Research Center, Langley Station, Va.
SPACE MISSION AND VEHICLE ANALYSIS
C. H. Nelson 703-827-2893

The purpose of this work is to provide studies of future space missions and new systems concepts to assist in developing the basis from which decisions can be made on future space missions, mission modes and systems. These include pre-

liminary studies of future space missions and techniques; feasibility studies of missions proposed as a result of preliminary studies; atmospheric and in-space trajectory analyses associated with proposed future missions; studies of guidance and navigation requirements relative to such missions; studies of the use of trajectory determination methods in defining planetary masses and gravity fields; and ephemerides improvement and error definition required for mission studies. The needs for various missions such as Multiple Comet/Asteroid Flyby and Planetary Rover missions are under study. These include types of orbits, types of propulsion systems, types of spacecraft measurements and instrumentation, and modes of operation being studied. Current activities include development of long range programs for the scientific exploration of the solar system through mission studies, analyses of Multiple Comet/Asteroid Flyby missions and Mars Rover missions, asteriod ephemerides improvement, and development of parameter-estimation and mission design techniques for mission planning purposes.

W73-70379 **790-91-44**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
MISSION AND VEHICLE ANALYSIS
Robert V. Powell 213-354-6586

One objective of this effort is to use the in-house data and experience combined with data from NASA and industry to develop a model for the support of pre-project planning activities of space exploration missions. This model would basically support qualitative trade-offs necessary to definitize planning of new missions having maximum return on investment, with emphasis upon the development of a model for science experiments. Basically, this would be accomplished consistent with the techniques used to develop the model currently in use at JPL. A second objective is the development of a methodology for imaging system quantitative evaluation. The characteristics and limitations of space imaging systems have a major impact on mission planning and spacecraft design. Therefore, the analysis of proposed imaging system capabilities and the timely determination of future imaging system technology requirements are significant aspects of advanced mission analysis. Elementary evaluation techniques adequate for the limited objectives of "first-look" imaging missions are not adequate for the sophisticated use of imaging systems demanded by future missions. The large number of complex parameters must be handled by digital computer simulation. Computer techniques will be used to develop performance data. Merit criteria and functions will be developed to optimize mission design and to evaluate expected mission performance. Merit criteria evaluation and maximization will provide a guide to future technology requirements.

W73-70380 **790-91-45**
Ames Research Center, Moffett Field, Calif.
SPACE UTILIZATION - MISSION AND SYSTEMS ANALYSIS
J. M. Deerwester 415-965-5897
(110-06-03)

The objective of this RTOP is to conduct and support studies to determine the potential applications of space. These applications are such that they meet current and anticipated future needs on earth and contribute to future space exploration missions. Applications so identified, and the attendant technology requirements, can respectively serve to aid in setting directions for Agency planning and for the OAST technology development programs. Candidate missions and systems will be evaluated with respect to fulfillment of needs; economic considerations; and technology implications. It should be explicitly noted that this RTOP applies to the utilization of missions and systems operating in space and not to earth-based applications of space technology. In some cases, however, analysis of space missions must include the consideration of similar applications performed by more traditional means.

W73-70381 **790-91-46**
Langley Research Center, Langley Station, Va.
STUDY OF AN ORBITING ADVANCED TECHNOLOGY LABORATORY (SHUTTLE COMPATIBLE)
C. H. Nelson 703-827-2893

A Langley Research Center in-house study to establish feasibility of a Shuttle Compatible Advanced Technology Laboratory (ATL) is nearing completion. This study included definition of LRC experiments, ATL concepts, and operational requirements. Further refinements of the ATL design is required to better focus LRC Shuttle Sortie research requirements and to make timely contributions to the concurrent OMSF Shuttle and Sortie Can design activities. The objectives of this definition study are to: define a Shuttle compatible ATL particularly suited to LRC's technical expertise and research requirements; advance the state-of-the-art of on-board systems; and focus in-house technical expertise on advanced systems. This ATL will provide LRC with the capability of implementing a spaceborne research program that is truly accessible to the ground-based researcher. This in-house and service support contracted effort will develop design concepts for an integrated payload system compatible with the Shuttle and the current payload carrier (i.e., Sortie Can) that will be based on requirements from a related LRC experiment payload definition study. Laboratory and systems concepts will be evaluated and a single concept selected for detailed design and development. In addition, costs, schedules, and implementation plans will be defined for phased follow-on activity.

W73-70382 **790-92-01**
Ames Research Center, Moffett Field, Calif.
SOCIO-ECONOMIC/TECHNICAL ASSESSMENT OF SPACE ACTIVITIES
H Hornby 415-965-5895

The objective of this work is to improve our ability to understand, use, and incorporate socio-economic/technical assessments into the evaluation of projected NASA activities. Some of the characteristics of this aggregate assessment which distinguish it from other concepts are its emphasis on social and economic impact of technological applications and its search for criteria by which the social costs and benefits of such application can be measured. In order to satisfy the objective, it is necessary to focus the activity into reasonably identified activities. Those identified for this RTOP include: (1) a critical review of planning studies carried out in the past to point out virtues and shortcomings of attempts to include factors other than the purely technical in analyses; (2) to increase our proficiency with current analytical tools by performing selected assessments in the realms of mineral resource depletion and earth observation satellites; and (3) develop criteria that will guide assessments of future programs while under development.

Space Systems and Experimental Programs

W73-70383 **755-43-11**
Marshall Space Flight Center, Huntsville, Ala.
OPTICAL COMMUNICATION FLIGHT EXPERIMENT (ATS-G)
Joseph L. Randall 205-453-3770
(502-23-16; 975-22-01; 115-22-06)

This research program is designed to develop and implement a flight program to prove the concept of optical communication (Op/Com) in space using synchronous and low earth orbiting satellites. This will also include the development of components and techniques necessary to carry out the flight experiment program. The approach will be to use the results of previous studies (OCEP) on Op/Com and the current Aircraft Op/Com Flight Project to develop an integrated and well planned satellite flight program. Foremost in FY73 will be the start of a contract to design and build an Op/Com experiment for the ATS-G satellite. This includes the satellite package as well as ground station hardware to perform the experiment. Included in the ATS-G Op/Com experiment must be the early development of space qualified hardware necessary to implement the program. A definition study for a low earth orbit Op/Com experiment to communicate with the ATS-G will be performed in FY73.

W73-70384 **755-42-01**
Langley Research Center, Langley Station, Va.
METEOROID TECHNOLOGY SATELLITE
C. H. Nelson 703-827-2893

The Meteoroid Technology Satellite (MTS) is a Scout launched near-earth experiment to obtain baseline data on the effectiveness of bumpers or multi-wall structures and the velocity distributions of meteoroids. Measurement will also be made of the flux of very small mass meteoroids. The velocity measurement is a joint Langley Research Center/Manned Spacecraft Center experiment.

W73-70385 **756-47-01**
Flight Research Center, Edwards, Calif.
LIFTING BODY FLIGHT RESEARCH
G. P. Layton 805-258-3311

The low supersonic and subsonic characteristics of lifting reentry vehicles are being studied by means of a coordinated flight and wind-tunnel test program with M2-F3, and X-24A aircraft. The program will yield the detailed aerodynamic characteristics of these aircraft and a measure of the ability of the wind tunnels to predict these characteristics. In addition, operational characteristics in the terminal area are being explored. This effort will ultimately yield an IFR terminal area energy management and approach technique applicable to unpowered low L/D entry vehicles After accomplishing the basic flight objectives, the M2-F3 will be used to evaluate command control system concepts and reaction control blending techniques. Subsequent to the basic program, the X-24A will be converted to an X-24B shape to evaluate a new class of vehicle.

W73-70386 **757-51-09**
Goddard Space Flight Center, Greenbelt, Md.
ELECTRIC AUXILIARY PROPULSION SYSTEMS FOR APPLICATION SATELLITES
R. A. Callens 301-982-4205
(113-26-17)

Unmanned meteorological, communication, earth observation and other application spacecraft require, not only long lived, light weight auxiliary propulsion systems, but also ones capable of providing north-south station keeping, precession control, east-west station keeping, or precise attitude control. The objective of this RTOP is to identify and develop the auxiliary propulsion systems needed for these spacecraft. When necessary, they are evaluated in either GSFC's Electric Propulsion Laboratory or its Hydrazine Test Facility. Additionally, when necessary, space flight tests of candidate systems are conducted to further demonstrate their capability for space flight application.

W73-70387 **757-53-30**
Jet Propulsion Lab., Calif Inst. of Tech., Pasadena.
LIQUID PROPULSION SYSTEMS TECHNOLOGY FOR PLANETARY SPACECRAFT
Paul J. Meeks 213-354-2546
(502-04-20; 502-24-26)

The work conducted under this RTOP is directed toward the demonstration of the performance and operational capability of a space storable propulsion module under simulated environmental test conditions for eventual use on planetary orbiters. Feasibility testing at the system level, utilizing the hardware assembled in FY'72, will continue for the first three quarters of FY'73 at which time this portion of the program will be completed. Assembly of the Engineering Test Module will begin during the fourth quarter During this FY, an engine for the Engineering Test Module will be designed based on the information obtained during the basic experimental engineering phase and will be fabricated for the propulsion module. The thermal control subsystem and propulsion system structure will be designed, fabricated, and tested. The design will be based upon the results of the studies performed in FY'72. During FY'73, the Test Support Equipment required for the Engineering Test Module will be identified and preliminary designs of required equipment will be initiated. Work will continue during FY'73 on the feed system components required for the Engineering Test Module. These components include propellant valves, isolation valves, pressure regulators, relief valves, filter, and propellant acquisition.

W73-70388 **758-56-42**
Langley Research Center, Langley Station, Va.
DELTA HYBRID TECHNOLOGY DEMONSTRATION
C. H. Nelson 703-827-2893

The objective of this work is to complete the technology for a high energy (flox/lithium-lithium hydride) hybrid propulsion system so as to allow initiation of a development of a new third stage for Delta using this system. The approach will be a contracted program in which the primary effort will be a design and demonstration at full scale in heavyweight hardware of (1) a suitable fuel configuration using an already developed fuel formulation, and (2) a suitable nozzle which will survive the required extreme temperature and chemical environment for 100 seconds. Secondary emphasis will be on altitude performance verification and on demonstration of the benign nature of the fuel in response to cracks, separations, etc.

W73-70389 **758-56-47**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
UPPER STAGE AND PLANETARY EXPERIMENTAL MOTORS
Paul J. Meeks 213-354-2546
(502-04-45; 502-24-46)

The first objective is to establish in FY'73 the technologies of a prototype solid propellant flight type space motor in the 3000 pound class with a two pulse, two liquid quench termination capability. Program scope includes: motor design and analysis; bench design tests and early verification of small motor quench termination in near vacuum conditions. Full-scale test weight motors will also be fabricated and test fired to demonstrate: motor design adequacy; sustained termination; and, delivered specific impulse. Utilization of this motor in future launch vehicles is cost effective. All work will be done by an industrial contractor. The second objective is to complete the advanced development of a planetary spacecraft orbit insertion low thrust sold rocket. This motor is characterized by use of: a high performance

propellant; a light weight composite case; more effective insulators; and, a very light-weight all-carbon nozzle. This motor will reduce space craft acceleration levels and rates greatly but still provide high performance. This program will be accomplished in-house and will provide a low thrust, low program cost solution for future planetary spacecraft orbit insertion missions.

W73-70390 **758-57-04**
Lewis Research Center, Cleveland, Ohio.
30-CM ION THRUSTER AND POWER CONDITIONER DEVELOPMENT AND TEST
P. D. Reader 213-433-4000
(502-04-01; 502-24-03)

The broad objective of the work described herein is to provide flight prototype thruster subsystems of demonstrated efficiency and durability. The overall program is directed at assuring a firm base of technology ready hardware for application to anticipated electric propulsion spacecraft. A major program is to provide a qualified thrustor for synchronous satellite raising missions and 0.1 to 3 a.u. interplanetary missions. Pertinent information from experimental and analytical studies and demonstrated components are being integrated into a specific thruster system design. This design will cover the widest possible range of currently foreseen mission types Studies and investigations into thruster system interaction and integration problems will be conducted to the extent necessary to clearly define interface problem areas.

W73-70391 **758-57-11**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
SOLAR ELECTRIC THRUST SUBSYSTEM DEVELOPMENT
A. Briglio, Jr. 213-354-6137
(502-24-10; 502-25-56)

The objective is to prepare the technology of solar-powered electric propulsion for unmanned missions. The propulsion system technology planning and development effort covered herein will concentrate on laying the foundations for a thrust subsystem engineering model development program, which will carry the technology to the next major plateau beyond the level already demonstrated in the non-completed SEPST III subsystem test. Major aspects be the investigation of internal and external thrust subsystem interfaces and interactions, definition of thrust subsystem automatic control requirements and their implementation mode, and development planning and detailed design of the engineering model thrust subsystem. Using the SEPST III experimental setup as a test bed, new elements proposed for use in the engineering model subsystem will be evaluated for interactions and interfaces required with other subsystem elements and with support subsystems (such as the computer command subsystem), and interactions of these elements with noninterfacing space vehicle subsystems (such as the science subsystem). Particular attention will be given to proper definition of thermal and mechanical interfaces, to mechanical interactions with the space vehicle structure, and to conducted and radiated electromagnetic interference The baseline subsystem control program developed for SEPST III is presently being adapted to the language of the Viking Orbiter '75 command computer. The program derived from this effort will be analyzed for optimum mix of software and hardwired logic, and the consequences of transferring selected routines from onboard to ground control will be evaluated. From this trade-off a baseline definition of the engineering model thrust subsystem control program will be made.

W73-70392 **770-18-01**
Lewis Research Center, Cleveland, Ohio.
ENVIRONMENTAL ENGINEERING-ENERGY MANAGEMENT, GROUND TRANSPORTATION, AND AIR POLLUTION REDUCTION
L. I. Shure 216-433-6995
(770-90-10; 770-90-11; 771-90-04)

The nation faces a critical need for control and conservation of energy and the environment. The problem is how to measure, quantify, and reduce major pollution sources while ensuring a continuing supply of energy resources with minimum insult to the environment. The objective of this program is to apply NASA space and aeronautical technology, skills, and expertise already developed to ameliorating these problems. The approach is to focus on areas of established and recognized LeRC capability primarily related to power and propulsion. These capabilities will be selectively applied to: (1) ground transportation, (2) stationary power generation, (3) pollution measurement and purification. The above activities will be implemented where encouraged or supported by those agencies charged with the primary responsibilities in these areas at the federal and local levels. In addition, the above efforts will be coordinated with related programs to avoid duplication of effort and to ensure a significant contribution to national needs.

W73-70393 **770-18-02**
Ames Research Center, Moffett Field, Calif.
FIRE SAFETY, AIR POLLUTION REDUCTION, AND HEALTH CARE DELIVERY
Glen Goodwin 415-965-5065
(501-38-19)

This RTOP includes the application of space- derived technology to the resolution of problems of national interest, specifically (a) the application of fire retardant materials technology to high rise building fire safety, (b) the application of chemical technology to the production of low pollution hydrocarbon fuels for furnaces and other power sources such as automobile engines and, (c) the application of magnetics technology to the resolution of medical and geodetic problems such as the utilization of Ames developed magnetometers for setting and maintaining standards for earth magnetic field measurements on the ground. These projects will be conducted in cooperation with other Agencies and organizations which have indicated interest in the above projects. These Agencies include the Department of Housing and Urban Development (building fire-safety), the Environmental Protection Agency (low pollution fuels), the National Oceanic and Atmospheric Administration and the National Insititute of Health (magnetics technology).

W73-70394 **770-18-04**
Langley Research Center, Langley Station, Va.
TECHNOLOGY APPLICATIONS TO ENVIRONMENTAL PROBLEMS
C. H Nelson 703-827-2893

The objective is to apply Langley technical capability utilizing advanced aerospace technology to the solution of selected environmental problems, such as air and water pollution, and water and waste management. Problem areas for consideration are those identified by one or more user agency, such as EPA, Corps of Engineers, HEW, as well as State governmental organizations, as being of significant value to warrant new technologies. Projects for or in cooperation with individual user agencies where near-term demonstration can be achieved are most desirable. Proposals to other agencies are also coordinated as a part of this work. Included herein are tasks related to the applications of laser radar (LIDAR) to air and water pollution sensing, to domestic water and waste treatment, and to systems for applications in the marine environment. In each activity, demonstrations will be conducted in close cooperation

with users so that comparisons with other existing techniques can be made and so that the relevance of the new technology can be evaluated by the ultimate users.

W73-70395 **770-18-08**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
SPACE TECHNOLOGY APPLICATIONS (STA)
D. F. Spencer 213-354-6852

JPL will apply space-derived capabilities to the resolution of problems of national interest, particularly those relating to the civil systems areas, including Public Safety Support, Medical Engineering, Environmental Management and others. Space-derived capabilities include experience and technology that is applicable in. 1) Project and systems management 2) Systems analysis and project engineering 3) Specialized technical disciplines (e.g., communications, guidance, propulsion, etc.) 4) Design, operation, and evaluation of complex test programs. Within the civil systems areas, JPL will (1) identify and define problems, (2) determine requirements, (3) apply a systems approach, and (4) concentrate on evaluating feasible hardware pilot demonstrations that will help interested government agencies and/or industrial companies in solving problems that are national in scope. A mix of tasks will be performed appropriate to JPL's capability and emphasizing the application of space technology.

W73-70396 **770-18-15**
Goddard Space Flight Center, Greenbelt, Md.
LONG RANGE LASER TRAVERSING SYSTEM
Louis O. Caudill 301-982-4820

This RTOP is for development of a lightweight, backpacked prototype laser system and for performing field evaluation experiments to determine the feasibility of establishing precise line of sight using the scattered laser light from a distant vertically pointed laser. This work is a direct application of Optical Technology, developed under OAST program, and will provide the United States Forest Service with a surveying technique that will save a great deal of time and money.

W73-70397 **770-14-02**
Lewis Research Center, Cleveland, Ohio.
AEROSPACE SAFETY DATA BANK
George Mandel 216-433-6285

To establish an Aerospace Safety Data Bank to gather, analyze, evaluate, retrieve and disseminate safety-related technical information available to all elements of NASA, its contractors and the technical community; to assure that information on the latest state-of-the-art regarding safety is available for use in planning, design, fabrication, testing and operations of aerospace vehicles and systems and associated ground facilities. ASRDI will call on all elements of NASA, its contractors, and other organizations to provide basic, applied and operational data related to ground-based and flight safety experience for the Aerospace Safety Data Bank Cooperative and exchange programs have been established with similar information activities in government and industry with the intent of utilizing existing compilations of accurate data. Liaison is being established with these activities to assure access to the information contained in these sources as needed, and/or selected information will be identified and incorporated into the Aerospace Safety Data Bank as appropriate. A management mechanism will be established to provide for the flow of all such information into the Data Bank. The information will be made available to all elements of NASA, its contractors, other government agencies and the technical community. Improved methods of storing, searching, retrieving and disseminating information are being developed and implemented.

Nuclear Research and Technology

W73-70398 **503-05-01**
Lewis Research Center, Cleveland, Ohio.
ENERGY CONVERSION GENERATION AND TRANSPORT RESEARCH
S. J. Kaufman 216-433-4000
(503-25-01; 503-25-04; 503-25-05)

To conduct research in various technical areas of interest for advanced nuclear electrical power systems. Specific areas to be covered are: (1) Heat pipes, (2) Basic and applied shielding, and (3) Properties of fuels under investigation. Investigations will be conducted on characteristics, limitations and reliability of heat pipes. Basic shielding studies will be performed to develop and improve procedures for designing nuclear space shields. The fission gas release and retention properties of several fuels will be investigated.

W73-70399 **503-05-02**
Jet Propulsion Lab., Calif. Inst of Tech., Pasadena.
LIQUID METAL MHD
John W. Lucas 213-354-4530

Liquid Metal MHD is a prospective electric propulsion power system with no moving parts, moderate source temperature of 1100C (1800 F), and AC output. Lithium flowing from a reactor heat source is mixed with cesium, causing the cesium to vaporize. The mixture flows through a nozzle and separator and the lithium flows through a generator and returns to the heat source. The cesium flows through a condenser and is pumped back to the nozzle. The system is attractive for high reliability and low development cost. Problem areas requiring investigation are efficiency and lifetime. Nozzles and separators are being investigated with water-nitrogen mixtures, generators with cold NaK, and converter materials with hot lithium. The approach is to solve the problems that can be studied with such simulations and then proceed to cesium-lithium converter experiments. The FY'73 objectives are: (1) power generation tests at 30 kWe with closed-loop NaK simulating lithium and open-loop nitrogen simulating cesium vapor, (2) installation and test at 1000C and 130 m/s of a new Cs-Li loop test section representing a generator channel configuration, (3) water-nitrogen flow tests of multiple impinging nozzle, short surface separator, converter configurations to evaluate design concepts for a 150 kWe, 1000C Cs-Li converter, and (4) research on advanced separator concepts.

W73-70400 **503-25-01**
Lewis Research Center, Cleveland, Ohio.
THERMIONIC REACTOR POWER TECHNOLOGY
R. Breitwieser 216-433-4000

Nuclear-powered thermionic conversion systems are of interest for space power generation. Lewis Research Center will continue its support of nuclear thermionics with primary emphasis on the in-core concept based on flashlight-type fuel elements. A major part of the program will be directed toward achieving dimiensional and chemical stability of tungsten clad fuel elements at high burnup conditions. The physical properties and creep behavior of uranium carbide fuel forms and fuel cladding materials will also be established in out-of-pile test programs. Analyses will be conducted to define a reference reactor design and, using this as a framework, flight safety problems will be considered. Thermionic converter work will focus on improvement of performance using better electrode materials and oxygen additives

in controlled amounts. The effect of transport of carbide fuel constituents through the emitter on converter performance will also be investigated. Because the state of the art of in-core thermionics is not as yet advanced to the point that success can be insured, a low level analytical effort will be continued on the externally-fueled and out-of-core thermionic concepts.

W73-70401 **503-25-02**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
THERMIONIC REACTOR POWER SYSTEM TECHNOLOGY
John W. Lucas 213-354-4530
(180-06-51; 118-60-01; 113-60-01)

The overall objective of the joint NASA/AEC technology effort is to achieve thermionic reactor power subsystem technology readiness. The work performed under this RTOP is one part of this joint technology effort. The main objective of this RTOP work is to establish the thermionic reactor operating requirements for unmanned electric propulsion. This is accomplished by system design studies, mission engineering studies, well defined key technology experiments and detailed evaluations of technology from other programs. A thermionic reactor power subsystem (50 to 300 kWe) would be useful for both electric propulsion and auxiliary power missions. The power subsystem consists of a thermionic reactor, a radiator, a nuclear shield, a liquid metal pump or pumps, controls, and structure. The power subsystem technology (except reactor) is being developed under this RTOP. The primary thermionic reactor concept uses internally fueled 'flashlight' thermionic fuel elements (TFE). The 'flashlight' TFE technology is being developed primarily under AEC contract. The TFE and system technology for an external fueled converter is also being investigated under this RTOP as a backup concept. The major milestones required to achieve technology readiness are several thousand hours operation of a prototypic thermionic reactor, 10,000 hours operation of several flight prototype TFE's and 10,000 hours of operation on flight protoype heat rejection subsystem components. A 'focus technology' application for an unmanned nuclear electric propulsion (NEP) system Halley's Comet rendezvous in mid FY'86 is recommended for consideration. The NEP system developed for Halley's Comet mission would be useful for many unmanned outer planet missions The NEP power subsystem would then be available for auxiliary electric power missions in the 1985 time period.

W73-70402 **503-25-03**
Atomic Energy Commission, Germantown, Md.
THERMIONIC REACTOR TECHNOLOGY
D. S. Beard 301-973-4558
(503-25-01; 503-25-02)

The thermionic reactor is being developed to meet electrical power requirements in space from 10's of kilowatts to megawatts. Present emphasis is on the 50-300 kWe range. Potential applications include nuclear electric rocket missions to the outer planets, large manned space stations, advanced unmanned orbital satellites and satellite-raising propulsion stages. It would also be useful for remote terrestrial or undersea applications. The key technology element in a thermionic reactor power system is the thermionic fuel element (TFE) from which the reactor core is constructed. The TFE contains not only the nuclear fuel but also the thermionic diodes which convert the heat generated by the reactor into electricity. The ojbective of this program is the development of materials technology for this TFE. Primary emphasis will be given to the collector/insulator/sheath composite structure and UO2 fueled emitters.

W73-70403 **503-25-04**
Lewis Research Center, Cleveland, Ohio.
NUCLEAR POWER REACTOR TECHNOLOGY
S. J. Kaufman 216-433-4000

A technology program is continuing to explore the feasibility of a compact fast spectrum reactor for use as the heat source for a space electrical power system. If successful it could significantly improve the performance, lifetime, reliability, safety and cost effectiveness of space power reactors. The technology base being pursued is for a liquid-metal cooled fast spectrum reactor which will be compatible with a variety of power conversion systems and will have an operating life at rated condition of at least 5 years and a growth potential to 10 years. The thermal output capacity of the reactor covers a range of power in excess of 2 Megawatts. The continuing effort this fiscal year will center around an increased in-pile fuel and material testing program and alternate reactor designs such as heat-pipe cooled concepts. Additional work in the area of flight safety and cost effective analyses will also be actively pursued. Results of data and analysis obtained to date in the program show that the reactor neutronics are well in hand that the in-pile testing of fuel elements has proceeded remarkably well with very little fuel or fuel pin damage. Analytic procedures in these two areas also predict the behavior very well.

W73-70404 **503-25-07**
Atomic Energy Commission, Germantown, Md
NUCLEAR POWER SYSTEMS TECHNOLOGY
G. A. Newby 301-973-4423

The objective of this RTOP is to conduct technology tasks to support the on-going technology programs at the other NASA research centers and the AEC industrial contractors and to perform advanced planning and applications studies which may lead to new technology efforts. The output of these technology tasks will help to guide the on-going technology programs and will provide planning guidance for the future direction of the space nuclear power program. Specific task areas will include activities such as advanced applications studies for reactor power systems, including evaluations of satellite raising from one orbit to another using nuclear electric propulsion, procurement and testing of a high powered SNAP-19 RTG as a possible backup to the AEC's MHW RTG system currently being developed for military and NASA missions, studies to evaluate the feasibility of using space technologies for waste disposal of nuclear power reactor wastes or the transmission of reactor electric power from space to earth, investigations of the feasibility of noise thermometer concepts for measurement of high temperatures, development efforts associated with reentry bodies and materials, and investigations of thermoelectric materials degradation modes.

W73-70405 **503-25-05**
Lewis Research Center, Cleveland, Ohio.
ZrH REACTOR POWER SYSTEM TECHNOLOGY
M. J. Saari 216-433-6638
(503-25-06)

The ZrH Reactor Power System Technology Program is a joint AEC/NASA effort directed toward the development and demonstration of technology required for the design of long-life reactor thermoelectric systems in the 1 to 10 kWe power range with future growth potential to 20 kWe. This technology will be gained through the design, development, fabrication, and long-term testing of an unmanned flight-type 5 kWe reactor thermoelectric system having at least five year life. This system will utilize a ZrH reactor, a shadow shield, and compact tubular lead telluride thermoelectric converters. Tasks performed under this RTOP include: (1) engineering analysis and design of the system; (2) fabrication and assembly of the radiator/structure; (3) design, development, and fabrication of piping, insulation, and diagnostic

instrumentation; (4) assembly of the reactor shield subsystem with the power conversion subsystem; (5) conduct of long-term system testing; and (6) analysis of test data and life potential evaluation. The thermoelectric converter technology; provision of thermoelectric converter modules for system assembly; the design development, fabrication of liquid metal components and life testing of these components; and provision of electrical components are covered by the related RTOP. The reactor, shield, controls, application studies, system test facilities, and test support equipment will be provided by the AEC.

W73-70406 **503-25-06**

Lewis Research Center, Cleveland, Ohio.

THERMOELECTRIC POWER CONVERSION TECHNOLOGY FOR REACTOR HEAT SOURCES

M. J. Saari 216-433-6638

(503-25-05)

The ZrH Reactor Power System Technology Program is a joint AEC/NASA effort directed toward the development and demonstration of technology required for the design of long-life reactor thermoelectric systems in the 1 to 10 kWe power range with future growth potential to 20 kWe. This technology will be gained through the design, development, fabrication, and long-term testing of an unmanned flight-type 5 kWe reactor thermoelectric system having at least five year life. This system will utilize a ZrH reactor, a shadow shield, and compact tubular lead telluride thermoelectric converters Tasks in this RTOP include: (1) engineering analysis and design of liquid metal and electrical components; (2) conduct of the thermoelectric converter technology program including provision of power and pump thermoelectric converters for system assembly, (3) fabrication and development testing of components; (4) fabrication of components for the test system; and (5) evaluation of component life potential subsequent to endurance tests. The system engineering design, system assembly, and system test are covered by RTOP 503-25-05.

W73-70407 **503-35-01**

Lewis Research Center, Cleveland, Ohio.

BRAYTON CONVERSION TECHNOLOGY

D. R. Packe 216-433-4000

The Brayton Conversion Technology program is to provide a broad technology base for highly reliable, long lived, and very efficient power conversion systems with electrical power capability from 500 watts to multiple kilowatts. Typical applications for this type of power system would include communications and earth observation satellites, earth-orbiting space stations, lunar surface and orbiting missions, and interplanetary missions as well as ground applications in transportation and stationary power. The technology program up to this time has been primarily directed toward a 2-15 kWe power conversion system. This system has been performance and partially endurance tested in vacuum at the Plum Brook Space Power Facility, and in FY'73 the system will be installed at the Marshall Space Flight Center for testing from a 'user's vantage against user requirements'. Almost all new effort will be devoted to developing the technology applicable to the 0.5-to-2.5 kWe (mini) Brayton power range. An inhouse analytical and conceptual-design study has been completed and will serve as the basis for preliminary design and fabrication efforts for an eventual performance test of this power system. In general, supporting technology will be conducted which is applicable in a broad power range (0.5 to 500 kWe) in areas which hold promise of improved reliability and in potential problem areas.

W73-70408 **503-35-02**

Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.

RTG TECHNOLOGY AND APPLICATIONS

John W. Lucas 213-354-4530

During FY 73 the work will be aimed primarily at improving the state of art in RTG technology for advanced missions and assessing RTG technology for near term applications. This will be accomplished through basic materials research and generator and component design studies and test. Assistance will be provided in the analysis, integration and optimal use of RTGs in spacecraft missions. Research will also be conducted to define and measure the radiation environment from RTG systems and to determine the influence of this environment upon radiation sensitive subsystems. The work will be conducted in four parallel tasks involving both in-house and contracted efforts and will be performed within the newly constructed isotope thermoelectric system application laboratory (ITSAL) at JPL. The efforts will include; (1) a silicon-germanium technology program, (2) a thermoelectric generator and material evaluation program, (3) and RTG nuclear radiation program, and (4) an RTG analysis and integration effort.

W73-70409 **503-35-03**

Ames Research Center, Moffett Field, Calif.

NUCLEAR FLIGHT-ABORT SAFETY TECHNOLOGY

Glen Goodwin 415-965-5065

(502-28-31)

The objectives are: To appraise abort-reentry performance of space nuclear power supplies, such as multi-hundred watt radioisotope heat sources and their components; and to develop and evaluate improved heat source configurations that will lessen heat source susceptibility to environmental challenges against the heat shield but will be fully compatible with operational requirements. Results will provide design information for nuclear space power systems capable of intact abort reentry and ground impact. Exploratory testing and analysis will be carried out on existing and proposed space nuclear power supply systems and their components. Breakup modes, aerodynamic stability, heating rate distribution, internal temperature distribution, ablation, thermal stress and terminal velocity will be determined for various abort entry trajectories. In cooperation with LASL experts on fuel and its compatibility with materials. Efforts will be made to design and develop integrated fuel protection and containment modules suitable for assembly into large RTG heat sources.

W73-70410 **503-35-04**

Goddard Space Flight Center, Greenbelt, Md.

THERMOELECTRIC SYSTEMS TECHNOLOGY

J. Epstein 301-982-4564

The success of missions aimed at exploring the outer limits of the solar system will depend heavily on the availability of stable, long term Radioisotope Thermoelectric Generators (RTG). Accurate predictions for long term performance (5 years) and the precise definitions of the RTG created environment are required. Life test and evaluation of several RTG concepts and spacecraft experiments for radiation and magnetic environmental compatibility are the tasks required to enhance the success probability of these missions. The processes involved in the interactions within the RTG must be determined and controlled. The development of methods for minimizing the environmental interference and the verification of these methods by empirical means are required. With the advent of space shuttle concepts for recoverability of radioisotope and enhanced production methods for useful power producing radioisotopes, systems studies aimed at the cost effectiveness of isotopic thermoelectric power systems for earth orbiting applications satellities should be actively pursued.

W73-70411 **503-35-05**
Goddard Space Flight Center, Greenbelt, Md
THERMAL POWER FOR CRYOGENIC REFRIGERATORS
T. A. Cygnarowicz 301-982-6078
(112-27-06)

A closed cycle, heat driven Vuilleumier (VM) cryogenic refrigerator is being developed for cryogenic cooling of infrared detectors aboard spacecraft. A joint effort with AEC will be undertaken to evaluate the suitability, technology requirement, interface problems and integration aspects of a radioisotope heat source for application to cryogenic refrigeration systems. Studies will be performed aimed at defining and evaluating detailed designs of a radioisotope heat source, thermal control system and interface coupling with the refrigerator.

W73-70412 **503-04-01**
Atomic Energy Commission, Germantown, Md.
ADVANCED NUCLEAR PROPULSION RESEARCH
F. Schwenk 301-973-4546

This RTOP addresses a research grant with University of Arizona where Principal Investigator assigns graduate students to research involving both theory, simulation, and computations on problems that arise from working with the Los Alamos Scientific Laboratory and, in the past, NASA Centers and the NERVA contractors.

W73-70413 **503-04-01**
Lewis Research Center, Cleveland, Ohio.
ADVANCED NUCLEAR PROPULSION RESEARCH
M. H. Krasner 216-433-4000

The objective is to investigate feasibility, performance potential and applications of advanced fission reactor concepts for space missions. The approach will be to conduct laboratory research, theoretical analysis, and system studies to determine basic characteristics of nuclear rocket engines based on the porous-wall and lightbulb gaseous fuel reactor concepts, and on the rotating fluidized bed reactor concept; and conduct research on system and mission studies to provide basis for planning future programs on advanced propulsion.

W73-70414 **503-24-02**
Atomic Energy Commission, Germantown, Md.
NUCLEAR ROCKET ENGINE TECHNOLOGY
F. X Gavigan 301-973-4335
(503-24-03; 503-29-05)

The objective of this effort is to provide research and technology support in the areas of nuclear engine components and reactor components applicable to the small nuclear engine concept. Although the previous NERVA nuclear rocket work at Aerojet and at Westinghouse has been terminated, nuclear rocket engine research and technology capability at the Los Alamos Scientific Laboratory remains intact and is being redirected to furnish technology support to a low thrust engine concept. Close coordination and interaction with those organizations involved in engine definition and stage and mission studies will be maintained. FY 73 efforts include Nuclear Furnace planning, operation and analysis, fission product studies in support of scrubber design, carbide and composite (carbide plus carbon) fuel improvement and support of other reactor and engine component technology.

W73-70415 **503-24-03**
Atomic Energy Commission, Germantown, Md.
NUCLEAR ROCKET ENGINE DEFINITION
N. J. Gerstein 301-973-4567
(792-91-01; 792-91-02)

The objective of this RTOP is to arrive at a reference design for the development of a nuclear rocket engine for use in unmanned scientific exploration of the outer planets in the 1980's. The nuclear vehicle would provide for not only early probe type missions but also for later missions such as outer planet orbiters or orbiters of their moons and sample return missions. The nuclear rocket engine would be designed for a thrust of 15,000 to 20,000 pounds As an initial development goal, its specific impulse would be approximately 870 seconds with an endurance of up to 2 hours as required by the missions for which it will be used. Development of the small nuclear rocket engine would be based on the same technology assumed for development of the NERVA engine and would be conducted by the Los Alamos Scientific Laboratory (LASL). All development testing would be conducted at the Nuclear Rocket Development Station in Nevada using existing facilities with modifications made to suit the specific needs for the small engine and its components. Development of this system should be, therefore, a straightforward application of existing nuclear propulsion technology developed in the nuclear rocket program.

W73-70416 **503-24-04**
Atomic Energy Commission, Germantown, Md.
FLIGHT SAFETY R AND D
G. P. Dix 301-973-4236

During the nuclear rocket technology program, the high thrust nuclear engine (NERVA) was investigated from a safety viewpoint to establish basic limits and envelopes on chemical and physical reactions which could occur and to establish probabilistic estimates of dose effects. The purpose of the safety program was to identify in a gross way the safety advantages and features of the nuclear rocket. The redirection of the nuclear rocket program from a large, high thrust engine to a small, low thrust engine requires that another type of safety program is now needed to consolidate the results of past studies and to emphasize flight safety aspects of the small nuclear rocket engine so that safety requirements can be developed and fed into the overall small engine and stage design. Studies are being made by the stage and engine contractors for each of their elements of the small engine nuclear rocket program. Overall studies must be performed to look at these operations from a broader application viewpoint, and to examine interfaces and to identify unique needs. This is to be carried out through contractors who have systems safety capability, except where R and D needs are identified. In the latter case the stage, engine, reactor or a specialty contractor will be utilized to obtain data. The approach will vary depending on whether a safety logic analysis technique is being used or whether detailed R and D information is being obtained to fill gaps in knowledge. All of the output will be used to generate small engine or stage requirements, to establish criteria, or to aid in establishing a firm base of knowledge to assure that the small engine nuclear rockets may be safely flown.

W73-70417 **503-24-05**
Atomic Energy Commission, Germantown, Md.
NUCLEAR ROCKET TEST OPERATIONS
F. X. Gavigan 301-972-4335
(502-24-02; 503-24-03)

The objective of this RTOP is to continue the capability for test operations and support to be maintained at the Nuclear Rocket Development Station (NRDS). The following specific items of effort will be conducted: (1) The Nuclear Furnace tests will be conducted at Test Cell C with unloading and reloading

to be accomplished at the E-MAD Building. (2) The Hybrid Hydrostatic bearing in the Mark 25 pump will undergo testing at the Test Cell C. (3) Test Cell A will be utilized for heat exchanger and component tests in support of scrubber designs. (4) The Pewee 2 and XE backup will be disassembled at the E-MAD Building.

W73-70418 **503-24-01**
Atomic Energy Commission, Germantown, Md.
TELEOPERATOR SYSTEMS
E. G. Johnsen 301-972-3353

This teleoperator effort is directed towards the development of a multi-moded manipulator system. The FY 1973 effort is a continuation of the work initiated at MIT's Draper Laboratory in FY 71. The principal elements of the project are (1) development of operational manipulator pointing system, (2) further development of a hand controller, and (3) extension of the TOAD Simulation System. The work to be done in FY 73 will be related to developing practical applications of the multi-moded manipulator concept.

W73-70419 **503-24-01**
Marshall Space Flight Center, Huntsville, Ala.
TELEOPERATOR SYSTEMS
W. G. Thornton 205-453-5530
(112-30-13; 970-63-20; 503-24-06; 792-91-02)

The objective of this RTOP is to continue the development of advanced tools for manipulator systems of space teleoperators To achieve this objective the following tasks will be performed: (1) A detailed analysis of representative tasks associated with teleoperator operations in space will be completed and updated. This task was begun in FY 72 and will be updated as required in house. (2) Develop methods of using the Adage Graphics Terminal in the design analysis and operation of terminal tools. (3) Adapt existing tools to manipulator operations and evaluate in house. (4) Develop advanced terminal tools and end effectors as required by the functional analysis of task No. 1 above. Three actions have begun along these lines: (1) The development of a multi-fingered multi-jointed hand of an advanced design; (2) Conceptual design of unique wrist mechanism adapted to transfer of information and interchangeability; and (3) Design and development of specific terminator tools for end effectors.

W73-70420 **503-24-06**
Marshall Space Flight Center, Huntsville, Ala.
NUCLEAR STAGE TECHNOLOGY
H. E. Attaya 205-453-1121
(112-30-19; 121-30-19)

The long range objective of this RTOP is the development of an adequate technology base to permit the design of a low cost, lighweight, simple nuclear stage suitable for delivery to orbit in the Reusable Space Shuttle. Because of the limited space in the Space Shuttle cargo bay, efforts must be made to develop a very lightweight and inexpensive nuclear stage suitable for clustering in earth orbit. The first applications are for single burn, unmanned missions, with no reusability requirement. Compatibility with the Space Shuttle cargo bay dimensions are required. Propellant storage duration is not expected to exceed 10 hours from earth launch to completion of nuclear rocket firing from earth orbit. The PPO foam/gel hydrogen concept acts as an excellent groundhold insulation system with maximum simplicity. The use of slushes, gel/slush mixtures or solid hydrogen could eliminate the need for complex and more involved insulation concepts. For longer storage times, vapor-cooled shields, multilayer insulation and reliquefiers will be more advantageous. However, trade studies and thermal investigation must first be performed to determine the most optimum combination. In addition, reliquefier improvements must be made to support the trade study efforts. In cryogen research experimental and analytical investigations will be conducted with emphasis on the collection of data, improvement in instrumentation response and stability, and improvement in the freeze-thaw technique. The slush hydrogen generation system will be operated in-house to collect data, develop experience and evaluate the generator system and instrumentation. This is a continuation of FY 72 effort under RTOP 112-30-19.

W73-70421 **503-10-01**
Atomic Energy Commission, Germantown, Md.
QUANTUM ELECTRONICS
H. Harrison 301-973-4546

The objective is to obtain new knowledge of fundamental processes underlying laser action in order to advance the technology of high energy lasers. The present approaches include gas dynamic lasers, chemical lasers, and electric discharge lasers, all of which utilize the electronic and vibrational energy levels of atoms and molecules, to provide coherent radiation at optical and infrared wavelengths. A theoretical analysis will be made of the possibility of using the nucleus itself to obtain lasing action at gamma ray wavelengths. Also an experiment has been started to find nuclei whose spin levels can be used to obtain maser action at microwaves. In addition, research should be initiated on the basic mechanisms of liquid lasers, independent of dye lasers, to obtain high energy radiation.

W73-70422 **503-10-01**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
QUANTUM ELECTRONICS
J. W. Lucas 213-354-4530
(503-10-02)

The first objective of this research is to develop various types of high power, efficient, short wavelength lasers Emphasis is placed on the understanding of the basic physical phenomena governing the interaction of radiation and plasma kinetic processes that determine the efficiency, operating wavelength, size, and power output of laser devices. A second objective is to investigate experimental phenomena associated with population inversion in nuclear Zeeman levels and to study the feasibility of using this phenomena for a radio/microwave frequency maser. The specific efforts to be undertaken in FY'73 are: (1) experimental and theoretical studies of rate processes and radiative transport in metallic vapor and molecular inert gas plasmas specifically directed toward the development of nuclear and magnetogasdynamic lasers, (2) experimental study of a supersonic copper-vapor laser operated both repetitively pulsed and steady state with a stabilizing applied magnetic field, (3) feasibility study of a pulsed molecular inert-gas, ultraviolet laser, and (4) experimental study to develop a method of producing population inversions of the nuclear Zeeman levels and a study dealing with the production of internal energy in a maser by rapid increases in the magnetic field

W73-70423 **503-10-01**
Langley Research Center, Langley Station, Va.
HIGH RESOLUTION ATMOSPHERIC LASER PROPAGATION STUDIES
C. H. Nelson 703-827-2893

The objective of this research is to apply continuously tunable diode laser monochromators (TDLM) to performing high resolution spectroscopic studies of atmospheric absorption by major atmospheric constituents in the wavelength range of high power infrared lasers (i.e., HF approximately 2.8 micron, DF

approximately 3.5 micron, CO approximately 5 micron, CO2 approximately 10.6 micron). The TDLM has 5 to 6 orders higher resolution than existing high resolution infrared spectrometers and makes it possible to probe for new atmospheric windows. This is of special importance for propagation studies with the new and promising CO (approximately 5 micron) and HF (approximately 2.7 micron) lasers whose wavelength ranges lie in the edges of the 6.3 micron and 2.9 micron water vapor absorption bands and need high resolution definition of absorption windows. Research will be continued on high resolution computer models for horizontal and vertical transmission through these absorption windows in the wavelength ranges of CO and HF lasers. The new experimental high resolution information from the TDLM will be used to improve the computer models. High-power pulsed T laser operation will be extended from operation with CO2 to CO, HF and DF for study of atmospheric absorption and molecular relaxation effects for laser propagation.

W73-70424 **503-10-01**
Ames Research Center, Moffett Field, Calif.
QUANTUM ELECTRONICS
Glen Goodwin 415-965-5065
(503-10-03)

The general objective of this RTOP is to conduct experiments and analyses of specific topics in the physics of quantum electronics with the view of determining those aspects of coherent EM radiation particularly applicable to space science and/or technology. Specifically, the work will be concerned with quantitative evaluations of the physical processes that take place during the generation of the EM radiation within lasers and masers, during the transmission of this radiation through the media of natural environments or through man-made devices, and in the detection of this radiation. The purpose of the program is to provide the fundamental knowledge necessary for the development of an optical technology which can utilize coherent radiation in communications, power transmission, display devices, and general measurement instrumentation to be applied in planetary exploration, space physics, and avionics.

W73-70425 **503-10-02**
Lewis Research Center, Cleveland, Ohio.
ELECTRON WAVE INTERACTION AND ELECTROMAGNETIC RESEARCH
J. C. Laurence 216-433-4000

The primary objective of the Lewis program is to achieve intense, magnetic fields in large volume with a minimum mass and power requirement. Progress toward this objective requires both basic and applied research on ways to improve the current density, operating temperature, and strength of superconducting materials suitable for use in large coils. A second objective is to achieve better understanding of the physical processes involved in conduction of electricity both in the normal and the superconducting state, with a view to improving the performance of electrical components of aerospace power and propulsion systems. Superconductors will be studied theoretically and experimentally on both physics and engineering levels. In normal metals and semiconductors, the galvanomagnetic effects (magnetoresistance, Hall effect, magnetothermal effects, etc.) will be studied, especially in high fields where Landau quantization is important. The processes of excitation and dissociation of gases in strong electric and magnetic fields will be studied. The intent in each area will be to understand and to develop materials and processes with unique characteristics for specific applications. Various forms of superconductors (wire, ribbon, composites, etc.) will be tested in short samples and in actual coils to ascertain relative merits of different materials and construction techniques. Improved superconducting composites will be sought by analytic and experimental methods in order to improve superconducting magents. The high field superconducting and---

W73-70426 **503-10-02**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
ELECTRON WAVE INTERACTIONS
John W. Lucas 213-354-4530
(502-10-01)

The general objective is to advance understanding of the interaction of electromagnetic radiation with semiconductors with a long-range goal of developing highly efficient energy conversion devices to be used in laser beam energy transmission systems. Semiconductors which may be suited for photovoltaic operation in various wavelength intervals will be chosen from examples such as silicon, gallium arsenide, gallium phosphide, germanium, and indium arsenide, and will be examined for their potential in energy conversion of laser beams. Barriers in the semiconductors will be both p/n junction barriers for the medium and longer wavelengths and Schottky barriers (thin metal film-semiconductor) for the shorter and medium wavelengths.

W73-70427 **503-10-02**
Atomic Energy Commission, Germantown, Md
ELECTRON-WAVE INTERACTIONS
H. Harrison 301-973-4546

One objective is to reach a higher transition temperature (Tc), hopefully ambient, for superconductors. The maximum Tc of any known substance is 21 K. Theoretical analysis will be undertaken to determine if any combination of atoms within a bulk solid or thin film can be arrayed that they should have a higher Tc. In conjunction with the theoretical analyses, experiments will be conducted to determine whether a higher Tc is indeed reached. In addition, experiments will continue on the present paths to explore the possibility of achieving higher Tc by thin films alone, by sandwiches of thin film superconductor-insulator-superconductor, and by the inverse. Another objective is to explore distinctly new ideas seemingly leading to highly efficient methods for converting laser radiation to direct or alternating current power by solid state components.

W73-70428 **503-10-03**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
PLASMA DYNAMICS
J. W. Lucas 213-354-4530

The general objective is to advance understanding of the behavior of ionized gases. The long-range purpose is the utilization of nuclear energy in spacecraft applications and the development of high-power ion lasers. The work will emphasize advancement of knowledge of (a) ion molecule interactions, (b) electron impact spectroscopy, (c) the physics of thermionic converters, and (d) interactions between laser beams and liquid metal. Specific topics for FY'73 are (1) production of electronically excited ions by ion-molecule reactions, (2) cross-sections for electron-molecule (atom) collision processes, (3) study of correlations between the theory and the power performance of a low-temperature converter that would have an extended life expectancy, and (4) ionization of liquid cesium with laser energy. Applications are for MHD generators for nuclear power conversion, gas core nuclear reactors, nuclear and high-power ions lasers, thermionic power conversion, and laser plasma dynamic (LPD) generators for laser power conversion.

W73-70429 **503-10-03**

Lewis Research Center, Cleveland, Ohio.
PLASMA DYNAMICS
W. D. Rayle 216-433-6203
(112-28-13)

Research is directed toward gaining understanding of plasma behavior in useful ranges of density, temperature, and magnetic field strengths. The aim is to gain the ability to generate, confine, and manipulate plasmas of desirable characteristics in ways relevant to potential applications of importance to NASA programs. Theoretical and experimental tools will be investigated and developed to improve our understanding and to check that understanding with specific experiments. Applications for the knowledge sought are widespread, including MHD power generation, plasma thrusters, and thermonuclear plasmas. Experimentally, the approach is first to identify specific plasma processes relevant to specific potential applications, concerning which the present state of knowledge is inadequate; then to devise means by which a plasma demonstrating such a process may be generated and diagnosed. Among the plasma processes being studied experimentally and/or theoretically are interaction of flowing plasmas with magnetic fields, turbulence and diffusion, plasma wave interactions for plasma heating and as diagnostic tools, plasma ion heating processes, and magnetic containment

W73-70430 **503-10-03**

Atomic Energy Commission, Germantown, Md.
PLASMA DYNAMICS
K. Thom 301-973-4546
(503-04-01)

Fundamental research on specific plasmadynamics problems under a grant and contract program for supplementing NASA in-house research in areas in which in-house competence does not exist, or in which in-house research facilities are lacking. Specific research objectives are: absorption coefficients of uranium plasmas; radiation from fissioning uranium plasmas; stability of fissioning plasmas; nuclear pumped lasers; plasma boundary layers, particularly as applicable to high temperature MHD power converters.

W73-70431 **503-10-03**

Langley Research Center, Langley Station, Va.
PLASMA DYNAMICS
C. H. Nelson 703-827-2893

A plasma focus device will be used to investigate the emission spectra of a fissioning uranium plasma in the UV range (below 2000 Angstroms), since the non-thermal contribution from the fissioning plasma in a gas-core reactor is assumed to be significant in this range. The plasma temperature and density will be determined by optical methods such as the slope of the bremsstrahlung, ionization stage, and line profile. Studies of the formation of the dense plasma focus and potential application of the device will be continued. The extremely hot (50 to 80 million degrees K) and dense (10 to the 19th power particles per cubic centimeter) plasma produces very high neutron fluxes of the order 10 to the 17th power neutrons per second per square centimeter. Various parameters of the plasma focus will be changed to investigate scaling laws, using neutron yield as the performance indicator. To gain additional information on the focus formation, the studies of neutron and x-ray emissions will be continued. In addition, the possibilities of neutron radiography and fast activiation methods will be investigated. The radiative properties of a non-fissioning uranium plasma for the range of operating conditions of proposed gas-core reactors will also be experimentally investigated by means of laser produced plasmas and by existing magnetic compression devices. Specifically, the emission and absorption properties of a non-fissioning uranium plasma in the spectral range from about 300 Angstroms to 2000 Angstroms at pressures from 100 to 1000 atmospheres and for the temperature range of 10,000 K to 100,000 K will be observed.

W73-70432 **503-10-03**

Ames Research Center, Moffett Field, Calif.
PLASMA DYNAMICS
Glen Goodwin 415-965-5065
(503-10-01)

The objective of this RTOP is to improve methods for plasma generation, acceleration, containment, manipulation and diagnosis to facilitate development of arc jets accelerators, thrusters, lasers, and fission and fusion machines. Using capacitor-driven coaxial guns as plasma sources, the interaction of plasma bursts of known velocity with a strong axial magnetic field is being followed in space and time by laser-scattering and interferometry techniques. Along with u.v. spectroscopy and neutron yield (from deuterium plasmas) these measurements permit determination of temperature, density, and confinement time.

W73-70433 **503-10-04**

Langley Research Center, Langley Station, Va.
NUCLEAR PHYSICS
C. H. Nelson 703-827-2893

The objectives are: to investigate interactions of intermediate energy protons, alphas and other particles with nuclei; and to determine production and differential cross sections for ions, protons, alphas and other charged secondaries. In one part of this project, experimental data have been obtained on production of protons and heavier secondaries with energies less than 30 MeV from targets under 600 MeV proton bombardment. Cross sections will be calculated by analyzing this data in terms of numbers of secondary particles of given mass, charge angle, and energy, as a function of number of incident protons. In another part of this project, experimental data have been obtained on the production, in aluminum, of protons and charged pions at small angles (approximately less than 10 degrees) and at energies greater than 50 MeV. Data consist of photographs of particle tracks in an optical spark chamber in a magnetic field. From measurements of incident and secondary particle trajectories, particle mass, charge, emission angle, and energy will be determined Cross sections will be calculated for several types of interactions. Fully relativistic description of proton-deuteron (p,d), scattering will be formulated. Deuteron structure parameters will be extracted by comparison with experimental deuteron structure by comparison with experimental data. Calculations to describe analytically proton-nucleus reactions at high energy (greater than 100 MeV) will be extended. Phenomenological model of heavy-heavy interactions--those between nuclei of mass greater than or equal to 10 amu will be developed. Predictions of previously constructed fully relativistic multiple---

W73-70434 **503-10-04**

Lewis Research Center, Cleveland, Ohio.
NUCLEAR PHYSICS
J. W. Blue 216-433-4000

Project 1 - Cyclotron Development and Operation covers the work required to make the newly modified cyclotron operational and to provide the various beams required to meet the diverse needs of the research program. Project 2 - Cyclotron Simulation of Reactor Radiation consists of setting up and performing reactor simulation experiments on thermionic insulators, high temperature thermocouples, refractory metals and fused silica. Project 3 - Theoretical Studies of Nuclear Reactions aim at improving the accuracy with which nuclear

reactions can be calculated. The objective is to provide better data for shielding calculations. Project 4 - Experimental Nuclear Reactions covers the single encounter of charged and neutral particles with nuclei. The many possible outcomes are studied and their absolute probabilities determined at solar flare and Van Allen energies. Project 5 - Experimental Multiple Nuclear Reactions covers the work related to reactor technology and to reactor and space shields. In this case the summation of the diverse number of single nuclear encounters are studied. Project 6 - Non-Equilibrium Reactions covers the work on solid hydrogen and uranium plasmas in which ionizing radiation produces atomic electron excitations and ionizations far from temperature equilibrium. These species subsequently undergo chemical reactions with atoms and molecules that are in thermal equilibrium. Project 7 - Technology Applications for Nuclear Physics are studied for their use in space technology, medical applications and pollution problems.

W73-70435 **792-91-01**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
ADVANCED PROPULSION COMPARISON STUDY
John W. Lucas 213-354-4530

It is the objective of this RTOP to provide authoritative, factual and unbiased information to the Advanced Propulsion Comparison (APC) Committee relative to four specified classes of upper-stage and spacecraft propulsion: advanced chemical propulsion, nuclear rocket, nuclear electric propulsion, and solar electric propulsion. Cost, schedule, performance and risk information will be provided for each mode as utilized in various mission sets to be defined by the committee. The approach used in this effort is to organize a team of experienced specialists drawn from the JPL technical divisions to analyze mission and spacecraft requirements for the defined missions, and to derive the requirements of the four propulsion concepts. The mission, spacecraft, propulsion, and other appropriate requirements will be defined by this team in a mission definition document. Based on this document, a second team, assisted by specialists in each of the propulsion techniques, will develop additional data and more detailed information to be presented in a mission description document. A third team will use the mission description document as a baseline to develop a broad implementation document which will include mission costs, risks and other comparative parameters. A close, informal, and frequent interaction with the committee will be maintained so that results from all the teams are easily assimilated and are credible to the committee.

W73-70436 **792-91-01**
Space Nuclear Systems Office (AEC), Washington, D.C.
ADVANCED PROPULSION COMPARISON STUDIES
P. G. Johnson 301-973-4546

The objective of this study activity is to compare the several potential advanced propulsion systems (and combinations thereof) in terms of their overall effectiveness in the space program of the 1980's and beyond. A major part of the comparison will be an economic basis, including transportation costs (recurring and non-recurring), spacecraft costs (taking advantage of variations in performance capability), mission costs (including relative success probabilities and revised implemenation plans) and the sensitivity to activity levels, budget constraints and technology projections. The study approach consists of a committee-coordinated accumulation of consistent input data (defining mission models, performance specifications and system costs) feeding first into detailed mission definition studies (which derive spacecraft and mission descriptions and costs corresponding to each propulsion system combination) and then into an overall economic analysis (which will display program costs as functions of propulsion system combinations and other porgrammatic and technical constraints and assumptions) The Advanced Propulsion Comparison committee will then integrate the economic analysis results with other factors and considerations into a broad assessment of the proper role of advanced space propulsion.

W73-70437 **792-91-02**
Marshall Space Flight Center, Huntsville, Ala.
NUCLEAR STAGE DEFINITION
R. J. Harris 205-453-2370
(112-30-19; 503-24-06)

The objective of this project is to provide Phase A conceptual definition of a stage utilizing the small nuclear rocket engine. In one programmatic approach, the anticipated application for this stage, during the early operational period, is an injection system for high energy, unmanned planetary spacecraft. Evolution to a system capable of shuttling manned or unmanned payloads between orbits in a reusable mode is anticipated in later operational time periods. Another approach for comparison in the study calls for initial development of an unmanned reusable stage which evolves later into a manrated stage. In addition there are several variations of the small nuclear rocket engine and potential combinations with other propulsion systems which could alter the nuclear stage approach. Current study efforts are investigating a wide spectrum of system concepts and mission applications. The objective is to arrive at a versatile system with many mission applications through the use of systematic synthesis/screening approaches. Studies of these systems were initiated in February 1972 via the re-orientation of the Reusable Nuclear Stage studies which were begun in October 1969. It is planned to use FY 73 funds to define the selected concepts and related operations in greater depth, provide stage related data for engine design and support the Advanced Propulsion Comparison Study.

OFFICE OF APPLICATIONS

Earth Observations SR&T

W73-70438 **160-20-51**
Goddard Space Flight Center, Greenbelt, Md.
SPACECRAFT SYSTEMS AND TECHNOLOGY
John Flaherty 301-982-6862

The impact on the various spacecraft systems of a large aperature high resolution earth observing scanning radiometer will be studied. The use of a large oscillating mirror in the object plane has a substantial effect on the spacecraft attitude control and determination systems. The hardware requirements for attitude control to properly scan the earth and for attitude determination with accuracy comparable to the radiometer resolution will be developed. Both automated stellar referencing and earth landmarks recognition systems will be used. Functional models of the hardware will be developed where feasible. The accurate referencing of the large scanning mirror relative to the spacecraft is also necessary, and shaft angle encoders somewhat beyond the present state-of-the-art will be necessary. The spacecraft structural requirements for supporting the large scanning mirror without causing detrimental vibrations will be determined. High resolution sensors will require high data transmission rates, with a directional, gimbaled antenna. They will require many very low temperature detectors for the infrared spectral regions, which will necessitate a large radiation or cryogenic cooler. They will also require high power levels, such as may be attained from large, lightweight flexible solar arrays. The impact to these requirements on the spacecraft will be determined. The impact on spacecraft operating at synchronous and very low orbit, as well as the intermediate 500-1000 mile altitudes, will be studied.

W73-70439 **160-20-52**
Goddard Space Flight Center, Greenbelt, Md.
DATA MANAGEMENT AND STORAGE
Marvin S. Maxwell 301-982-4036

The next generation of Earth Observation Spacecraft with their advanced sensors will generate very large quantities of data. This RTOP will investigate and develop systems that will provide the needed spacecraft and supporting ground systems to acquire, process, store, and calibrate this data. The first consideration is how to optimize the sensor multiplexer and ground processing elements as a total system to maximize the information. Techniques are being developed to multiplex and demultiplex data at very high data rates. Techniques for data distribution within a large repairable, shuttle compatible, spacecraft using the data bus concept will be investigated. Systems for distributing commands and the desirability of using an on board computer to optimize the control and data acquisition in large observatory spacecraft will be studied. Systems to allow efficient direct transmission (APT) of Earth Survey data are being developed A study will be conducted of the preferred ways to radiometrically calibrate the data from multispectral scanners. On board storage of data is one of the major problems in development of adequate data systems for Earth Observation Spacecraft. Magnetic tape recorders are being developed to provide a 5 year life and to efficiently accommodate variable input data both before launch and in orbit. Buffer memories and mass memory systems requiring no moving parts are also being developed. Close liaison will be maintained with RTOP 160-20-53 to assure compatibility with the advanced sensor developments, with RTOP 120-20-59 to assure compatibility with the EOS ground data processing developments and with the EOS advanced studies RTOPs.

W73-70440 **160-20-52**
Jet Propulsion Lab., Calif. Inst. of Tech , Pasadena.
DATA MANAGEMENT AND STORAGE
Donald P. Burcham 213-354-3028
(186-68-56; 125-23-12)

Advanced data management and processing system technology will be developed to satisfy future Earth satellite requirements. The focus of the activity will be to develop preliminary design of a Computer Aided Telemetry System, an adaptive high performance television data compressor, and a reliable, flexible mass data storage device. It is planned to demonstrate the feasibility and utility of these designs the end of fiscal year '74. These advanced development activities will be performed in-house by personnel who have developed innovative solutions to similar problems related to advanced planetary missions.

W73-70441 **160-20-53**
Jet Propulsion Lab., Calif Inst. of Tech., Pasadena.
EARTH OBSERVATION IMAGING ANALYSIS TECHNIQUES
D. P. Burcham 213-354-3028

The successful choice of imaging systems for space applications has been continually hampered by the lack of effective communication between the investigator and the designer and by the lack of quantitative analysis tools for performing system evaluation, tradeoff, and optimization. The communication problem consists of the fact that the investigator cannot generally express his requirements in the language of the designer, both because he is unfamiliar with the language and because adequate data to quantify the relationship may not exist. The lack of quantitative analysis tools results from the large number of parameters involved, the non-linear components, and the adequacy of existing techniques for the simple objectives of the past. The objectives being established for earth observation missions are more sophisticated, more rigorously defined, and more demanding in scope than the objectives of past missions Past analysis techniques cannot provide for meeting these objectives without prohibitively costly empiricism. Sufficient evidence now exists that useful new analytic techniques can be developed based on a combination of recent experience in image simulation and in computerized performance analysis, tempered by long experience in the practical aspects and limitations of space imaging systems. Quantitative analysis techniques will be developed through a combination of imagery simulation and computer simulation will be used to determine parameters necessary to meet the requirements of the imagery user. The IMSYS computer program will, after modification for earth observation missions, perform tradeoff and optimization studies. The techniques will then be available for selection and evaluation of imaging systems for earth observation.

W73-70442 **160-20-53**
Goddard Space Flight Center, Greenbelt, Md.
VISIBLE AND IR SENSOR TECHNOLOGY
H. Ostrow 301-982-4107

Imaging systems with advanced performance capability are required for future earth survey missions. Systems with increased spatial and spectral resolution, response into the emissive IR along with inherent registration between spectral channels are required. The desired characteristics can be achieved by development of suitable new sensors, such as large photosensor line arrays and advanced scanner systems. Solid state linear arrays with thousands of elements can be assembled. By using multiple arrays, registered high spatial resolution images can be obtained without using mechanical scanning techniques. Scanning spectro-radiometers can provide radiometrically accurate data from the visible through the emissive IR region, but additional development is required in the area of detector technology and coolers to achieve high resolution at high signal-to-noise ratio. Other advanced image sensor techniques appear applicable. One technique uses an optical filter which encodes each spectral band into a discrete and separable channel in the frequency domain. This technique is now being used in some ground based applications and provides inherently perfect registration. The extension of the technique to earth observation systems will be pursued.

W73-70443 **160-20-54**
Goddard Space Flight Center, Greenbelt, Md.
MICROWAVE SENSOR TECHNOLOGY
C. Laughlin 301-982-5971

The objective of this program is to develop the technology of remote sensing of the earth's surface and atmospheric properties by microwave radiometry and scatterometry from a spacecraft. Active radar scatterometry will be studied both as an independent sensor in its own right and as a supplementry tool with passive microwave radiometry. Studies will be performed to devise combined microwave radiometer/scatterometer systems that can be accommodated by existing and future spacecrafts. System studies will be performed to develop various solid aperture and phased array antennas with the aim of designing multi-frequency and multi-polarity scanning antennas suitable for space borne microwave radiometers and scatterometers. Components and calibration techniques that are critical to microwave radiometry and scatterometry will be developed. This includes the RF switches, stable solid state microwave sources, low noise RF preamplifiers, and accurate reference sources.

W73-70444 **160-20-54**
Langley Research Center, Langley Station, Va.
MICROWAVE RADIOMETRY FOR REMOTE SENSING
G. B. Graves 703-827-3745

The objective of this work is to improve the remote sensing capability of microwave devices The general approach is to develop the techniques for the application of passive radiometry for obtaining earth resources measurements with emphasis in the area of oceanography. Research is focused on, (1) improved measurement techniques, and (2) improved techniques for the analysis and interpretation of data. The scope of this work includes the development of key components such as low-noise antennas and image line integrated circuits, the development of techniques for multifrequency or broadband measurements, and the development of data processing techniques and validation of analytical models for inferring physical properties from the measurement of scattering and emissions from rough surfaces such as the ocean. This work includes the acquisition and analysis of experimental data obtained in the laboratory and at remote sites.

W73-70445 **160-20-54**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
IPL METHODS FOR GEOLOGIC MAPPING
Donald P. Burcham 213-354-3028

Regional geologic problems and geologic mapping on a regional scale (1:250,000) are best attacked with high-altitude aircraft and spacecraft multispectral images. This new dimension in geologic mapping has not yet been exploited and should prove to be a valuable adjunct to the present standard photogeologic methods. In addition to multispectral information, spacecraft images, because of the narrow angle camera field of view, should allow the use of photometric function information for discrimination of surface rock types. A substantial reduction in field time required to produce a regional geologic map is expected from use of computer data analysis methods. A systematic approach to the use of remote sensing images requires the investigation of the geomorphic and surface physical properties, both in situ and by remote imaging. This has three main activities: (1) Examinations of typical test sites, using, initially, our present ERTS test sites. (2) Obtaining of suitable images from available image libraries and by new overflights. This will include photographic images, data outputs from multispectral scanning systems and special purpose scanning devices. (3) Develop and apply new methods of image processing to the solution of geologic problems. From this broad scale investigation we can determine the optimum set of indicators and propose specific techniques. These methods would be developed using one or more test areas or ground truth sites. The geologic support might come partially from JPL, however, it is expected that a number of interested users in the USGS, possibly funded by the ERTS-SKYLAB and EROS program, would provide the main inputs.

W73-70446 **160-20-55**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
SURFACE MOTION MONITOR
Donald P. Burcham 213-354-3028

The objective is to measure the motion of a surface with respect to benchmarks by using coherent radar techniques. Areas that are of particular interest are the ice areas in Greenland, the region covered by the Alaskan pipe line and the Antarctic ice cap; and these areas can be used to establish the degree of practicality of the system. Key areas will be imaged by the JPL 25 cm radar and the imagery will show the large scatterers buried beneath the surface of snow. The position of these scatterers will be checked four times during the course of a year. This measurement uses the imaging properties of the coherent radar. Several Luneberg lens reflectors will be placed on the surface, some located on mountains or regions not expected to move to serve as reference positions. The others will be placed on ice fields, permafrost areas, glacial areas or slide areas The relative location of these reflectors will then be measured to within a fraction of a wavelength during the four over-flights during the year. These measurements will demonstrate that snow cover, cloud cover or weather will have little or no effect.

W73-70447 **160-20-56**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
ATMOSPHERIC POLLUTION SENSING: HETERODYNE SPECTROSCOPY
D. P. Burcham 213-354-3028

The general objective is to develop sensing systems which utilize infrared laser technology for the remote monitoring of atmospheric pollutants from aircraft and spacecraft altitudes. The systems under investigation and development are of both passive and active types. They will provide certain capabilities which are not presently available using passive radiometers or solar absorption spectrometers. The initial remote sensing instrument will be an active laser absorption spectrometer, using a narrow bandwidth heterodyne radiometer as a receiver. Utilizing previously determined spectral overlaps between certain emission lines of CO2 and CO molecular lasers and pollutant absorption lines, the plan is to initially use the instrument as a monitor of NO or SO2. A closely related passive heterodyne radiometer, using a wider IF bandwidth, will also be developed. The goals for FY'73 are to conduct several ground based observations and to develop an instrument which will be suitable for use in aircraft. Concurrent analysis will continue on the potential of other remote sensing systems which make use of laser technology and appear to offer advantages over present instruments.

W73-70448 **160-20-58**
Goddard Space Flight Center, Greenbelt, Md.
CALIBRATION, EVALUATION AND SIMULATION OF EARTH RESOURCE MULTICHANNEL SURFACE SENSORS
W. A. Hovis 301-982-6465
(160-75-51)

The objective of this effort is to develop and utilize techniques to calibrate advanced earth sensors, to determine the accuracy and repeatability of these sensors and to carry out measurements and to determine how best to optimize sensor characteristics for future earth observations sensors Techniques to calibrate large aperture, multi-spectral sensors, designed to view extended sources, are developed in this area and utilized to define sensitivities and determine noise performance of aircraft, field and space flight sensors. Vender calibration sources are calibrated periodically and delivered flight sensors are checked for compliance with NASA specifications. Simulation is carried out with field and aircraft sensors specifically matched to spacecraft sensor spectral character and radiant sensitivity. Underflights of aircraft in conjunction with ERTS overpasses will be utilized to verify ERTS sensor performance and internal calibration accuracy. Field measurements are carried out to determine optimum characteristics for future spacecraft sensors especially in the areas of optimum spectral intervals, optimum spectral bandwidths and determination of dynamic range for varying surface characteristics.

W73-70449 **160-20-59**
Goddard Space Flight Center, Greenbelt, Md.
ADVANCED IMAGE PROCESSING TECHNIQUES

John Y. Sos 301-982-2841
(160-75-53)

The ERTS Ground Data Handling System (GDHS) is being established with little flexibility and essentially no R&D capability. This approach is satisfactory to meet initial user requirements for ERTS-A and -B. But as user applications of satellite imagery evolve into articulate requirements and as future systems develop, the GDHS must also evolve to insure effective utilization of imagery data. The tasks in this RTOP will provide the research required to develop new techniques and systems for image processing and analysis. Techniques will be investigated that will lead up to the generation of more useful image data products such as image mosaics, enhanced images, and false color presentations. Emphasis will also be placed on the development of efficient digital image processing algorithms and systems that do not require very large digital computers to keep up with the anticipated analysis

W73-70450 **160-44-51**
Goddard Space Flight Center, Greenbelt, Md.
TECHNIQUES FOR UTILIZING SATELLITE OBSERVATIONS IN METEOROLOGICAL APPLICATIONS
R. Wexler 301-982-2188
(160-44-63; 160-44-65; 160-44-58)

The objective is to apply satellite observations to the quantitative measurements of meteorological phenomena. Specifically, the satellite data are applied to determine sea surface temperature, vertical distribution of atmospheric temperature, humidity, and ozone, and cloud motions (wind) from geostationary satellites. Applications of these derived parameters may then be made to studies of mesoscale systems, planetary scale phenomena, stratospheric circulation, the radiation heat budget and climatic change. Special focal points of this research are the establishment of a basis for the specification of a system for continuous observations of weather features so that these observations can be applied to short-term weather forecasts.

W73-70451 **160-44-53**
Goddard Space Flight Center, Greenbelt, Md.
REMOTE SENSING TECHNIQUES FOR ATMOSPHERIC STRUCTURE AND SURFACE CONDITION RELEVANT TO METEOROLOGY
W. A. Hovis 301-982-6465

The objective of this RTOP is to develop and test techniques for remote sensing of the atmosphere, including suspended particulate matter and surface interface conditions such as solid surface temperatures, soil moisture content as it is pertinent to meteorology, and ocean surface temperature and roughness. Cloud physics studies are carried out to determine the ability of remote sensing to ascertain such parameters as phase; i.e. ice or water, particle size, size distribution and particle shape. Studies are conducted with sensors measuring reflected solar energy spectrally, polarization of reflected solar energy, cloud top temperature, in situ laser nephelometer measurements of particle size and size distribution, and atmospheric water vapor content. Nephelometer, temperature, and water vapor measurements are made from high altitudes down through cloud decks to obtain a complete profile of physical characteristics of clouds observed by the remote sensors. Measurements of surface conditions that are pertinent to meteorological investigations are carried out throughout the spectrum from the visible through the infrared and into the microwave region of the electromagnetic spectrum. The results of these measurements are utilized to guide the specification, production, and data handling procedures for experiments on applications spacecraft.

W73-70452 **160-44-54**
Goddard Space Flight Center, Greenbelt, Md.
RADIATIVE TRANSFER MODELS RELATING TO ATMOSPHERE AND SURFACE CHARACTERISTICS
R. Fraser 301-982-4235
(160-44-60)

The objective is to determine the radiative characteristics of gaseous and particulate constituents of the atmosphere and of natural surfaces. Laboratory measurements, involving absorption tubes, will be made to study the radiative properties of the optically active gases. Theoretical analyses of spectral line intensities, positions, and shapes will be made in conjunction with the experimental measurements. An Infrared Interferometer Spectrometer (IRIS) will be flown aloft by means of a high altitude balloon and infrared spectra will be obtained with a resolution of 0.2 wavenumbers in the spectral region 4-50 micrometers. These measurements will be used to investigate radiative properties of the surface of the Earth and of optically active gases and particulates in the atmosphere. A microwave radiometer mounted on aircraft or high altitude balloon will measure radiances at selected wavelengths near 5 mm over different kinds of terrain and through a variety of clouds. Theoretical analysis will be made to determine absorption line models. These studies will provide the physical basis for remotely sounding the atmosphere and for sensing characteristics of the surface boundary such as land and sea surface temperatures, soil moisture, etc.

W73-70453 **160-44-55**
Goddard Space Flight Center, Greenbelt, Md.
ANALYSIS OF ENERGY INTERACTIONS BETWEEN LEVELS OF THE ATMOSPHERE AND SOLAR TERRESTRIAL RELATIONSHIP
D. F. Heath 301-982-6421

The objective is to investigate the mechanical, radiational and chemical energies between the lower and upper regions of the atmosphere. The areas of investigation include: tides, turbulence and gravity waves originating in the lower atmosphere and propagating into the stratosphere and mesosphere, the derivation of global distributions of atmospheric ozone, the photochemistry and transport mechanisms in the stratosphere, the conversion of Nimbus instrumentation and its subsequent use to provide high accuracy spectroradiometric measurements of the UV solar energy which is absorbed in the stratosphere, the development of new absolute spectroradiometric calibration techniques and the development of low cost sounders to measure ozone, water vapor, and other trace constituents from small inexpensive sounding rockets.

W73-70454 **160-44-56**
Goddard Space Flight Center, Greenbelt, Md.
EARTH OBSERVATIONS LABORATORY, FIELD EXPERIMENTS, AND CALIBRATION OF RADIATION SENSORS
W. A. Hovis 301-982-6465

The objectives of this effort are to provide laboratory calibration facilities, improve sensor techniques and components, and provide support for field tests of sensors particularly those of NASA aircraft. New calibration techniques for new sensors such as the SMS VISSR with a 16 inch diameter telescope are necessary, especially in the visible and near infrared, and are developed in this effort. Calibration of flight sensors by vendors requires validation before integration into spacecraft so a major objective of this effort is to maintain an up-to-date NASA facility for such validation. A master calibration source for calibration of instruments viewing diffuse surfaces by reflected solar energy is maintained and constantly recalibrated providing

a standard for vendors and other NASA centers. In the microwave region of the spectrum the emissivities of natural surfaces will be determined together with development of new components and new calibration techniques. Microwave radiometers at several frequencies will be used to study the distinguishable features of materials such as water, ice, dry soil, swamps, dense vegetation, clouds and rainfall. The NASA CV-990, the major aircraft support for the NASA meteorology program is modified and equipped, as a part of this effort, to provide a high altitude platform for tests of meteorological experiments in cloud physics, solid surface boundary conditions, sea surface conditions, and temperature sounding.

W73-70455 **160-44-57**
Ames Research Center, Moffett Field, Calif.
AIRCRAFT SUPPORT OF THE METEOROLOGY PROGRAM
Glen Goodwin 415-965-5065
(160-44-60)

This RTOP is to provide an airborne platform carrying instruments for meteorological measurements to calibrate and flight test experimental concepts, demonstrate feasibility of new instruments, and determine instrument modifications required to obtain optimum results from subsequent space borne sensors; and also to correlate aircraft remote sensor measurements with those of meteorological satellites for evaluation and interpretation of the satellite sensors and measurements. Experiments developed in the meteorological program will be mounted and flown aboard Ames Research Center aircraft. Along with supporting experiments, environmental sensors will be used to obtain the information required to evaluate and demonstrate the adequacy of the experimented concepts and instrumentation. In-flight performance of the aircraft and flight environmental data are collected by a high speed airborne digital data acquisition system (ADDAS) for collation and use with the data collected by the various meteorological experiments.

W73-70456 **160-44-58**
Marshall Space Flight Center, Huntsville, Ala.
CLIMATOLOGICAL-STATISTICAL ATMOSPHERIC AND CLOUD COVER MODELS
S. C. Brown 205-453-3141

World-wide Cloud Cover Model - The consequence of cloud cover on earth-viewing space missions is evaluated by a Monte-Carlo computer simulation procedure using the world-wide cloud cover statistics. These cloud and severe weather (thunderstorm, electrical activity, hurricanes, etc.) data contain probability distributions for various categories arranged by monthly and three hourly reference periods. To account for cloud persistence, spatial and temporal probability values are included. Simulation results are given for a specified satellite pass number. These analyses are directly applicable to Skylab and other Earth Resources mission analysis studies. Four-Dimensional Atmospheric Models (World-wide) - Atmospheric data comprised of monthly means and variances were collected and analyzed for the purpose of making electromagnetic energy attenuation predictions. While atmospheric moisture is the most important parameter other thermodynamic quantities (pressure, temperature, and density) are included in the study These data are being extended to a uniform altitude on a global basis. After analysis, analytical functions were fitted to these empirical data so that profiles required in attenuation computations could be internally generated by the computer. Next, a Monte-Carlo procedure will permit selection of a profile for mission simulation (mission analysis) studies. The ultimate goal of both tasks is to develop a consistent set of atmospheric data for use in earth viewing mission analysis studies. This includes sensor design and selection, mission feasibility, and mission planning. A by-product of Task 2 is a "Reference Atmosphere" at any given latitude-longitude. The committee on Extension to the U. S. Standard Atmosphere has recently identified this as a requirement.

W73-70457 **160-44-60**
Ames Research Center, Moffett Field, Calif.
ATMOSPHERIC EFFECTS UPON REMOTE SENSING FROM AIRCRAFT AND SATELLITES
Glen Goodwin 415-965-5065
(160-75-22)

The purpose is to determine the effects of spectral transmittance and variability upon the quantitative interpretation of radiometric data obtained from aircraft and spacecraft; and to develop analytical models for subsequent correction and interpretation. The research will directly support the present NASA Earth Resources Program in that the measurements and analyses will aid the interpretation of multispectral data from Earth Resources Technology Satellites (ERTS) and will delineate optimum spectral regions for detection and identification of selected resource targets. Analytical studies will be made of the solar and infrared regions to determine the characteristics and influence of the atmosphere, including clouds, on the sensing of surface temperatures and selected spectral reflectance and emittance signatures. Parametric studies will be made of atmospheric transmission effects and spectral signatures of selected earth resources targets to determine optimum spectral regions for detection and identification. Airborne spectroradiometric measurements of direct and scattered solar radiation and emitted infrared radiation from the earth and atmosphere will be made.

W73-70458 **160-44-63**
Langley Research Center, Langley Station, Va.
NUMERICAL MODEL AND SIMULATION OF SEVERE STORMS COUPLED EARTH ENERGY AND MASS TRANSPORT CYCLES
C. H. Nelson 703-827-2893

This work is aimed at the development of a coordinated set of mathematical models applicable to a number of problems involving the earth's atmosphere and oceans, either individually or in a coupled fashion, on either a regional or global scale. Specifically, the models will be developed to study (1) severe atmospheric disturbances such as hurricanes and tornado producing thunderstorms, (2) the dispersal of pollutants in the atmosphere and the influence of these pollutants on the earth's energy balance, (3) ocean currents and polluant dispersal in coastal zone oceans and bays, and (4) the planetary boundary layer and the problems associated with the air-sea interface. More specific objectives can be given for each of these problem areas. As an example, the severe storms models will be used in conjunction with meteorological data to (a) develop a detailed understanding of the atmospheric conditions necessary for the development and growth of storms, (b) develop requirements for better meteorological data and instrumentation including the requirements for remote sensing from satellites, (c) predict storm motions with sufficient accuracy to provide meaningful storm warnings. After development, the models will be available for computer experiments in each of the four areas mentioned above. To cite an example consider item (2) above, "the dispersal of pollutants in the atmosphere." With the proposed models it will be possible to study the effects of increasing or decreasing the pollutant load injected---

W73-70459 **160-44-64**
Langley Research Center, Langley Station, Va.
ATMOSPHERIC POLLUTION SENSING
G. B. Graves 703-827-3745

The objective of this work is to develop techniques and sensors to measure atmospheric trace constituents, both gaseous and particulate. The primary emphasis is on development of remote sensors for measuring pollutant distributions over regional and global areas. In situ sampling techniques are included to provide improved ground-truth measurements for flight tests of remote sensors. Chemical analysis techniques for atmospheric particles are included to study the origins of the aerosols at different altitude regimes. The research on passive remote sensors operating in both infrared and microwave spectral regions requires that the spectral signatures of the important trace constituents and interferring gases be accurately determined, and work is underway on the signatures of SO2, CO, NO2, CH3. An engineering model of a non-dispersive gas filter correlation analyzer has been developed for aircraft flight testing in early FY 73, and analytical feasibility studies of a limb-scanning gas-filter radiometer to measure vertical profiles of SO2 and NOx in the lower stratosphere are proposed. The work on in situ samplers includes work on solid-state resonant cavity microwave spectrometers to measure sulfur dioxide, ammonia, and formaldehyde, and on development of particle samplers which can determine the atmospheric aerosol size distributions of various altitudes.

W73-70460 **160-44-65**
Langley Research Center, Langley Station, Va
EXTENDED MEASUREMENT OF ALBEDO AND TERRESTRIAL RADIATION
C. H. Nelson 703-827-2893

The principle objectives are to adopt existing methods, materials and flight hardware to the development of an accurate, but inexpensive, satellite system for measuring the earth heat budget. It will be necessary to continue these measurements for perhaps two solar cycles (about 22 years) in order to assess both short and long-term trends. Studies using existing data will be used in designing and planning the experiment, and data analysis. Engineering studies, environmental tests, and systems tests using existing facilities will be made to ensure that sensors and electronics will operate accurately over long periods. Plans for reducing and analyzing data over a long period will be implemented. In addition, measurements to validate the proposed experiment are planned. These measurements will be made with existing sensor designs on a planned meteorological satellite.

W73-70461 **160-44-67**
Goddard Space Flight Center, Greenbelt, Md.
TECHNIQUES FOR MEASUREMENT OF STRATOSPHERIC CONSTITUENTS
D. F. Heath 301-982-6421
(160-44-68; 160-44-64; 160-44-79)

Detection techniques will be developed for the measurement of stratospheric trace constituents. The research will be directed towards those constituents introduced by stratospheric pollution and those naturally occurring in the stratosphere whose concentration may be affected by the addition of stratospheric pollution. The instrumentation developed will be used to determine the changes in space and time of the distributions of the trace constituents and an assessment will be made of the effect of stratospheric pollution.

W73-70462 **160-44-68**
Wallops Station, Wallops Island, Va.
OZONE MEASUREMENTS
J. F. Spurling 703-824-3411

The objective is to improve the techniques for the measurement of atmospheric ozone. The approaches are: 1) Improvement of the methods of evaluation of remote optical measurement of ozone and other atmospheric trace constitutents by improved utilization of the theory of atmospheric transmission of light; 2) Evaluation and intercomparison of satellite-borne, aircraft-borne, balloon-borne, and ground-based sensors for the measurement of ozone; 3) Development of system design parameters of a system for routine synoptic measurement of total atmospheric ozone and vertical ozone profile.

W73-70463 **160-44-69**
Marshall Space Flight Center, Huntsville, Ala.
INTERRELATIONS BETWEEN ATMOSPHERIC MOTIONS OF DIFFERENT SCALES
W. W. Vaughan 205-453-3106

Past research has demonstrated the existence of significant relationships between small size systems which are detectable in synoptic data and subsynoptic or mesoscale systems. The results show the relationships are complicated and depend on the Four-Dimensional structure of the entire atmosphere from the stratosphere to the ground. The best and most promising approach is to define small-scale synoptic systems and then relate these systems to weather events. This approach will allow an attack on the problem on a theoretical basis using principles of hydrodynamics, kinematics, and thermodynamics. In numerical weather prediction models, systems with a dimension of less than approximately 500 km are assumed to be functionally related to larger scale or mean motions. The proposed research is to investigate the relationship that exist between mesoscale atmospheric phenomena and larger-scale averages of the same or related phenomena. In addition, the atmospheric structure derived from satellite remote sensing measurements will be assessed relative to applicability of mesoscale structure definition. This will be revealed by selected atmospheric variability experiments involving radiosonde, rocketsonde, and satellite soundings data sets.

W73-70464 **160-44-78**
Ames Research Center, Moffett Field, Calif.
LABORATORY INVESTIGATION OF MINOR ATMOSPHERIC CONSTITUENTS
Glen Goodwin 415-965-5065
(160-44-78; 501-38-17; 160-75-22)

The objective of this work is to provide the spectroscopic data needed to detect and to quantitatively determine the amounts of various minor constituents in the earth's atmosphere. The constituents to be studied will include pollutant gases such as NO2, SO2, CO and O3. High resolution spectrometers and interferometer-spectrometers will be used in conjunction with a variety of existing absorption cells to measure the absorption spectra of each of the minor constituents. An interferometer-absorption cell system will be fabricated and installed on an aircraft to permit vertical and horizontal sampling of the atmosphere. Data obtained in the laboratory will then be used in the interpretation of the spectra of the samples to determine the amounts of various pollutants actually present in a given path through the atmosphere.

W73-70465 **160-44-79**
Ames Research Center, Moffett Field, Calif.
GLOBAL STUDY OF STRATOSPHERIC CONSTITUENTS
Glen Goodwin 415-965-5065
(160-44-78; 501-02-02, 501-38-17)

The long range goals are to reach as complete an understanding as possible of stratospheric air chemistry and

physics. Specifically, we propose to (a) establish a global 'bench-mark' as a background against which to compare future measurements, (b) determine the effect of surface sources of contaminants on stratospheric air composition and turbidity, (c) evaluate the effect on stratospheric structure of natural weather phenomena and volcanic activity, and (d) evaluate the effect or stratospheric structure of artificial perturbations (e.g., space shuttle, SST). Airborne measurements of stratospheric minor constituents including material in the 0.1 to 1 micron range will be carried out over large geographic areas using aircraft capable of flying in the stratosphere. These measurements will be made above regions far removed from surface sources (in the sense of prevailing circulation patterns) as well as during, immediately after and long after large volcanic eruptions and large scale weather phenomena capable of affecting the stratosphere. The measurement of most of the materials of interest (O3 H2, CO, CO2, SO2, NO4 aerosols) is currently within the state-of-the-art. An instrument package has been assembled using commercially available items. Flight tests in the CV990 have commenced. When the package is working satisfactorily, operations using the U-2 aircraft will commence. A sampling program will be designed and carried out to provide the desired air chemistry data, and the data so obtained will be correlated with model studies in order to meet the objectives of the program.

W73-70466 **160-75-01**
Wallops Station, Wallops Island, Va.
REMOTE SENSING OF VEGETATION, SOILS AND RELATED WATER RESOURCES
J. H. Scott 703-824-3411
(160-75-21; 160-75-32; 160-75-30)

This project is designed to apply remote sensing and advanced technology to the agricultural and forestry problems in the Chesapeake Bay Area Climatological data and soil conditions will be related to the vigor of major crops under both normal and stressed situations using multispectral remote sensing techniques in combination with ground truth data obtained by trained observers. Synoptic identification of crops will be accomplished by establishing multispectral signatures. The information obtained in this program of immediate benefit to the agricultural community will be made available in real-time form. A combination of ground instrumentation and trained observers will be utilized with multispectral remote sensing techniques to follow the development of crops over the growing season. An important part of this work will be the assessment of damage done by the pine bark beetle, and conditions that relate to susceptibility and control.

W73-70467 **160-75-02**
Marshall Space Flight Center, Huntsville, Ala.
REMOTE SENSING OF VEGETATION AND WILDLAND RESOURCE STRESSES
G. F. McDonough 205-453-2880

The primary objective of this work is the application of existing aerospace techniques to local or regional problems of concern to state and county decision makers and other groups in the regional user community. A secondary objective is to introduce such user groups to the potential value of ERTS and Skylab Resources data for agricultural purposes and to encourage them to plan the use of such data as it becomes available in the future. To accomplish the above, certain projects are proposed to demonstrate the application of existing remote sensing techniques to the detection of stress in crops of this regions. User-partners have been chosen, including the Auburn University Cooperative Extension Service and the University of Georgia Experiment Stations, to provide representation variety in crops and test sites for the Southeastern region. Test sites will be identified for each of the crops at various locations in Georgia and Alabama by the Extension Service and Experiment Station personnel. MSFC will provide aircraft overflights of the selected sites at the proper time in the growth cycle to gather multi-spectral photographic data, and possibly infrared scanner data, of crops under insect or nutrient stress and also of healthy crops. Detailed study and analysis of the remotely sensed data and its correlation to ground truth data will be done, for the most part, by the Extension Service and Experiment Station personnel, using their own or MSFC interpretation equipment Determinations will be made as to the effectiveness of such data in determining plant stress in this region, and the potential for scaling up to the use of satellite data for this purpose. University and county Extension Service personnel will cooperate to develop techniques for utilization and dissemination of the results to the user community The proposed projects are continuations of demonstration projects begun in FY 72 by MSFC.

W73-70468 **160-75-02**
John F. Kennedy Space Center, Cocoa Beach, Fla.
REMOTE SENSING OF VEGETATION STRESS
J P. Claybourne 305-867-6132

The purpose of this proposed work is to establish a cost-effective method using remote sensing to accurately determine the amount (temperature and duration) of crop freeze exposure over large geographical areas and to develop a comprehensive cold weather climatology classification and geoatmospheric model of Florida's croplands for accurate freeze exposure forecasting. A specific technical approach has not been decided upon. Selection of performing organization will be based in part on the technical approach proposed.

W73-70469 **160-75-02**
Ames Research Center, Moffett Field, Calif.
REMOTE SENSING OF VEGETATION AND WILDLAND RESOURCES
H. P. Klein 415-965-5094

Research programs directed to aircraft measurement of airborne phytopathogens responsible for wide-scale crop damage and the destruction of natural wildland resources are presented. Objectives are to develop and/or apply existing aerosol sampling technology to the study of microorganisms in specific environments for the purpose of predicting the extent and severity of disease within a given locality, and to provide real-time information on disease development. Interest is in light- and medium-weight aircraft outfitted with aerosol sampling instrumentation operating in the lower troposphere. Flight instrumentation will be analyzed for suitability in conducting atmospheric surveys over agricultural and natural areas. Working relationships with the USDA and NOAA have been established to effectively utilize information collected. The value of aircraft sampling surveys in providing supplemental data (ground-truth verification) to proposed ERTS-B experiments dealing with plant/crop disease measurement will be assessed using information gained in this study.

W73-70470 **160-75-04**
Marshall Space Flight Center, Huntsville, Ala.
REMOTE SENSING OF SOIL/VEGETATION RELATIONSHIPS FOR LAND-USE PLANNING
G. F. McDonough 205-453-2880
(160-75-14; 160-75-23; 160-75-31)

The primary objective of this effort will be to continue on-going demonstrations of the use of aerospace technology to land-use planning by state and regional officials. Specifically, effects of strip mining, the influence of micro-relief, and the delineation of physiographic areas will be studied with remote

sensing techniques in cooperation with other agencies and institutions. Demonstrations of data analysis will be made, and ERTS and Skylab data will be used when available. The approach will be to use MSFC sensors and aircraft to obtain medium scale data in modes of multispectral photography, laser altimeter profiles, and color infrared photography. In situ instrumentation will also be used for ground correlation. Preliminary demonstration analysis will be at MSFC's facilities in Alabama, and will involve photogrammetric and computer techniques. Land-use classification will continue to use the NASA/USGS system being developed with other agencies. The strip mine study was begun by MSFC in FY 1972.

W73-70471 **160-75-06**
Marshall Space Flight Center, Huntsville, Ala.
REMOTE SENSING FOR THEMATIC MAPPING OF CULTURAL, NATURAL AND PHYSICAL PATTERNS AND CHANGE
G. F. McDonough 205-453-2880
(160-75-32)

Basic research will be performed which will develop the systems and methodology for rapid and economic processing of remote sensed data (primarily multispectral imagery) for use in traffic flow pattern analysis, thematic mapping production techniques, and user information display applications. In the field of pattern recognition, a dual approach will employ both optical processing techniques using laser holography and digital techniques including image enhancement and feature classification. MSFC's demonstrated capabilities in optical data processing and data acquired from low altitude multispectral photography will serve as resources to investigate traffic patterns in the New Orleans area as a joint demonstration project. Digital data processing research will investigate the translation of image scene properties, such as tonal and textural variations, into terms of thematic map representations and corresponding data structures.

W73-70472 **160-75-07**
Marshall Space Flight Center, Huntsville, Ala.
REMOTE SENSING FOR GLOBAL LAND-USE MAPPING AND RESOURCE MANAGEMENT IN GEOGRAPHY, DEMOGRAPHY, AND CARTOGRAPHY
G. F. McDonough 205-453-2880

The primary objective of this work is the application of existing aircraft and spacecraft remote sensing techniques to the gathering and dissemination of information urgently needed by planners and others at all levels of government. Proper planning for the use of the region's land resources requires present land-use information which is not otherwise available. This work is to provide such data on a demonstration basis to a potential user community in the Southeastern United States, and will therefore fulfill a further objective of introducing the users to the potential benefits of ERTS, Skylab, and aircraft remote sensing data. To accomplish these objectives, the completion of an existing demonstration project is proposed, plus the supplementation of the Alabama ERTS proposal with local aircraft flights and the extension of these techniques on a sample basis to other southeastern states. Multispectral photography has already been obtained for a five county test site. This data will be interpreted and the land-use information given to the Tennessee Valley Authority in manuscript form for their conversion to multicolor map form. In order to supplement the ERTS and high altitude aircraft data to be taken over Alabama as part of the Alabama ERTS proposal, MSFC will gather lower altitude multispectral data over selected sample areas from three different physiographic regions within the state and will assist in the interpretation and correlation of this data with the ERTS data. The result is to be a land-use study for the whole state, and this plus the preceeding information will be made available to the entire user community. The same methodology will be applied to small demonstration projects in other southeastern states, with the results and benefits to be demonstrated to the appropriate officials of those states.

W73-70473 **160-75-08**
Marshall Space Flight Center, Huntsville, Ala.
MODELS FOR MONITORING, MANAGING AND CONSERVING LAND AND WATER RESOURCES
G. F. McDonough 205-453-2880

The objective of this research is to design and develop mathematical models which describe and predict the impingement effects of urban expansion on rural areas and the resultant 'backlash'. Methods for modeling and displaying information for regional planners, policy makers, and decision makers in an effective manner will be developed. The user oriented Marshall Interactive Retrieval and Display System (MIRADS) which was developed for applications to automated land utilization studies will serve as the primary building block for the computerized information system. This prototype system will be designed specifically towards interaction with and support of a State of Alabama agency and a regional council of government's agency.

W73-70474 **160-75-10**
Marshall Space Flight Center, Huntsville, Ala.
REMOTE SENSING FOR GLOBAL GEOLOGICAL RESOURCE SURVEY
G. F. McDonough 205-453-2880

Multispectral photography and thermal scanner data will be obtained from low level and high altitude aircraft. Ground geological surveys will be made and geological files of appropriate state geological survey offices will be used. Jointly with the state geologists and other scientific officials these data will be studied using multispectral projectors and stereo viewers, etc., to determine features or factors related to geothermals which can be detected from remote sensing to identify specific locations to be explored or prospected for geothermal drilling. This task will be associated with a second broader investigation to identify other geologic and environmental factors which can be detected in areas of heavy vegetation cover.

W73-70475 **160-75-11**
Marshall Space Flight Center, Huntsville, Ala.
REMOTE SENSING FOR GEOLOGIC HAZARDS AND DISASTERS, MINE AREA CONSERVATION, SOIL MAPPING AND LAND-USE PLANNING
C. T. Paludan 205-453-2142

The MSFC personnel with background capabilities in remote sensing, data handling, geological surveys, and regional planning activity have been requested by several users to assist in determining: (1) geological hazard due to limestone cavern cave-ins, (2) geological factors affecting proposed new community sites, (3) the extent of the effect of strip mining in areas not easily accessible by ground surveys, and (4) problems of general application of remotely sensed data for regional development. These efforts are usually one-of-a-kind requests, which have as an ancillary purpose, the transference of demonstrable technology to the requesting agency.

W73-70476 **160-75-11**
Ames Research Center, Moffett Field, Calif.
REMOTE SENSING FOR GEOLOGIC HAZARDS AND DISASTERS, MINE AREA CONSERVATION, SOIL MAPPING

AND LAND USE PLANNING
Glen Goodwin 415-965-5065
(160-75-11)

The objectives are: (1) To analyze landslides and other geologic structures prone to mass movement using an infrared radiation imaging system. (2) To help solve specific problems of several State of California agencies by obtaining infrared imagery of water and land features, and assisting in image interpretation. Large scale imagery is required for detailed analysis and correlation with carefully completed field studies. To determine those factors that influence soil and water surface temperatures, low altitude flights on a diurnal and seasonal basis using an infrared line scanner will be made.

W73-70477 **160-75-13**
Ames Research Center, Moffett Field, Calif.
REMOTE SENSING FOR SNOW AND ICE MAPPING
Glen Goodwin 415-965-5065
(160-75-30; 160-75-31; 160-75-15; 160-75-01)

Global snow and ice mapping, hydrological cycle implications for better utilization of water resources, flood forecasting, navigation and related activities will be determined. Remote sensing techniques will be applied to the study of hydrological parameters related to water resource management, with particular regard to the California Water Project. Specific watershed areas will be defined in terms of run-off characteristics, snow pack, vegetation, etc. Land use, as affected by the Project, will be studied. Imagery from U-2 overflights, ERTS and Skylab missions will be provided in useable format to selected agencies and personnel.

W73-70478 **160-75-13**
Lewis Research Center, Cleveland, Ohio.
REMOTE SENSING FOR SNOW AND ICE MAPPING
H. Mark 216-433-4000

(HL-1) The primary objective of this program is the application of remote sensing techniques to the problem of providing accurate ice maps at operational frequency to Coast Guard and to private shipping captains for their use as an aid to navigation across the Great Lakes during the ice season. To achieve this objective a study is being made of the ice types that occur throughout the season, and techniques are being developed for obtaining ice information remotely and eventually under all weather conditions so that this data can be processed automatically and the resultant information appropriately displayed as it applies to navigational requirements.

W73-70479 **160-75-13**
Goddard Space Flight Center, Greenbelt, Md.
REMOTE SENSING FOR SNOW, ICE, AND SOIL MOISTURE MAPPING
T. Schmugge 301-982-6360

The objective is to apply satellite microwave data to the quantitative measurement of parameters of hydrological interest. These include the mapping of sea and lake ice, snow, and soil moisture. Microwave radiometers are well suited for these measurements because of the large contrasts between the emitted radiation from liquid and solid surfaces The emissivity of liquid water at microwave frequencies is about 0.3 - 0.4, while that of snow, ice, or land surfaces is generally greater than 0 7. Data from the electrically scanning microwave radiometers (ESMR) scheduled to be on the Nimbus E (wavelength = 1.55 cm) and Nimbus F (wavelength = 0.81 cm) satellites will be used. For ice mapping the approach will be to prepare mosaics of the imagery for the areas of interest. From these mosaics it will be possible to determine the areal extent of the ice and to study the ice dynamics. The capabilities of the satellite borne radiometers for snow and soil moisture mapping are less well defined. Here we plan to employ multi-stage sampling over selected areas. In addition to the satellite data this will involve the use of aircraft radiometers and ground based field measurements. The latter are necessary to increase our basic understanding of the emission from these surfaces.

W73-70480 **160-75-14**
Langley Research Center, Langley Station, Va.
REMOTE SENSING FOR GLOBAL SURVEY OF COASTAL, RIVER, LAKE AND GROUND WATER FEATURES
Clifford H. Nelson 703-827-2893

The objective will be to evaluate, in cooperation with the Environmental Protection Agency, remote sensing capability for the purpose of monitoring water quality with a particular emphasis on eutrophication. Present state-of-the-art instrumentation available from AAFE; in-house or by contract will be used from aircraft and helicopters. Detailed aircraft surveys will be made in conjunction with in situ EPA acquired data. Problem areas of initial interest as defined by EPA include the eutrophication processes of natural waters, such as lakes. Factors such as temperature, nutrients, chlorphyll, dissolved oxygen, and pH are important and will be measured in situ by EPA. Remote sensing techniques will be applied for direct and indirect inference and correlation with these and other relevant factors.

W73-70481 **160-75-14**
Marshall Space Flight Center, Huntsville, Ala.
REMOTE SENSING FOR GLOBAL SURVEY OF COASTAL, RIVER, LAKE AND GROUND WATER FEATURES
G. F. McDonough 205-453-2880
(160-75-15)

Multispectral aircraft and spacecraft observations will be explored in feasibility studies of future hydrological flight missions. These missions will be for the purpose of (1) formulating and testing prediction models of the cyclic thermal effects of power plant condenser discharge on deep reservoirs, (2) determining the effects of strip mining and forest practices on regional hydrology, (3) substantiate a thermal mixing model for the Tennessee River, (4) predict run-off of stream flow in those water sheds without accumulating an historical data base, and (5) assessing the physiological thermal tolerance to plants and organisms in heated waterways A suitable combination of remote observations and prediction models will be explored by using the MSFC's statistical information retrieval algorithms on aircraft, NIMBUS, ERTS, EREP AND GEOS data.

W73-70482 **160-75-15**
Goddard Space Flight Center, Greenbelt, Md.
INVESTIGATIONS OF THE HYDROLOGIC CYCLE AND LARGE SCALE HYDROLOGIC SYSTEMS
V. V. Salomonson 301-982-6481
(160-75-13; 160-75-14; 160-75-32)

The objective is to develop hydrologic models which, as closely as possible, represent real hydrologic systems and at the same time include parameters which can be observed by spaceborne sensors and systems. The development of these models will permit a quantitative and definitive assessment of where and how spaceborne systems may be used to improve the ability of scientists, engineers and water resources managers to observe, monitor, and predict hydrologic systems response to various inputs such as precipitation and evapotranspiration. Specifically, a set of models, either conceptual, stochastic and/or deterministic models, will be constructed and developed which pertain to hydrologic systems ranging in scale from those that

concern global phenomena to those that simulate localized processes such as those occurring on a small agricultural watershed. Through the development of these models the relative impact of various parameters such as evapotranspiration, infiltration, and soil moisture on the eventual streamflow and water balance will be assessed for the gobal, regional, and local scales. At the same time a parallel objective will be to assess the results as they provide a definition of: (a) the roles that spaceborne observations and remote sensing can now play in specifying boundary conditions in hydrologic models, and (b) the characteristics and accuracies of sensors that would permit systems on future Earth Resources Satellites to make a greater contribution to the management and monitoring of hydrologic systems Full cognizance will be maintained throughout the study of available and planned sensor technology and systems on manned and unmanned spacecraft. In addition, the study---

W73-70483 **160-75-15**
Marshall Space Flight Center, Huntsville, Ala
INVESTIGATION OF THE HYDROLOGIC CYCLE AND LARGE SCALE HYDROLOGIC SYSTEMS
G. F. McDonough 205-453-2880

The task of planning proper use of the State of Alabama water resources is an area of concern for state planners and the Alabama Marine Science Institute. Collection of hydrological data on the rivers and in the Mobile Basin is difficult and extremely slow by conventional means. A combination of advanced in situ instruments/communications, remote sensing and automated data bank of relatively modest proportions will enable several objectives to be attained. Future hydrological data in areas which have significantly different patterns of precipitation and runoff (i.e. semi-arid and mountainous regions) will be incorporated into the data base. These data will be obtained from remote sensors, and the algorithms formulated with recourse to only limited ground truth confirmation

W73-70484 **160-75-16**
Marshall Space Flight Center, Huntsville, Ala.
REMOTE SENSING OF OCEANOGRAPHY - OCEAN BIO-PRODUCTIVITY
R. R. Morton 205-453-3410

The object of these studies is to determine if there is a feasible means, within existing technology or instrumentation, of automating or instrumenting various data gathering processes in the field of marine bio-productivity. Advanced concepts of instrumentation will also be studied to determine the most promising direction for applied research.

W73-70485 **160-75-16**
Ames Research Center, Moffett Field, Calif.
REMOTE SENSING OF OCEANIC BIO-PRODUCTIVITY
H. P. Klein 415-965-5094
(160-75-26; 160-75-24; 164-76-60)

Biologically rich and productive areas of the world's oceans will be determined, mapped, and assessed by aerospace vehicles and technology. Oceanic biomass data will be collected by platforms located on marine vertebrates which transect highly productive areas. Joint efforts by NASA/ARC, the Navy/NUC, NOAA and California Fish and Game correlate remote sensed data, ground truth, and platform data. Aircraft and long range telemetry is used with development toward satellite use. Fish production in the ocean is dependent on the rate of primary CO2 fixation in marine photosynthetic microorganisms. Correlations will be attempted between ocean CO2 fixation measured locally and chlorophyll content as determined by remote sensing from aircraft. Subsequently, EOS-A sensing of chlorophyll will give an ocean-wide figure for primary production of food. A prototype long range telemetry/sonic buoy system to map fish approaching fishing grounds is under construction. Ground, ship and aircraft receiving systems will be used to develop a satellite data handling system. Development of future satellite data communications systems will be guided by ARC and NASA Headquarters satellite communications expertise. On site sampling is correlated with remotely sensed data. Data are sent via telecommunications to a large computer for input to a fishery management model. Solutions for optimum fishing strategies are returned immediately for fisheries management agencies, e.g. Alaskan Department of Fish and Game

W73-70486 **160-75-16**
Goddard Space Flight Center, Greenbelt, Md.
REMOTE SENSING OF OCEANIC BIO-PRODUCTIVITY
W. A Hovis 301-982-6465
(160-20-58)

The objective of this effort is to develop techniques for chlorophyll detection by remote sensing of ocean color. Ocean color in the 400 to 700 nm range is affected by chlorophyll absorption bands centered at 450 and 675 nanometers. Low altitude measurements over water with varying chlorophyll concentration have shown a clear correlation between color, especially in the blue, and chlorophyll content. High altitude measurements and theoretical calculations indicate, however, that the atmosphere adds severe complications by providing a strong background of scattered radiance and by scattering radiance that has been reflected off the ocean's surface out of the field of view of the sensor. The only practical approach to the total problem is to spectrometically determine the radiance emerging from the top of the atmosphere due to the ocean-atmosphere system, determine the effects of the atmosphere by nearly simultaneous low altitude measurements and select channels for scanning radiometers to determine both the chlorophyll concentration and the effects of Rayleigh and Mie Scattering from the gases and particles of the atmosphere. The aircraft measurements also indicate than glitter is a more difficult problem than originally foreseen and an effort is required to determine the range of solar zenith angles that will allow useful measurements of ocean color to be made. The polarization of sea glitter, through the atmosphere, will be determined to see if a polarized sensor can be utilized through a wider range of solar zenith angles than an unpolarized sensor.

W73-70487 **160-75-17**
Langley Research Center, Langley Station, Va.
REMOTE SENSING OF PHYSICAL OCEANOGRAPHY, COASTAL PROCESSES AND ESTUARIES
Clifford H. Nelson 703-827-2893

The objective is to investigate the use of existing and planned remote sensing data to problems pertinent to coastal regions, particularly the coastal and estuary portions of mid-eastern U.S. Data sources include the ERTS A and B, SKYLAB-EREP, ITOS, the supporting aircraft underflights, and additional supplementary aircraft- or helicopter-borne sensors. Supporting surface observations will be obtained as required by contractual and in-house efforts. Problem areas of interest include circulation, sedimentation, thermal properties, wave climate, shoreline characteristics, pollution distribution, and wetlands. Analytical modeling will be used to support development and utilization of remote sensing systems and data analysis techniques to provide both understanding and prediction capability for coastal zone problems.

W73-70488 **160-75-17**
Wallops Station, Wallops Island, Va.
REMOTE SENSING OF PHYSICAL OCEANOGRAPHY, COASTAL PROCESSES AND ESTUARIES
J. D. Oberholtzer 703-824-3411
(160-75-21; 160-75-30)

The purpose of this plan is to evaluate and demonstrate remote sensing capabilities for determining oceanographic and earth resource parameters while providing practical and useful support to a controlled demonstration project being conducted by NASA and the Virginia Institute for Marine Sciences (VIMS). The objective of the VIMS project is to understand coastal circulation on a scale large enough to answer quations regarding pollution and distribution continent derived material. The objective of this program is to apply remote sensing technology to directly support the VIMS project and to expand the remote sensing utilization to a wider range of problems. The applications to be evaluated are the determination of surface roughness, water color, tidal, current and thermal structure of the waters in the test area and oil slick identification. The data acquisition and experiment results presentation phases will be closely coordinated between NASA and VIMS and concomitantly with local, regional and national user agencies to insure that the data gathered and results obtained have the widest possible user application. Initially, a limited number of overflights of the test site by the Wallops instrumented aircraft will be performed to evaluate systems performance and to obtain the measurements to serve as the data base for the project. The results obtained from the reduction and analysis of this data will be compared and correlated with the in situ measurement information gathered by the VIMS projects. Accompanying the outputs will be assessment of the quality of the sensor performance and comparative in situ measurement data. User comments and recommendations will be solicited and these comments along with sensor performance evaluations will serve as the baseline for future flight missions.

W73-70489 **160-75-19**
Goddard Space Flight Center, Greenbelt, Md.
OCEANOGRAPHIC SENSOR TECHNOLOGY
P. Gloersen 301-982-6362

This effort is directed towards the testing and improvement of multichannel microwave radiometer techniques for the remote sensing, under nearly all-weather conditions, of the properties of the ocean surface from which are determined certain oceanographic parameters of interest. These parameters include ocean surface temperature, roughness, white water coverage, wind speeds, ocean-atmosphere energy exchange, cloud water, precipitation, and ice cover properties. While the presently used remote infrared techniques are superior in both spatial and temperature resolution for the determination of ocean surface temperature in clear weather, the technique fails in areas of persistent cloud cover and does not provide information for the determination of the other ocean parameters. Utilization of multichannel microwave radiometry for this purpose overcomes these difficulties, but at the expense of spatial resolution. The ultimate temperature resolution obtainable from microwave radiometry is unknown at this time, but indications are that better than plus or minus 0.5 K may be possible. Such accuracies require careful attention to the corrections required by atmospheric fluctuations and variations in the emissivity of the ocean surface due to roughness and salinity changes. These effects may be minimized by the proper choice of frequency, polarization, and view angle. The remaining corrections are obtained from a dual-polarization, multi-frequency microwave radiometer approach. A matrix data inversion technique will be developed and continually updated to extract the desired oceanographic parameters from the multichannel data.

W73-70490 **160-75-21**
Wallops Station, Wallops Island, Va.
REMOTE SENSING OF BIOMES, ECOSYSTEMS, ECOLOGICAL DYNAMICS AND PRODUCTIVITY PRESSURES
C. R. Vaughn 703-824-3411
(160-75-32, 160-75-01)

The team approach adopted by the University of California for study of hydrological resources in the Feather River Headwaters area of California will be applied by Wallops Station to the study of the Chesapeake Bay wetlands. Various multidisciplinary teams are presently studying some of the Bay estuary systems. One such team will be contracted to provided detailed inputs of the data requirements for wetlands study and management. Spectroradiometric analysis of wetlands communities and community components will be performed by Wallops to define the best sensor system - either film filter combination or scanner channels - for delineation of these structures Ground studies being conducted by the contractor will be used as the basis for evaluation of remotely sensed data. Maps showing marsh community structure will be developed from ground studies. Photography acquired at a series of altitudes and seasons will be digitized. Automated processing techniques developed by the U. of Kansas and Purdue will be applied to the imagery to produce maps which will be compared with the community structures delineated by the scientists. Based on efforts within the detailed study areas the entire wetlands regions of the Chesapeake Bay and of the oceanside of the Eastern Shore will be mapped. Because of the large area involved (2000 square miles) emphasis will be placed on using the lowest scale imagery compatible with the requirements of accuracy.

W73-70491 **160-75-22**
Marshall Space Flight Center, Huntsville, Ala.
REMOTE SENSING: WATER AND LAND POLLUTION
W. W. Moore 205-453-3917

The objectives are to detect, identify, monitor, analyze, and assess the quantity and quality of the dynamics and distributions of air particulate pollution. A particulate matter measuring system would be utilized for field applications with the general detection approach being intercavity scattering of laser radiation by the particulate pollution. Measurement capability would include particles to 25 microns in size and 50 meters per second in speed. Distributions would be directly read out by measurement size interval both graphically and digitally. Thus all measurement objectives would be attained.

W73-70492 **160-75-22**
Lewis Research Center, Cleveland, Ohio.
REMOTE SENSING/WATER AND LAND POLLUTION
H. Mark 216-433-4000

(EEQ-2) The objectives of this research are to detect, identify and monitor by remote sensing techniques and to analyze and assess the quantity and quality of dynamics of water pollution in the Great Lakes, particularly Lake Erie and Lake Ontario. Similarly by remote sensing techniques to detect, identify and monitor land pollution due to strip mining damage and the contribution of this to the degradation of streams by run off from the polluted land (toxic spoilbank).

W73-70493 **160-75-22**
Goddard Space Flight Center, Greenbelt, Md.
CHEMICAL, RADIOCHEMICAL, AND GEOLOGIC FACTORS AFFECTING THE ENVIRONMENTAL QUALITY OF THE CHESAPEAKE BAY WATERSHED
David F. Nava 301-982-5483

The objective of this research is to understand the nature, sources, and effects of chemical, radionuclear, geological, and biological pollution influxes to the geoecological system of the Chesapeake Bay watershed. The multidisciplinary approach, designed as integrated investigations to view various aspects and components of the system simultaneously, involves the following: (A) Development and application of sensitive and accurate classical and instrumental laboratory methods of chemical analysis for determinations of trace element and radionuclear pollutants in water, air, biotic, and geological samples. (B) Sample analyses to establish background levels and fluctuations of pollutants. (C) Radiochemical and bulk chemical analyses of water, sediment, and biological samples from areas to be affected by the Calvert Cliffs Nuclear Power Plant. (D) Establish detailed knowledge of the interactions of natural and man-made activities on the problems of erosion, siltation, and sedimentation. (E) Design of coordinated sample collection, preparation, and calibration programs to maximize system data return. (F) Conceptual formulation of analytical instrumentation to monitor the water and air pollutants in remote locations. The research data, conclusions, interpretations, and correlations, including studies of possible correlation to ERTS imagery, along with data obtained at other laboratories, will serve as the basis for recommendations and/or implementation of significant programs to alleviate some of these ecology and environmental quality problems.

W73-70494 **160-75-22**
Langley Research Center, Langley Station, Va.
REMOTE SENSING: WATER AND LAND POLLUTION, BIOTIC AND ABIOTIC DEGRADATION, ENERGY, BUDGET AND CULTURAL PRESSURES
Clifford H. Nelson 703-827-3431

Cooperative efforts with local marine institutions have been established to quantitatively measure the ecological consequences of specific man-made and natural pollutants in estuaries of the lower Chesapeake Bay. This research includes: (1) An investigation to detect and trace organic compounds through the air-water-biota interfaces of the marine environment, (2) An investigation to monitor the fate and effects of oil spilled in mini-ecosystems constructed in a tidal marsh, and (3) The application of existing and planned remote sensing data to measure estuarine sedimentation, circulation, and chlorophyll concentrations. Samples taken from air, water, sediments, and marine biota are analyzed for trace synthetic organic compounds, in parts per billion, using advanced sampling and concentrating techniques in conjunction with microwave spectrometry to assess the effects of these organic compounds on marine ecology. Distribution, residence times, transport modes, concentrating mechanisms, and toxic effects of major chemical components of fuel oils will be determined using samples taken from dosed mini-ecosystems and analyzed by gas chromatography interfaced with mass spectrometer computer systems. ERTS-A, Skylab A, and aircraft data, coupled with mathematical models of estuaries, will be employed to correlate color, thermal, current, and fluorescence patterns with sediment transport, chlorophyll concentration, and bathymetry of selected areas in the lower Chesapeake Bay.

W73-70495 **160-75-22**
Ames Research Center, Moffett Field, Calif.
REMOTE SENSING FOR WATER AND AIR POLLUTION
Glen Goodwin 415-965-5065
(160-44-78; 160-44-79; 160-44-60)

A comprehensive study of water and air pollution will be accomplished to establish the sources, types and levels of natural and artifically introduced pollutants. Emphasis will be on the application of existing NASA technology to the establishment of background levels of principal pollutants and thus obtain a reliable data base for the development and testing of user application models. Intensive remote sensing of water and air quality parameters will be utilized together with ground truth data and other complementary data, obtained by the cooperative efforts of Federal and State user agencies, to interpret and extract information from the remote sensor data and demonstrate the benefits resulting from the application of this information. Of general importance are the measurements of chlorophyll concentration, sedimentation as it relates to eutrophication, the extent and nature of oil films, the biological activity and growth capacity of organisms in water and sediment. The spatial extent of key atmospheric pollutants will be measured remotely and a determination made as to their usefulness as tracers for specific emission sources. Site monitoring and analytical techniques will be utilized for the measurement of atmospheric transport deposition and assimilation of chlorinated pestides and mercury by marine organisms and their predators. The interaction of floral emissions in the photochemical production of smog will be investigated.

W73-70496 **160-75-22**
John F. Kennedy Space Center, Cocoa Beach, Fla.
REMOTE SENSING OF WATER AND LAND POLLUTION
J. P. Claybourne 301-867-6132

The purpose of this proposed work is to establish a cost-effective remote sensing technique to obtain large area seawater thermal data adequate for realtime control of the dispersion of power plant thermal effluent in a manner as to not adversely effect the ecology of South Biscayne Bay and Card Sound, Florida. A specific technical approach has not been selected. Selection of a performing organization will be based in part on the technical approach proposed.

W73-70497 **160-75-23**
Marshall Space Flight Center, Huntsville, Ala.
REMOTE SENSING NATIONAL PARK AREAS AND ARCHEOLOGICAL AND HISTORICAL SITES
C. T. Paludan 205-453-2142

Comprehensive information on factors affecting choice of recreational areas is not presently available, and it is difficult to obtain by conventional field methods. These factors include such parameters as (1) terrain, (2) transportation, (3) environmental impacts and interaction, (4) neighboring land-use, both present and projected, and (5) aesthetic qualities and consciousness. This information can be supplied and is discernable on medium-scale multispectral photography.

W73-70498 **160-75-24**
Ames Research Center, Moffett Field, Calif.
REMOTE SENSING FOR CONSERVATION MANAGEMENT AND UTILIZATION OF ANIMAL RESOURCES
H. P. Klein 415-965-5094
(160-75-16; 164-76-60)

The objectives are to convene a conference of experts to review the NASA program on wildlife migration and explore potential applications of aerospace technologies to the management, conservation and utilization of wildlife resources. The conference will be asked the following: (1) To identify those aspects of the study of wildlife migration to which significant contributions can be made by the use of aerospace science and technology. (2) To demonstrate on a cost-effective base the value of wildlife migration programs utilizing aerospace systems. Benefits considered should include those related to sciences, the economy, conservation, recreation, and the preservation of endangered species. (3) To recommend the allocation of

resources in proportion to the relative importance of each element of the program. (4) To determine the principal categories of scientific and technical data which will be needed. (5) To recommend major directions for research and development in the technology of bioinstrumentation and relay systems. (6) To identify the technologies and systems which would be required to execute the program. (7) To recommend further studies or other activities necessary for the future development of the program. A final report embodying the recommendations will be submitted by the Chairman to NASA within three months of the meeting.

W73-70499 **160-75-26**
Ames Research Center, Moffett Field, Calif.
BIOLOGIC AND BEHAVIORAL MECHANISMS IN ANIMAL NAVIGATION AND ORIENTATION
H. P. Klein 415-965-5094
(160-75-24; 164-76-60)

The objectives are: To determine the behavioral and physiological characteristics of whales migrating over long distances so that adequate data can be made available to national and international organizations concerned with the preservation of disappearing species and with regulations which will permit whale catches commensurate with the rate of breeding, To investigate the use of the whale as a mobile platform which will give data on the distribution of food sources, as consumed by the whale, throughout the oceans; To determine the feasibility of the use of the whale as a platform for obtaining physical and chemical oceanographic date on the surface and at depth; and to define dates, number of times, formats and bit rates needed for future satellites. Initially a few whales will be instrumented with backpacks equipped with relay systems for telemetering data on location, diving behavior, and oceanographic parameters to aircraft. Harnesses, telemetry systems and the backpack relay will undergo systems engineering tests designed to prove the feasibility of the experiment. Later whales will be instrumented and equipped with backpacks designed to transmit to satellites and proposals submitted for experiments on ERTS, EOS or other appropriate missions. Programs will be worked out with the Marine Mammal Committee of the International Biological Program, the Smithsonian Institution, NOAA, and the universities. Satellite interface will be guided by ARC, GSFC and Headquarters expertise in satellite communications.

W73-70500 **160-75-27**
Wallops Station, Wallops Island, Va.
GROUND-BASED PLATFORMS, BIO-INSTRUMENTATION AND ANIMAL TRACKING SYSTEMS & TECHNIQUES
Charles R. Vaughn 703-824-3411
(160-75-26)

Two years of bird tracking experience at Wallops Station has demonstrated tracking radar effectiveness for migration and orientation studies. During spring and fall, radars at Wallops, Bermuda, Trinidad, Cape Cod and Antigua will continue to map migratory routes over the Western Atlantic. At station where sufficient data is accumulated, the influence of weather and time of day on density and mean altitude of migration will be analyzed. Various aspects of bird migration and orientation, and flight dynamics will be studies using Wallops high power tracking radars. A platform for carrying a bird to a predetermined altitude will be developed. Since the volume density of birds can be very high during migration, a device will be perfected to increase the released birds effective cross-section above the background noise introduced by the general migratory density Using a single bird species, wing beat, speed and various physiological variables will be studied as a function of altitude. An S-Band transponder for birds will be developed which will be capable of transmitting physiological data. At Wallops a radar signature catalog of birds will be developed which can be used by biologists to identify unseen birds species acquired by the high power radars. Initial efforts will center on modification and use of a hand held perimeter defense doppler radar to obtain signatures of close, identifiable targets. Signatures of released birds from the above tasks will be compared with these signatures to determine uniformity of signatures.

W73-70501 **160-75-27**
Ames Research Center, Moffett Field, Calif.
GROUND-BASED PLATFORMS, BIO-INSTRUMENTATION AND ANIMAL TRACKING SYSTEMS & TECHNIQUES.
H. P. Klein 415-965-5094
(164-76-60; 160-75-24)

The objective is to develop ground-based platforms, bio-instrumentation and telemetry systems and techniques for tracking and monitoring wild animals. Physiological sensors will be categorized, qualified, and field tested. A microminiaturized biosensors back pack relay will be designed, built and tested. Use NASA sponsored equipment to investigate large mammal physiology and life histories. Implantable physiological sensors of primary interest to free roaming animal investigations will be collected, categorized on use basis. Systems tests will qualify the sensors for field use by use of profiles defined by expertise at ARC and currently funded wildlife investigators. A final report of sensor tests will be made available for the FY 73 NASA Summer Conference on Wildlife Migration. Design and fabrication of microminiaturized relay collar will be done by ARC instrumentation experts. Previous experience in sensor development, microminiaturization, GSFC input from past experience and future satellite channels will guide design and fabrication. Field testing with ground and aircraft receivers will be done with ARC facilities and animals. The design, fabrication, test and use of bio-instrumentation at University of Montana will be reviewed and guided by ARC expertise. Black and Grizzly bears will be instrumented to investigate hibernation physiology, behavior and environmental data. A computer model of Grizzly bear will be tested by tracking animals which have radio collars attached to investigate transplant behavior. ERTS imagery and Nimbus F potential for bear, mountain sheep and elk habital studies will be investigated.

W73-70502 **160-75-28**
John F. Kennedy Space Center, Cocoa Beach, Fla.
ENVIRONMENTAL CHANGES RELATED TO PUBLIC HEALTH
J. P. Claybourne 305-867-6132

The purpose of this proposed work is to assist the Brevard County, (Florida) Mosquito Control District in establishing a cost-effective method, by application of remote sensing techniques, to quickly locate pools of still water in dense foliage areas to permit timely larviciding operations. A possible technical approach is airborne L-band radar. Technical feasibility tests will be the initial task. If satisfactory results are obtained from these tests, the next task would be operational and economic analysis to develop a cost-effective implementation plan based on this suggested technical approach.

W73-70503 **160-75-28**
Wallops Station, Wallops Island, Va.
REMOTE SENSING OF ENVIRONMENTAL CHANGES RELATED TO PUBLIC HEALTH AND WELFARE PROBLEMS
E. M. Holton 703-824-3411
(160-75-30)

Environmental (air, water, land) degradation and changes will be monitored, analyzed, assessed; the data obtained will be correlated with public health and welfare problems. Interdisciplinary teams have been established in Richmond, Virginia, and Newport News, Virginia, for this effort. The lower Chesapeake Bay area (air, water, sediment) will be mapped for trace element concentration. The concentration of these elements will be correlated with diseased and normal populations. The health of a productive segment of the population of Richmond, Virginia, as affected by air and water pollution will be monitored and assessed. The feasibility of a mobile health screening van for similar correlations in the Chesapeake Bay Ecological Test Site will be studied. Overflights will initially focus on single point source and ambient air pollution, sediment transport, tidal fluxes, and water tables in these areas using aerial photography. The extent to which remotely sensed data correlates with public health data will be determined.

W73-70504 **160-75-30**
Marshall Space Flight Center, Huntsville, Ala.
REMOTE SENSING FOR MULTIPLE RESOURCE SURVEY
G. F. McDonough 205-453-2880

This study is directed to objective "MRS-1" as specified in the FY-73 Earth Resources RTOP Request. It will identify, demonstrate, and evaluate practical applications of remote sensing in various regional test areas of the southeastern U.S. These projects will, (1) be concentrated on relatively small areas, (2) make use of MSFC sensors and aircraft and orbital and aircraft program data when available, and (3) be conducted in cooperation with local, state, regional, and federal agencies. It is anticipated that this study will provide, (1) valuable experience and information relative to user agency information needs, (2) enhance the NASA-User agency interface relationships, and (3) contribute to other NASA efforts to prepare the broad user community for ERTS, Skylab, and other earth resources data. Using laboratory techniques and equipment MSFC will examine possible means of identifying and acquiring selected natural resource data in small scale areas for local and regional decision makers and means of applying rapid and accurate data interpretation and analysis for accuracy and timeliness. The tasks described on T8's attached represent selected areas of effort for demonstration of capability.

W73-70505 **160-75-30**
Wallops Station, Wallops Island, Va.
REMOTE SENSING FOR MULTIPLE RESOURCE SURVEYS IN THE CHESAPEAKE BAY AREA
J. F. Bettle 703-824-3411

In cooperation with local, state, regional, and federal agencies and academic institutions, NASA Wallops Station will continue the development of the Chesapeake Bay test site as an area where many practical applications of remote sensing from aircraft and spacecraft can be identified, demonstrated, and evaluated. Remote sensing systems and techniques will be applied to representative disciplines of the Earth Resources Survey Program including ecology and oceanography. A major objective of this effort is to conduct unfunded cooperative multiple resource surveys to aid resource managers in determining specific ecological resources and interrelationships in the test site area. Information resulting from work within, and the exchange and interaction between, these program objectives and disciplines will strongly aid immediate and long-range problems of interest. Relation of the test site program to other and future NASA activities (GEOS, AAFE, ERTS, EREP, etc.) will be actively pursued for specific applications and experiments. An additional objective of this effort is to provide necessary 'operational' supporting services to the unfunded surveys as well as to other RTOP's submitted by Wallops Station to the Earth Resources Survey Program Office. To meet automated data handling and managing requirements, however, this effort must be supported by 160-75-32.

W73-70506 **160-75-31**
Langley Research Center, Langley Station, Va.
REMOTE SENSING SENSOR TECHNOLOGY FOR EARTH RESOURCES SURVEY
C. H. Nelson 703-827-2893

Photographic film has been utilized extensively in space missions because of its high resolution and will be particularly important to future applications missions emphasizing earth resources and pollution where unique signatures and identifying features must be recognized and quantified. The work proposed here deals with four areas where improvement of techniques will aid measurably in enhanced mission capability: (1) Techniques to improve film threshold sensitivity, (2) calibration techniques for remote sensing photography, (3) improved multispectral signature identification, and (4) investigation of zero 'G' B and W and color processing concepts.

W73-70507 **160-75-31**
Wallops Station, Wallops Island, Va.
REMOTE SENSING SENSOR TECHNOLOGY FOR EARTH RESOURCES SURVEY
R. E. Carr 703-824-3411
(160-75-16)

Emphasis on the need to develop improved remote sensing techniques in order to lower the cost and improve the effectiveness of current coastal resource and wetlands management programs was strongly emphasized during the Conference on Remote Sensing of the Chesapeake Bay held April 1971 at Wallops Station. It is proposed therefore to utilize the Wallops C-54 aircraft as a platform to explore the potential of two previously developed remote sensors hitherto unavailable for evaluation in this program. An AN/APQ-102A airborne radar mapping system, acquired on bailment loan, will be installed at minimal cost and evaluated, using grey-scale density slicing techniques, primarily to aid in acquiring improved wetland maps. Also, an image intensifier camera system will be installed and evaluated, using standard photographic techniques, as an aid in locating and mapping biologically rich areas in coastal waters and estuarine marsh environments and in other areas of interest including shoreline and wetland mapping, and migratory bird population studies.

W73-70508 **160-75-31**
Marshall Space Flight Center, Huntsville, Ala.
REMOTE SENSING SENSOR TECHNOLOGY FOR EARTH RESOURCES SURVEY
D. K. Weidner 205-453-3424

This effort is directed to the development of criteria, information, and end products that will contribute to the sensor technology requirements of earth resources survey applications. More specifically, this effort is directed to, (1) the development and testing of a Geodetic Laser Altimeter, and a second generation crossed-beam system with two multispectral fan beam radiometers, (2) the development of in situ instrumentation and communication equipment need for various regional demonstration programs, (3) studies relative to the extension of the scanning range and speed of infrared and fourier transform spectrometry, and (4) studies relative to alternative vehicles (model aircraft, drone helicopter, or other remote controlled platform) and sensors for obtaining earth resources data from low and/or medium altitudes.

W73-70509 **160-75-31**
Ames Research Center, Moffett Field, Calif.
REMOTE SENSING SENSOR TECHNOLOGY FOR EARTH RESOURCES SURVEY
Glen Goodwin
(160-44-60; 160-75-22)

The objective is the development of remote sensor technology essential for earth resources survey applications. Remote sensing techniques are analyzed theoretically, tested experimentally then subjected to field tests for comparison to ground truth. The present program includes (A) an airborne differential video system for real-time surveys of water quality and agricultural stress; and (B) an airborne multifrequency electromagnetic sounder for measurement of snowfield water storage and ice thickness. For each system field tests show that the desired quantities can be measured. Specifically, for (A) the conclusions are that (1) oil on water can be seen best when the viewing light is reflected in the ultraviolet and red portions of the spectrum, and (2) enhancement is obtained by measuring the difference between the polarization components of reflected light. For plants, the slope of chlorophyll absorption (650-700 nm) region is an indicator of plant stress, which can be measured by a two-color difference technique. For (B) the conclusions that frozen lakes can be used as large-scale snow gauges have been verified by calculations for models (assuming a wide variety of snow types) and by field (tower) tests. Flights over frozen lakes will be compared to ground truth, and to water run-off measurements obtained by other government agencies. All components in each of the applications are state-of-the-art.

W73-70510 **160-75-32**
Wallops Station, Wallops Island, Va.
REMOTE SENSING DATA MANAGEMENT AND INTERPRETATION TECHNIQUES FOR EARTH RESOURCES SURVEY
C. M. Curtis 703-824-3411
(160-75-30)

This effort consists of two major subdivisions in support of the Chesapeake Bay Ecological Test Site Program. One is for information storage and retrieval of the Earth Resources data, and the other is for the expansion of digital image processing capabilities. The information storage and retrieval system for a regional data bank will be tailored to the particular needs of the region's users. A data base will be developed for 'on-line browsing' of the index. This data base requires software development and conversion of the HW-625 for on-line access. The initial effort to develop a digital image processing system for the Wallops HW-625 computer is being continued by expanding the capabilities of the Wallops Digital Image Processing System (WALDIPS). WALDIPS is the Wallops version of the Kansas Digital Image Data System (KANDIDATS). WALDIPS will be expanded to include both batch processing and interactive graphics for processing of Chesapeake Bay Earth Resources data. The most feasible means of providing a gray scale and color display for the HW-625 will be determined. In addition, new techniques will be added to WALDIPS as required by the system users. The long range objective will be a fully interactive graphic system. A remote terminal to Purdue University's Laboratory for Applications of Remote Sensing (LARS) will provide Wallops experimenters with a small data analysis capability.

W73-70511 **160-75-32**
Goddard Space Flight Center, Greenbelt, Md.
REMOTE SENSING DATA MANAGEMENT AND INTERPRETATION TECHNIQUES FOR EARTH RESOURCES SURVEY
S. C. Freden 301-982-5818

GSFC resource scientists (in geology, hydrology, agriculutre) and information and computer science specialistis will participate jointly to apply digital interpretation techniques developments directly to resource management problems. In geology, mineralized (ore-bearing) regions will be examined using remote sensing technology to develop automatic methods for recognition of potential ore-bearing sites on a regional and national scale. Also, predictive seismic models will be developed and data from known sites of earthquake hazards obtained for test of these models to coordinate the capabilities of the Earth Resources missions to reduction of loss of lives and property due to earthquakes. In hydrology, necessary data processing developments will be carried out to establish a prototype near real-time hydrological data dissemination network. In agriculutre/forestry, digital classification, and recognition techniques will be applied to plant species distribution mapping and to plant stress detection. In each discipline, model applications will be devised to enhance the automation and generality of the data processing activities. Techniques development will be coordinated in the Image Processing Branch (GSFC) facilities. Coordination with universities, government agencies and industry for accomplishment of this task will be maintained to maximize use of existing data and software and to facilitate determination of resource management requirements. This effort is related to an Advanced Study RTOP 683-71-02, "Survey of Resource Models for Potential ERS Use".

W73-70512 **160-75-32**
Marshall Space Flight Center, Huntsville, Ala
REMOTE SENSING DATA MANAGEMENT AND INTERPRETATION TECHNIQUES FOR EARTH RESOURCES SURVEY
G. F. McDonough 205-453-2880

This effort is directed to the development of criteria, information, and end products that will contribute to study objective 'DIT-1' specified in the FY-73 RTOP Request. More specifically, it is directed to the development of more refined techniques and conceptural/mathematical models for the processing, display, and management of large amounts of earth resources data. A hybrid digital/optical processor and an electooptic modulator will be developed and three studies will be conducted for the continued refinement of automatic data processing techniques. All of the studies defined will be directed to an ultimate application, the extraction of information from remote sensor data and to the demonstration of benefits resulting from applications of this information.

W73-70513 **160-75-32**
Lewis Research Center, Cleveland, Ohio.
REMOTE SENSING DATA MANAGEMENT AND INTERPRETATION TECHNIQUES FOR EARTH RESOURCES SURVEY
H. Mark 216-433-4000

(DIT-1) The objective is development of data acquisition, handling, processing, display and management techniques and conceptual/mathematical models essential for translation of remote sensing data into information suitable for decision by resource managers. The area of interest includes vegetation stress damage correlation with causative agents, automated recognition and inventory of surface mining operations, automated ice classification and mapping. To achieve these goals selected sample spectral signatures will be obtained and examined in the laboratory and compared with field measurements to

determine differences and develop interpretation capability required for a real system development. In the ice studies pattern recognition computer programs are being developed to add to spectral data for practical ice classification.

W73-70514 **160-75-32**
Ames Research Center, Moffett Field, Calif.
REMOTE SENSING DATA MANAGEMENT AND INTERPRETATION TECHNIQUES FOR EARTH RESOURCES SURVEY
Glen Goodwin 415-965-5065
(160-75-22)

The objectives are: to augment the Earth Resources Survey Program by the automated interpretation and analysis of ERTS imagery and to obtain a simplification of multidimensional data enabling a better understanding of complex phenomena for which large amounts of experimental data are available, together with a physical mathematical model of ecological interactions. A prototypical data-processing, interpretation, and information-management system for ERTS imagery will be designed and implemented on the ILLIAC IV hardware system at ARC and made accessible to selected ERTS data users via facilities on the nodes of the Advanced Research Projects Agency (ARPA) network. A combination of statistical techniques will be combined in a new tool for the identification and extraction of significant information from multidimensional data. An ecological model will be developed for guidance in the collection and interpretation of data and prediction of the effects of short and long term changes.

W73-70515 **160-75-65**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
RADAR AGRICULTURE
D. P. Burcham 213-354-3028

The purpose of this task is to study the use of a multi-polarizable radar radiometer for identifying plant life, plant life conditions and their growth rates. The equipment that is available at JPL is mobile and will be transported to local agricultural sites such as California State Polytechnic College where reasonably controlled conditions exist. The final choice of location is open but operations at a local site seem to minimize the cost. This test will be the first test that combines polarization, reflectivity and emissivity as the key measured parameters on a simultaneous basis.

W73-70516 **160-75-66**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
RADAR RADIOMETER DEVELOPMENT
W. A. Collier 213-354-5036

JPL has been developing a unique instrument, a radar radiometer, which can simultaneously measure the radar cross section and microwave brightness temperature of naturally occurring materials as a function of polarization. The instrument, mounted on a portable field vehicle, will be used to generate polarization signals of plants and materials. A later version of the system will be flown over remote locations to identify the type and quality of target. The resultant data will be of interest to geologists and agronomists.

W73-70517 **160-75-66**
National Aeronautics and Space Administration, Washington, D.C.
OCEANOGRAPHIC REMOTE SENSING
M. J. Swetnick 202-755-8626

The objective is coordination of a research program to develop sensor specification, observational requirements, and data handling techniques for remote sensing and comparative in situ measurements of the oceans. The NOAA/NESS* Spacecraft Oceanography (SPOC) Group, in cooperation with NASA, coordinates a program of experiments, research studies, sensor evaluation, and data technology within the government, universities, and industry to fulfill the objectives. Administrative, technical, liaison and funding support is provided by the SPOC Group. Sensor utilization and appropriate ocean features are evaluated by the Group and its principal investigators. Microwave, infrared and optical sensors are being evaluated for observing ocean dynamics, ocean color, sea ice and coastal processes.

W73-70518 **160-75-67**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
OCEANOGRAPHY STUDIES (RADAR)
D. P. Burcham 213-354-3028

The purpose of this task is to apply linear coherent radar techniques to measure various ocean phenomena in support of Earth and Ocean physics programs. The objectives are: (1) To measure and map sea-state. (2) To measure ocean wave patterns to relate to surface meteorological conditions, high sea warnings to ships, harbor design (propagation of waves through breakwaters). (3) To track Luneberg lenses on buoys and measure ocean current direction. (4) To study estuary flow patterns and coastal currents. (5) To measure ice thickness and ice patterns. The same basic radar can be used to satisfy all these objectives. The JPL 25 cm coherent radar system will be used to acquire data and the data will be processed by the JPL radar data processing lab. The data analysis will be performed jointly with oceanographers.

W73-70519 **160-75-69**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
MICROWAVE GEOTHERMAL EXPLORATION
W. A. Collier 213-354-5036

JPL, in conjunction with the University of Nevada, shall conduct scientific and technical research and perform experimental programs for furthering the applications of passive microwave techniques to the remote sensing of earth resources. Specifically, they shall study the near-surface characteristics of known geothermal areas studied at depth and determine the extent to which the microwave signatures at longer wavelengths are related to these characteristics. Several representative geotherms will be chosen for study based upon existing data and logistic considerations. Geological studies will be conducted including determination of near-surface parameters, generation of near-surface isothermal maps, and correlation of near-surface data with existing down-hole information. Microwave studies will be performed at 21 cm wavelength on isolated controlling parameters such as penetration depth, moisture content, and salt content and microwave isothermal maps will be generated for each geotherm. The microwave and geologic maps will be correlated and the potential of the application defined. The studies will also be conducted at wavelengths longer than 21 cm if inexpensive modification of the existing 21 cm radiometer proves feasible.

W73-70520 **160-75-85**
Mississippi Test Facility, Bay St. Louis.
EARTH RESOURCES LABORATORY AT MISSISSIPPI TEST FACILITY
R. O. Piland 601-688-2034

The objectives are to: 1. Conduct research investigations in the Mississippi/Louisiana/Gulf areas in the application of

remote sensing, stressing the interests and needs of agencies in the area. 2. Extend these research investigations into experimental demonstration projects in cooperation with local agencies where appropriate; 3. Utilize existing aircraft and satellite programs as a primary source of remote sensing data, and collect and analyze surface data for correlation with these flight data; 4. Conduct continuing studies of user requirements of potential applications in order to guide future research efforts. The projects planned for FY 73 are in three major categories: 1. Automated Land Use System - Develop and demonstrate remote sensing techniques for land use mapping and updating including the definition/development of a prototype automated system for land use classification and update using the State of Mississippi as a demonstration area; 2. Wetlands characterization Study - Develop remote sensing techniques for making those environmental measurements necessary to manage the wetlands and coastal marshlands, 3. Sea Remote Sensing Study - Develop/define remote sensing systems to measure coastal water characteristics necessary for the evaluation/management of physical and marine resources Detailed objectives and plans for RY73 are presented in block 15.

W73-70521 **160-75-88**
Lewis Research Center, Cleveland, Ohio.
EARTH RESOURCES DATA BASE
Charles M. Goldstein 216-433-6660
(111-05-01)

The objectives are to provide for the storage and retrieval of information identifying images and sensor data obtained from the Earth Resources Technology Satellite (ERTS-A), to permit user queries based on geographical coordinates, sensor type, etc., to establish the communication capabilitites required to service the interagency user population, as well as those providing the primary input of data, to provide for the transferability of these capabilities to other computer configurations. The Aerospace Safety Research and Data Institute (ASRDI) generalized data base management system, NASIS, will provide the primary vehicle for implementation of the ERTS-A requirements. Modifications and extensions required to service the unique aspects of this data base will be implemented. The communications capabilities will be expanded to meet the requirements of users as well as of those providing the primary input of data. A conversion from the IBM 360 TSS time-sharing system to the IBM 360 OS operating system will be performed for purposes of transferability to other computer configurations. The transferability of NASIS to other computer systems such as the Digital Equipment Corporation's PDP-10 shall be investigated.

W73-70522 **160-79-51**
Goddard Space Flight Center, Greenbelt, Md.
SHORT AND LONG TERM GEODYNAMICS
D. E. Smith 301-982-4555

The long-range objective of this RTOP is the development of a model for the dynamics of the real-Earth that can ultimately be used in the assessment and alleviation of the disastrous effects of earthquakes. The near-term objectives are: (a) the determination of the capability and suitability of precision space tracking systems to provide the necessary measurements of the required quality and quantity; and (b) to develop the computer software necessary for the handling of these precision data and for the recovery of the geophysical parameters. The basic parameters for the final real-Earth model will include a description of the rotation of the Earth on its axis, the motion and properties of the major tectonic plates, crustal structure and changes, the relationship between seismic activity and Earth rotation, the tidal distortion of the solid and liquid Earth caused by the sun and moon, the spatial structure of the gravitational field down to wavelengths of about 100 km and the secular and periodic variations of the field with time. Thus the present plan gives descriptions of experiments and investigations that need to be performed to provide the basic measurements for the models.

W73-70523 **160-79-55**
Wallops Station, Wallops Island, Va.
OCEAN DYNAMICS AND MARINE GEODESY
Stanley H. R. 703-824-3411

This plan details the required research, studies, and experimentation necessary to advance the understanding of the dynamics and topography of the world ocean to 10cm accuracy; to advance the technology for providing geodetic control in broad ocean areas, and apply this knowledge to the monitoring and prediction of maritime hazards. The approach will be to conduct analytical studies and field experiments to develop instrumentation to meet the required accuracy; develop a calibration and verification plan, including appropritate ground truth; determine sea state, wave height, and electromagnetic wave scattering from the sea surface and their effects on instrumentation performance; test and demonstrate theoretically proven techniques for monitoring and predicting maritime hazards using data gathered from the experiments. The experiments and analyses rely heavily on information developed from ongoing projects at Wallops Station. For example, instrumentation development for the GEOS-C and Skylab projects indicate that 10cm instrumentation accuracy is feasible and could be flown in the 1977-78 time frame. The experimentation and analyses performed in the areas above indicate that there is a strong probability that it is possible to provide significant information concerning the patterns and transports of surface ocean currents, sea state, the gravity field, and geoid features; and will provide methods for improved marine geodetic control and prediction of maritime hazards.

W73-70524 **160-79-61**
Goddard Space Flight Center, Greenbelt, Md.
LASER INSTRUMENTATION FOR EARTH PHYSICS
Thomas S. Johnson 301-982-4835
(115-22-08)

The objective is the development, testing, and evaluation of advanced laser instrumentation and optical techniques to meet the specific requirements of the Earth and Ocean Physics Applications Program (EOPAP). In particular, to satisfy the immediate requirements of the San Andreas Fault Experiment (SAFE) and other specific observing programs and experiments scheduled in the EOPAP, this RTOP will: (a) Immediately apply new techniques to improve the precision and accuracy of laser satellite tracking over that presently achieved, extend the tracking range, optimize the transmitter-target-receiver parameters and simplify the ground station for economy and reliability of operation as well as ease of transportation; (b) it will apply the precision laser ranging techniques to the development of spaceborne packages which can be used as laser altimeters capable of 5 cm ranging to the ocean surface and the study of sea state conditions as well as tracking systems capable of ranging to cooperative targets on other spacecraft or to ground points. New signal processing techniques, including waveform digitizers and subnanosecond analog pulse centroid measurement systems are being developed and will be evaluated and applied to laser tracking systems presently in use and being funded by OTDA. Spacecraft retroreflector systems, both existing and new, will be analyzed and results used in optimization of overall ranging systems. Existing lasers and equipment will be used with new signal processing techniques to study ocean surface/sea state modeling parameters while development of long lead time space qualified laser transmitter for the altimeter system is initiated.

W73-70525 **160-79-64**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
EARTH STATICS/DYNAMICS - VLBI
A. W. Newberry 213-354-7240

The objective is to conduct studies, research and experiments leading to the demonstration of the utility of applying the Very Long Baseline Interferometry (VLBI) technique to (a) the Astronomical Radio Interferometric Earth Surveying (ARIES)* system for accurate measurements of earth strain and (b) the effectiveness of simultaneous two frequency VBLI for direct calibration of charged particle errors, and also to perform studies and analyses of flight missions and technology development requirements which have a direct and important bearing on Earth and Ocean Dynamics Program planning and implementation. The approaches are to adapt and refine systems analysis and data experience from intercontinental baselines to the specific goal of regional tectonic monitoring, develop and optimize methods of bandwidth synthesis for obtaining full three-dimensional measurements of VLBI station locations. Because the tropospheric water vapor is a likely limiting error source below 30 cm, direct calibration methods such as radiometry, will be investigated and feasibility demonstrations performed. (See continuation page)
*The acronym ARIES will be used to differentiate between the transportable stationregional measurement system and the better known but less versatile system which uses only fixed receiving stations.

W73-70526 **160-79-64**
Goddard Space Flight Center, Greenbelt, Md.
VERY LONG BASELINE INTERFEROMETRY (VLBI) FOR EARTH PHYSICS
J. Ramasastry 301-982-5462
(160-79-33; 160-79-34)

The objective of this program is to develop and utilize the techniques of Very Long Baseline Interferometry (VLBI) for precise geodetic and astrometric measurements, Universal time-synchronization, precision satellite tracking and Earth physics investigations with an operational network. This network should consist of a number of independent stations equipped with receiving antennas capable of observing both natural radio sources (Quasars, Pulsars, Radio Galaxies) and satellite borne radio sources in the frequency range 1 - 10 GHz, plus a central processing facility where the data taken at the stations is cross-correlated. Main effort will be concentrated on utilizing NASA tracking networks (MSFN, STADAN, ATSR), with simple modifications where and when necessary for conducting VLBI observations on a routine basis. Radio Astronomy sites (Owens Valley, California; Haystack, Massachusetts; Greenbank, West Virginia; Agassiz, Massachusetts; Goldstone, California and many others) will also be utilized where and when necessary. A prime benefit of VLBI for the Earth and Ocean Dynamics Program is the capability for utilizing a quasar-defined inertial reference-frame in geophysical investigations. This RTOP also seeks improvements in the hardware to enhance the precision of the VLBI technique, and refinements in associated software to process large volumes of data. An intensive, continuing, observational program has been undertaken governed by the particular geophysical phenomena to be analyzed and evaluated.

W73-70527 **160-79-68**
Goddard Space Flight Center, Greenbelt, Md
GEODETIC AND EARTH PHYSICS EXPERIMENT SYSTEMS
J. W. Siry 301-982-4905

The objective of this RTOP is to conduct the development of critical spacecraft and ground systems needed for the Earth & Ocean Physics Applications Program. These include: (1) A unified set of drag-free systems for the GRAVSATS and Geopause Spacecraft; (2) An Attitude Determination System for the MAGSATS spacecraft; (3) Theory and computer programs for analysis of spacecraft altimeter data for the GEOS-C and SEASATS spacecraft; (4) Satellite-to-satellite radio tracking systems for use with GRAVSATS, SEASATS, MAGSATS, and Geopause spacecraft; (5) Refraction Systems for use with Radio Tracking Systems and VLBI systems; (6) Geo-Applications Office Operations and Scheduling Systems for Laser and VLBI Observing Programs. The general aim of these developments is to provide measurement capabilities which are accurate to 2 cm in range and 0.003 cm/sec in range rate, in order to make possible the key experiments and flight missions needed to meet the program's earth dynamics and ocean dynamics objectives. The specific approaches for meeting these objectives are indicated in the individual task descriptions.

W73-70528 **160-79-69**
Goddard Space Flight Center, Greenbelt, Md.
GEODESY AND GEODETIC SYSTEMS
J. H. Berbert 301-982-5055
(160-79-51)

This program develops technology and utilizes available spacecraft tracking and surface gravity data to meet the NGSP goal for a Standard Earth Reference System accurate to 10 meters and 3 mgal with 12 deg x 12 deg resolution. Expected results include the development of a Standard Geometric and Gravimetric Earth Reference System by 1973. This Reference System is required as a basis for referencing the dynamic Earth measurements of the new Earth Physics Program. This will also provide a determination of the most suitable gravity models for Goddard trajectories near the Earth, and a more accurate determination of the coordinates of the NASA tracking stations on a Unified World Datum. Improved gravity fields and station coordinates are being developed from available data (NGSP, ISAGEX, surface gravity) and evaluated by comparisons with previous solutions and with independent data. A 22.5 deg x 22.5 deg field was reported in April '71. A 15 deg x 15 deg field will be reported in May '72 and a preliminary 12 deg x 12 deg field will be reported in August '72. The use of altimeter and SST data are beyond the scope of this RTOP, but are incorporated in RTOP 160-79-51-07.

W73-70529 **160-79-90**
Ames Research Center, Moffett Field, Calif.
APPLICATIONS OF VECTOR MAGNETOMETRY TO EARTH RESOURCES AND GEOLOGICAL STUDIES
John V. Foster 415-965-5083

NASA's highly-advanced vector magnetometer systems and data technology will be applied to the remote sensing of the geomagnetic field from satellites and high-altitude aircraft. Data analysis and interpretive assistance will be provided so that users, such as U.S.G.S., NOAA, and certain universities can more fully exploit the unique features of vector data. The immediate objective is to demonstrate feasibility of locating and identifying concealed mineral deposits at high aircraft altitudes and to determine the feasibility of spacecraft for similar purposes. NASA ARC will organize a broadbased constituency of user agencies and universities having specific requirements for vector geomagnetic data. The information provided by this group will be used to establish satellite mission priorities, hardware requirements and expected benefits. This information together with experimental data taken at high-aircraft altitudes will be used to determine feasibility of one or more magnetometer satellite missions.

W73-70530 **160-88-50**
National Aeronautics and Space Administration, Washington, D.C.
INTERDISCIPLINARY SUPPORT TO EARTH OBSERVATIONS PROGRAMS
R. T. Hibbard 202-755-8623

The Earth Observations Programs Office of NASA Headquarters is often called on by other NASA organizations and various Government agencies to perform and/or support certain technical functions which are either unrelated to current approved projects or span two or more disciplines. Typical of these activities would be support of various summer studies related to the Office, preparation of films and exhibits as well as the publication of related programmatic documents, support of the Earth Resources International Workshop, and the conduct of disciplinary and multi-disciplinary economic studies.

Communications SR&T

W73-70531 **164-06-50**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
COMMUNICATIONS SYSTEMS ANALYSIS
R. V. Powell 213-354-6586
(164-06-53; 164-06-56; 164-21-54)

This RTOP conducts applied research in the technological areas of modulation, demodulation, detection, and coding in order that efficient, low cost, highly reliable space-based information networks can be designed and built. Overall emphasis is motivated by the need for bandwidth minimization and management. The ultimate goal will be concerned with a specific application design which can be evaluated through prototype fabrications and satellite experiments. The near-term objectives stem from continuing research into modulation methods which produce minimum bandwidth RF signals. Since discrete or digital types of baseband signals (including quantized analog signals) offer the greatest amount of flexibility in devising bandwidth minimizing modulation systems, they are given prime consideration. Three approaches to bandwidth reduction via the modulation process continue to be investigated: 1) single-sideband suppressed carrier, 2) polyphase or M-ary PSK, and 3) multi-level (amplitude) encoding. Specific goals are: 1) a combination of the single-sideband, multi-level, and multi-phase modulation approaches to bandwidth reduction into a cohesive theory, from which maximum bandwidth reduction for minimum SNR increase can be determined, 2) a complete experimental evaluation of the duo-single-sideband suppressed carrier receiver, especially with regard to co-channel interference and the methods of implementing effective sideband filters, 3) a review of the transfer characteristics of presently operational communication satellites to determine their suitability for handling bandwidth compressive modulations, 4) investigations into the problems associated with ground communication links, concentrating on cable carrier systems (such as the mushrooming community antenna TV (CATV) networks) and 5) an amalgamation of all research areas into a preliminary design and functional specification for the complete information network.

W73-70532 **164-06-56**
Ames Research Center, Moffett Field, Calif.
INFORMATION TRANSFER VIA COMMUNICATION SATELLITES
J. V. Foster 415-965-5083

The objectives are: to determine the requirements for effective teleconferencing and interactive computer data transfer via communication satellites, fully exploit the technical potential of satellite links for this application - which cannot be provided by existing land-line facilities, maximize the communication link efficiency from power and bandwidth aspects by application of source and channel coding techniques, and analyze the trade-offtween system parameters to develop a cost-effective ground terminal. The approaches are to develop an all-digital teleconferencing system for voice, video, hardcopy, and computer data transfer, for video teleconferencing applications; to investigate effective source and channel coding techniques to reduce bandwidth and power requirements below those of an equivalent analog system; to design and fabricate system hardware to demonstrate these concepts; to implement a burst-mode random access, computer data transfer network concept; to determine the design requirements for a high data rate ground terminal for teleconferencing on appropriate 1971 WARC frequency bands; and to use the above data base to determine the effectiveness of satellite links for other user requirements in coordination with university studies.

W73-70533 **164-06-58**
Goddard Space Flight Center, Greenbelt, Md.
EDUCATIONAL COMMUNICATIONS SATELLITE SYSTEM STUDY
John E. Miller 301-982-5885
(164-21-72; 164-21-73)

The objecties are: to work with the user agencies to develop meaningful user oriented experiments to evaluate and demonstrate the applicability of technology to their needs and in support of this objective. to conduct a comprehensive program to develop the necessary analytical tools for effective system planning, to develop system concepts and supporting experimental data to assure optimum orbit and spectrum utilization, and to develop the critical space and ground technology. The RTOP tasks form four general categories corresponding to those enumerated in the objectives. The development of user oriented experiments will be accomplished through direct access to the user agencies and will be coordinated by NASA Headquarters. A methodology and data base will be developed to determine the temporal, spatial and communication channel capacity characteristics required for experimental and operational system. Cost models will be developed to provide insight into terrestrial vs. space techniques for telecommunications services. Studies to develop planning and coordination procedures at 2.5 GHz for the space and ground segment are currently in progress. These studies will be extended to the 12 GHz region. The development of system concepts to assure optimum orbit and spectrum utilization must of necessity await the emergence of firm user requirements. However, a significant amount of effort has been expended in the analysis of systems which conserve these resources. Studies of demand assignment mutliple access techniques, multiple beam---

W73-70534 **164-06-58**
Lewis Research Center, Cleveland, Ohio.
EDUCATIONAL COMMUNICATIONS SATELLITE SYSTEM STUDY
Joseph N. Sivo 216-433-6102

The objective is to conduct a study of the technological and cost factors of an advanced Educational Communications Satellite System utilizing the requirements provided by cognizant governmental organizations such as the Department of Health, Education and Welfare; Department of Interior; and the Corporation for Public Broadcasting. The scope of the study will encompass both space and ground segments, including integration of the space system into existing terrestrial facilities like CATV.

ITFS, state-wide educational networks and public broadcasting facilities. Educational television (ETV) embraces both instructional television (ITV) which is intended for classroom or formal education, and public television. The latter includes social, cultural, news and public affairs programming, and it is aimed at the general public.

W73-70535 **164-06-70**
Marshall Space Flight Center, Huntsville, Ala.
IDENTIFICATION OF FINGERPRINTS BY OPTICAL PROCESSING
J. H. Kerr 205-453-2600

By using an optical processor in conjunction with a digital computer, a fingerprint classification method is devised based on the Fraunhofer diffraction pattern of fingerprints. A library is constructed which catalogues fingerprints according to the devised classification method. By using an optical processor to perform correlation, the practicality of identifying randomly selected fingerprints is determined. An error analysis will be performed to assess the accuracy of the classification and identification methods. A breadboard system at MSFC for performing fingerprint classification and identification and a prototype system for performing fingerprint classification and identification will be fabricated. This prototype system would be used to demonstrate the feasibility to local, state, and Federal law enforcement agencies. By utilizing an existing in-house, state-of-art optical data processor in conjunction with an existing digital computer, fingerprint classification and identification studies will be performed. The existing optical processor is composed of an electro-optic input device, a fiber-optic detector for sampling the Fraunhofer diffraction pattern, thermoplastic material for making holographic spatial filters, and is interfaced to an IBM digital computer. Depending upon the results of the first study, at MSFC a breadboard of an automated system will be fabricated. This breadboard will consist of remote terminal to simulate a local law enforcement agency, a classification optical processor, a mass storage unit, an identification optical correlator, and digital control computer. A prototype system will be developed to demonstrate the concept to local, state, and Federal law enforcement agencies.

W73-70536 **180-06-01**
National Aeronautics and Space Administration, Washington, D.C.
LAUNCH VEHICLE PLANNING STUDIES
B. C. Lam 202-755-3726

The objective of this task is to provide the analysis and organization of program level data required in support of OSS Launch Vehicle and Propulsion Programs planning. A non-hardware organization established and experienced in the field of planning research is employed. Individual tasks are formulated and assigned by Launch Vehicle and Propulsion Programs. The contractor prepares technical reports presenting the results of analyses (economic analyses, trade-off studies, investigations in areas of launch vehicle technology; etc.) that provides a base of technical information that can be drawn upon in the formulation of program recommendations.

W73-70537 **164-18-54**
Goddard Space Flight Center, Greenbelt, Md.
TRAFFIC MANAGEMENT
Andrew B. Malinoswki 301-982-6462
(164-18-51)

The work in this RTOP is directed towards the development and application of satellite navigation, surveillance and communication systems to improve or augment the present maritime traffic management systems. The major services which can be provided by the navigation, surveillance and communication functions are: passive and active navigation, grounding and collison avoidance, voice and data links, and optimum ship routing. Because of the unique ability of satellites to keep in view all mobile traffic at all times over large geographic regions (e.g., Pacific, Indian and Atlantic Oceans), satellite systems which can 1) provide accurate navigation aids, 2) monitor ship traffic in congested areas to prevent collisions and groundings, 3) provide rapid information flow between ship and shore and ship to ship, become highly attractive candidates for maritime traffic management services. Although considerable study has been devoted to the economic soundness of satellites, there are numerous questions that need to be answered if satellite systems are to be implemented to operate in place of or in addition to any future ground systems. Some of the major questions are concerned with system performance (e.g., passive or active position determination accuracy, channel quality, application and resolution of environmental sensors, etc.), capacity (number of users, number of voice data channels, data rates, data type, etc.), cost factors, system reliability, state of art readiness for experimental and preoperational phases, and critical---

W73-70538 **164-21-54**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
COMMUNICATION SATELLITE ANTENNA RESEARCH
R. V. Powell 213-354-6586
(164-06-58; 164-21-55; 502-23-12)

This effort will complete the synthesis of antenna aperture distributions and initiate breadboard designs to determine the feasibility of practical antennas for NASA's communication, broadcast, and data relay satellites. This is done to determine operating characteristics at higher frequencies, e.g., K-band, to reduce sidelobe levels, and to create multiple shaped beams from a single aperture for selected shaped area coverage. Specifically, the multiple shaped beam information is needed for the proposed ATS-H and ATS-I experiments and the current AAFE program. Multiple shaped beams are planned and needed to allow transmission to different specific regions while using a mimimum of the allowed spectrum. Low sidelobes with beam shaping will permit coverage of unique areas with sharper cutoff at international boundaries within an allowed interference level. The results of the present shaped beam study will be used in this FY'73 program. These results will indicate one or more types of useful shaped beams to consider for implementation, one by using some type of phased array, the other by using some configuration of reflector and feeds. A breadboard system will then be built to determine problem areas and expected performance advantages.

W73-70539 **164-21-55**
Goddard Space Flight Center, Greenbelt, Md.
TRACKING AND DATA RELAY SATELLITE TECHNOLOGY DEVELOPMENT
George Q. Clark 301-982-6331
(150-22-20)

The two objectives are: 1) to provide for the definition of a Tracking and Data Relay Satellite System to be used for support of NASA missions, and 2) to provide for the orderly development of the technology required for implementing a first generation TDRSS by 1977. Various studies will be performed to establish the criteria for a TDRSS while other studies will look for solutions to problems inherent in the system. In addition, technology will be developed as required for a first-generation TDRSS.

W73-70540 **164-21-72**
Goddard Space Flight Center, Greenbelt, Md.
COMMUNICATION LINK CHARACTERIZATION
J. Eckerman 301-982-6786
(164-21-73; 164-06-58)

The NASA interference and propagation program was planned by a multiagency committee at the request of the Director of Telecommunications Policy. Initially, emphasis was placed on preparation of the United States position on interference between satellite earth stations and microwave relay links at frequencies below 10 GHz for the 1971 World Administrative Radio Conference (WARC-71). The program objective is to acquire, analyze, and disseminate space propagation data for a user community of space systems designers, operators and regulatory agencies. Measurements and analyses are being performed which lead to a centralized data base for characterization of radio frequency phenomena required to design space communications systems. The successful implementation of space applications services depends upon optimization of satellite communications systems. The design and operation of reliable communications links requires data on 1) propagation effects caused by natural phenomena, and 2) man-made noise that may adversely distort signal transmissions. The present data inadequacies may result in costly over-design, substandard system performance or perhaps mission failure. This communications sciences program is designed to obtain interference and propagation data needed by NASA and other agencies for their space programs.

W73-70541 **164-21-73**
Goddard Space Flight Center, Greenbelt, Md.
COMMUNICATIONS TECHNICAL CONSULTATION PROGRAMS
J. Eckerman 301-982-6786
(164-21-72; 164-06-58)

Analyses, technical positions and support on space communication matters will be given to various agencies as well as CCIR and UN working group members. It is the mission of this project to advise the Executive Office of the President, the Federal Communications Commision, Department of State, Office of Telecommunications Policy, Department of Defense, Department of Health, Education, and Welfare, and NASA organizations on Space Communications Technology Support is required for the following identifiable tasks: 1) Domestic Satellite Systems and Orbit Utilization optimization studies. Of particular concern is the problem of providing for growth of existing and planned satellite services as well as assuring orbital slots and frequencies for new services not yet defined; 2) CCIR interim and plenary in CY72 and 73 respectively; 3) anticipated UN or ITU sponsored working parties on direct broadcast; 4) World Administrative Radio Conference/Maritime and Mobile (WARC-MM) 1974. In addition, special requests from FCC, OTP, OST, etc., not yet defined but certain to come shall be supported.

W73-70542 **164-21-80**
Goddard Space Flight Center, Greenbelt, Md.
10 MICROMETER WAVELENGTH SPACE COMMUNICATION
Nelson McAvoy 301-982-4942

The objective is to develop efficient systems for very wideband communication suitable for NASA missions requiring high data rate links between two spacecraft and between spacecraft and ground stations. Ten micrometer wavelength systems using CO2 lasers can provide this capability with low power consumption, light-weight, small antennas, negligible interference, and no spectrum crowding. Effort under this RTOP will be on the development of techniques, components and systems with CO2 lasers that ultimately will be used in missions such as TDRS and Earth Resources Satellites. Component technology is now available for the development of an optical engineering model of a space-to-space communication link. During FY72, subsystems for an engineering model of a spaceborne receiver terminal were started. A contract was let for development of the optical, structural, and mechanical subsystem of the receiver. Also, in FY72, in-house component development commenced on tunable laser local oscillators to cope with tracking of plus or minus 710 MHz Doppler shift. FY73 and FY74 efforts will be directed toward advanced component development leading to the development of an engineering model of a 300Mbit/S optical communication link such as would be required between a low orbiting satellite and a synchronous satellite. Tests will be conducted to evaluate operation of high data rate links under simulated conditions of pointing instability and channel noise. Component development will emphasize requirements of the wideband receiver, such as tunable local oscillator concepts and gigahertz mixer response at 130 K.

W73-70543 **164-21-81**
Marshall Space Flight Center, Huntsville, Ala.
COMMUNICATIONS AND NAVIGATIONS SATELLITES SUPPORT STUDIES
D. O. Lowrey 205-453-1578
(164-76-61)

Studies and investigations, including laboratory experimentation and range testing will be performed in support of communications and navigation satellite programs aimed at earth user applications. The investigations will be concentrated in two primary areas: (1) multiple beam and beam contour forming antenna techniques, and (2) microstrip and microwave circuit techniques. Both tasks will be aimed at communications systems that operate at S-band and higher frequencies with primary concentration on Ku-band operation. The work at other centers will be studied closely so as to prevent duplication of techniques, to provide support in areas that may have been overlooked, and to take advantage of the results that are applicable to these tasks. A concentrated in-house effort will be employed in the performance of these tasks, making use of existing laboratory and antenna range facilities. The microstrip and microwave circuit task will develop circuit design and fabrication techniques of circuits that can possibly be used in the multiple beam and contour beam forming antennas in order to provide light weight systems as well as transmitter, receiver and other associated microwave circuitry.

W73-70544 **164-76-51**
Goddard Space Flight Center, Greenbelt, Md.
SYNCHRONOUS ORBIT SPACECRAFT TECHNOLOGY
Henry C. Hoffman 301-982-4496

This project will develop long lead time spacecraft system technology, of specific applicability to synchronous equatorial missions, planned for the late 1970's and early 1980's. The results could be applicable to missions such as ATS-H and ATS-I Tracking and Data Relay Satellite and TV Distribution/Direct Broadcast satellites. The efforts will be toward both high accuracy pointing systems (.001 degrees) and towards a deeper understanding of passive systems. Studies will be carried out on synchronous altitude system design concepts, precision measurement systems, advanced dynamic analyses of spacecraft flexibility, advanced thrusters and torquers for precise earth oriented spacecraft, and damping mechanisms. Damping mechanism studies will include both analysis and test of dampers for use on spinning and multi-spin satellites. In addition, components not intended as dampers, such as heat pipes and fuel in the tanks will also be analyzed and tested

W73-70545 **164-76-60**
Goddard Space Flight Center, Greenbelt, Md.
DATA COLLECTION
C. E. Cote 301-982-4215

The objective is to develop technology for collecting data and determining position location for upwards of 10 - 100,000 platforms in support of communications, earth science, earth survey and search and rescue applications. A significant objective is to develop systems which can be implemented economically in terms of user platform equipment, allow for continued growth in number of users, and meet increased requirements in terms of data traffic densities, location accuracy, velocity estimation and real time monitoring and reporting. Experimental systems are developed and proposed as experiments on NASA application satellites. Advanced mission planning and development form an integral part of the program. The approach to meeting the above objectives is: (1) initiate and maintain contact with the user community; (2) establish user needs and requirements; (3) develop technology in systems and hardware areas, and; (4) conduct flight experiments to validate and demonstrate concepts. User requirements are established through surveys using mailed questionnaires and direct personal contact. Requirements are configured into platform concepts to reflect the state of the art in technology and data collection systems evolution. With increasing demands for lower cost platforms, higher capacity systems, and improved precision of position and velocity estimation, studies are carried out in advanced techniques to perform satellite on-board data processing and improve position/location accuracy. A program of component/technology development is carried out, particularly as regards reducing---

W73-70546 **164-76-60**
Ames Research Center, Moffett Field, Calif.
DATA COLLECTION
H. P. Klein 415-965-5094
(160-75-24; 160-75-16)

The objectives are to investigate the capability of current and future satellite communications systems to meet the needs for tracking wildlife roaming within large geographical areas, evaluate the status of current satellite position location techniques, propose requirements for future NASA satellite communication systems to meet the economic and scientific needs for wildlife migration monitoring and management and to build a data transfer station for fishery management via satellite relay. A RFP will be prepared by ARC containing the data collection requirements (physiological, behavioral, positional and environmental) of experimenters studying wildlife migration. In turn these requirements will lead to further requirements for the satellite communication systems as follows: 1) status of position location technology; 2) power, frequency, and bit rate requirements of mobile platforms to transmit data to satellites from environmental and physiological sensors; 3) evaluate data processing and relaying requirements for satellites; 4) evaluate antenna requriements for data transmission to satellites; 5) evaluate microminiaturization of receiving-transmitting units used on animals. ARC communication expertise will specify hardware requirements for a remote data relay ground station to use the ATS. ARC will buy, assemble and check out the system and prepare for Summer of 73 prototype systems field test in fisheries measurements.

W73-70547 **164-76-81**
Marshall Space Flight Center, Huntsville, Ala.
MANNED COMMUNICATIONS AND NAVIGATION FLIGHT EXPERIMENT DEFINITION
C. W. Quantock 205-453-3424

This study is directed to the development of the in-depth Phase A level conceptual design, definition, and specification for selected experiments that will be flown in a Communications/Navigation Research Laboratory on early Shuttle Sortie missions. The conceptual definition of the laboratory is currently being developed under a parallel RTOP entitled, "Continuation of the Study Definition of Experiments and Instruments for A Communications/Navigation Research Laboratory." The experiments considered in this study will be selected by the NASA Headquarters Program Office. Recommendations relative to the experiment selection, which will be provided by the NASA COR, will be based upon the results of the Laboratory study. More specifically, this study is directed to the development of the items listed below for each of the selected experiments. (1) specifications, including such factors as weight, volume, power requirements, special orbital characteristics, unique environmental requirements, etc.; (2) drawings, including size, configuration, interfaces, etc; (3) interface definition document, wherein, structural, mechanical, electrical or electronic interfaces are identified.

W73-70548 **164-76-80**
Marshall Space Flight Center, Huntsville, Ala.
DEFINITION OF EXPERIMENTS AND INSTRUMENTS FOR A COMMUNICATION/NAVIGATION RESEARCH LABORATORY
Charles W. Quantock 205-453-3424

This study is directed to the conceptual design and definition of a manned Communications/Navigation Laboratory to be flown on Shuttle Sortie Missions. The laboratory will be designed to accommodate several experiments that will complement and supplement Communication/Navigation research data obtained from unmanned synchronous satellites. More specifically, the objectives of this study are to: (1) Define experiments and experiment requirements, (2) identify and develop conceptual designs for major laboratory equipment and experiment instrumentation, (3) perform a systems and operations analysis, (4) investigate alternative laboratory configurations, payloads, and missions, (5) conduct studies relative to the role-of-man and on-board experimentation and data management, (6) develop a conceptual design and definition of the Communications/Navigation Laboratory, (7) develop mockups, sketches, and floor layouts which show equipment/instrumentation and experiment locations, sizes, shapes, weight, volume, etc., (8) identify any requirements or constraints the laboratory might place upon the Shuttle Sortie missions, and (9) develop cost, schedule and SRT requirements. Experiment definitions, which are being developed under a parallel RTOP will be a driving factor in the development of the laboratory design. A limited amount of the total study effort will be directed to studies relative to pre-Shuttle flight opportunities in the event they are made available by NASA management decision.

W73-70549 **164-76-81**
Marshall Space Flight Center, Huntsville, Ala.
MULTI-USE REUSABLE ANTENNA TECHNOLOGY
K. R. Taylor 205-453-3424

During the Space Shuttle era, numerous missions in Communication/Navigation and other applications discipline are planned. The objective of this activity is to develop antenna designs that will meet the requirements of these missions, in the most cost effective manner; and also be compatible with the mode of operation of the Space Shuttle. Antennas on payloads which are deployed and retrieved by the Space Shuttle

must be reusable and multi-use designs This places a number of constraints and requirements on antenna designs; i.e., deployment/retraction capability and interchangeable feed capability. This activity will define antenna design and test models that will be needed to meet the requirements of future applications missions during the Space Shuttle era. Specific results will be: (A) A summary of the requirements for antennas to support future communications/navigation and earth observations missions. (B) An evaluation of available antenna designs for applicability of these requirements. (C) The definition of high gain, multi-use/reusable antenna designs. (D) The identification of future SR&T requirements for high gain, multi-use/reusable antennas.

W73-70550 **164-76-83**
Marshall Space Flight Center, Huntsville, Ala.
SOLAR POWER SYSTEM DEVELOPMENT
Walter E Whitacre 205-453-0470

The objective of this study is to assess the present and projected electrical power generation needs, technology, and supply status and to determine the technical and economic attractiveness of both ground based and orbit based solar power systems. Using available data and the results of recent studies an assessment will be made of the present known energy sources, the present expected life of these sources, the expected trends in per capita energy consumption, population growth, and industrial changes. There will also be technical and economic comparisons made between solar power systems and other known or postulated energy generating systems such as nuclear power plants, hydroelectric plants, etc. The study will also determine the technology needed to permit operation of a ground based solar power system, in the several megawatt range, by 1986. This technology development plan will include consideration of and for the various environmental costs and effects of both the present and postulated generation systems and the transmission and distribution subsystems which serve as part of the solar power system.

W73-70551 **164-76-84**
Marshall Space Flight Center, Huntsville, Ala.
USE OF THE SOLAR ELECTRIC PROPULSION STAGE (SEPS) FOR EARTH ORBITAL APPLICATION
C. H. Guttman 205-453-3196
(680-40-05; 113-26-24; 180-17-56)

This RTOP represents a new start effort in that it represents an application study to be used in conjunction with an ongoing project entitled "Use of the Solar Electric Propulsion Stage (SEPS) for Performing Earth Geosynchronous Missions." The objective of this RTOP is to determine and define the advantages that the Solar Electric Propulsion Stage (SEPS) can offer future Earth Orbital Application programs in terms of lower cost programs while maintaining a higher level of program flexibility and science return than presently exists.

OFFICE OF SPACE SCIENCE

Launch Vehicle Development SR&T

W73-70552 **180-06-50**
Langley Research Center, Langley Station, Va.
ANALYSIS OF ADVANCED PROPULSION SYSTEMS REQUIREMENTS
C. H. Nelson 703-827-2893

A continuing program has been underway for several years aimed at evaluating and analyzing the capability of existing and proposed propulsive systems. A large number of the proposed systems are of the low thrust variety. The theory, analytical approaches and computer implementation of the task necessary to study low thrust missions have been pursued at the Aerosystems Lab. of Princeton University and by Analytical Mechanics Associates, Inc. Current efforts will be directed at extending the capabilities of these computer programs, identifying new program requirements, and utilizing the programs to determine propulsive requirements for future missions. Comparisons will be made between high and low thrust missions as well as missions that combine the two. The approach to be taken is to study in greater depth selected earth orbital, planetary and interplanetary missions where preliminary work has indicated that low thrust propulsion systems show a distinct advantage over conventional propulsion in either payload or trip time. The current studies will incorporate detailed spacecraft systems performance models to include both space environment and spacecraft related constraints. Orbit determination and guidance analyses will be performed for those missions that show promise after an indepth study. The behavior of several orbit determination and guidance schemes will be analyzed to determine the relative merits of each as well as possible effects on spacecraft system performance.

W73-70553 **180-06-50**
Goddard Space Flight Center, Greenbelt, Md.
ANALYSIS OF ADVANCED PROPULSION SYSTEM REQUIREMENTS
R. E Coady 301-982-4731

A continuing program has been under way for several years aimed at evaluating and analyzing the capability of existing and proposed propulsion systems for accomplishing planned or proposed automated missions. The theory, analytic approaches and computer implementation necessary to conduct this work have been pursued at the Aerospace Systems Lab. of Princeton University and by Analytical Mechanics Associates, Inc. Current efforts are directed at extending the capabilities of these computer programs, as well as the use of the progams already developed, toward the generation of mission data for a broad range of missions and toward updating NASA's Launch Vehicle Estimating Factors booklet for solar electric propulsion. Included in the current efforts has been work directed toward making the relationship between impulsive and finite thrust trajectories mathematically explicit and the implementation of this work into an operational tool. Currently work is in progress to extend the capabilities of present programs to include more realistic performance and environmental models. Additionally, work has begun to study the behavior of several proposed guidance schemes in an attempt to establish the criteria on which a judgment can be made about the relative merits of one mode over another. The approach to be taken in the next few years is to study selected Earth orbiting, planetary and interplanetary missions where preliminary work has indicated that low---

W73-70554 **180-06-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
MISSION REQUIREMENTS FOR NUCLEAR ELECTRIC SPACECRAFT
P. J. Meeks 213-354-2546
(503-25-02; 503-05-02)

The objective of this RTOP is to investigate the direct consequence of using nuclear electric propulsion to provide prime propulsion aboard planetary spacecraft. This RTOP is to determine unique mission features, payload capability, launch vehicle characteristics, spacecraft integration problems and solutions, ground support equipment, prelaunch testing requirements, restrictions due to nuclear safety, and overall mission costs for nuclear reactor electric propulsion systems. This RTOP

will compliment overall spacecraft design studies presently being conducted which primarily emphasize the nuclear electric propulsion system. The program was started in late FY'71 with an industry study contract, which has been supplemented by some in-house support analyses in FY'72. The contract used a Comet Halley mission and an outer planet mission as a basis and concentrated the effort in four areas. (1) investigation of all operational aspects of a thermionic Nuclear Electric Propulsion (NEP) system, (2) definition of a multimission propulsion system, (3) estimation of gross development schedules and costs, and (4) definition of technology requirements. As a result of this study it has become clear that more effort is required in the immediate future in the following areas: (1) mission planning and requirements to determine the appropriate role for NEP, taking into account, from a scientific standpoint, its unique features such as target maneuver capability and the availability of large amounts of electric power at the target, (2) safety, including both nuclear hazards and hazards associated with the specific quantities of materials used in NEP, and (3) mission reliability studies in order to assess trade-offs in reliability for performance.

W73-70555 **180-06-52**
Langley Research Center, Langley Station, Va.
LAUNCH VEHICLE CONCEPTS AND ANALYSIS
C. H. Nelson 703-827-2614

The objective is to determine the feasibility of using a launch vehicle with a spin-stablized final stage to achieve lunar orbit. An investigation will identify allowable tolerances on injection errors to insure entry into the lunar sphere of influence, the translunar trajectory which is least sensitive to these errors on lunar arrival conditions and body attitude deviations in the vicinity of the moon. The approach is: to extend the successful design principles, experience, and operations technology of the Scout booster system by modifications which will enhance its current capability and cost effectiveness. The broad study will evaluate configurational changes in terms of performance, cost, and scheduled phase-in with the present system; to provide a trajectory analysis tool enabling a more rapid and realistic determination of the actual rocket motor performance. Any off-nominal system performance or system constants will also be revealed. This will be of special value in evaluating new configurations, and comparing measured bending moments of the Scout vehicle during flight with moments calculated based on measured inflight input parameters.

W73-70556 **180-11-06**
Goddard Space Flight Center, Greenbelt, Md.
ISOGRID CYLINDER TEST PROGRAM - COMBINED LOADS INCLUDING INTERNAL PRESSURE
Daniel J. Knighton 301-982-4258

The objectives of this test program are to determine the contribution of internal pressure towards increasing the buckling strength of cylindrical isogrid structures, Figure 1, and to determine the stresses and deflections associated with bulkhead/cylinder discontinuities for use on Delta and the Space Shuttle. Combined axial compression, bending, shear and internal pressure loading tests are expected to provide improved prediction techniques for designing more efficient structures.

W73-70557 **180-17-50**
Langley Research Center, Langley Station, Va.
ASTRIONICS SYSTEMS EVALUATION
C. H. Nelson 703-827-2893

A feasibility study will be conducted to define a guidance and control system concept for application to the final stage of a launch vehicle, based on trade-off studies, stability and control analyses, guidance and trajectory error evaluations, and a preliminary design utilizing the concept selected. Trade-off studies will emphasize versatility of use in satisfying varied mission requirements, capability for improving vehicle overall performance accuracy, and minimal impact on vehicle interface changes, system weight, and cost of implementation. Also, a survey of industry and government agencies will be conducted to determine the availability of a state-of-the-art inertial guidance (miniaturized gimbal or strap-down, conventional gyros or laser gyros) systems which could be utilized in launch vehicles or aircraft. Evaluation points will be weight, volume, cost, ease of maintenance, reliability, and accuracy. A feasibility study and system selection shall be completed for a spinning body control system for spin-stabilized stages of small launch vehicles. System parameter definition, operating specifications, and selection of an optimized low-cost spinning-body control system shall be accomplished.

W73-70558 **180-17-50**
Marshall Space Flight Center, Huntsville, Ala
SYSTEM PERFORMANCE AND TECHNOLOGY ASSESSMENT FOR UNMANNED MISSIONS
William D. Powers 205-453-3194

Methods and computer programs, developed under NAS12-550 and updated and tested under NAS8-26491, allow the definition of systems parameters for planned OSSA missions. These parameters include data needed to identify Astrionics/avionics subsystems and hardware requirements. The sensitivities of these requirements to mission and systems changes or modifications will be included. The methods and computer programs allow one to enter technical data of known applicable aerospace or commercial subsystems. The output will be comparison of requirements for specific OSSA missions with available subsystems. This comparison will aid NASA Management to take advantage of subsystems already developed or being developed for other programs and to identify new technology needed where applicable subsystems are not available.

W73-70559 **180-17-52**
Marshall Space Flight Center, Huntsville, Ala.
SYSTEM AND TRAJECTORY ANALYSIS
William D. Powers 205-453-3194
(180-17-53)

The evaluation of strapdown inertial systems for launch vehicles requires a determination of the performance in the launch environment. Studies and experiments completed show that the launch environment of the vehicle modifies the static error model of the system. These effects must be identified and concepts developed and tested for reducing these errors to an acceptable level. Studies will be performed to develop guidelines for selecting subsystem approaches. Experimental studies will also be continued to quantify the sensitivity of sensors and systems to the launch environment. Specifications for a normalized, single axis inertial measuring module will be defined. The designing and building of a prototype electronics set for a normalized gyro will be started.

W73-70560 **180-17-53**
Marshall Space Flight Center, Huntsville, Ala.
DYNAMIC TESTS OF INERTIAL SENSORS
William D. Powers 205-453-3194

The objective is to determine the performance quality of inertial sensors designed for Astrionics application. Approaches are to: 1) determine the suitability of existing methods and equipment for dynamic tests of inertial sensors developed as experimental prototypes for Astrionics applications; 2) develop

the necessary test data reduction methods; 3) evaluate the sensor coefficients of designated error models for Astrionics systems, with and without any error compensation equipment; and 4) conduct performance tests with the inertial sensors combined into an Astrionics sensor package.

W73-70561 **180-17-54**
Marshall Space Flight Center, Huntsville, Ala.
GUIDANCE COMPUTER TECHNOLOGY
William D. Powers 205-453-3194

The coming decade of vigorous space activity by NASA and other organizations will require an increasingly reliable launch vehicle family. This includes the development of technology to provide flexible and reliable guidance computation for future space missions. High performance data processing configurations with useful lifetimes up to five years for long duration earth orbital and planetary missions are to be emphasized. Digital logic, circuits and packaging techniques are to be developed to meet the reliability and environmental constraints of these advanced missions. Emphasis will be given to continuation of research in modular computer configurations including evaluation of Modular Computer Breadboard which has been developed and fabricated by NASA Electronics Research Center. Existing software will be refined and expanded and new software developed in the areas of failure detection, switching control, and recovery. The culmination of these developments and evaluations will result in the fabrication of a breadboard modular computer system utilizing LSI technology. Associated software will be developed concurrently.

W73-70562 **180-17-56**
Marshall Space Flight Center, Huntsville, Ala.
SOLAR ELECTRIC PROPULSION STAGE (SEPS) - SRT
C. H. Guttman 205-453-3190

This RTOP represents the total SEPS SRT project effort for FY-73. The objective of this task is to provide the initial technology research and development necessary to assure adequate, timely, and cost effective technology development for the SEPS project. The objective of this project in FY-73 is not to develop hardware at this time but to determine in detail a requirements and technology analysis in each case so that the need for, availability, programmatic, and cost aspects of the development item can be determined. The tasks to be researched and developed under this project include: Dynamics of Off-Loaded Stage Mercury Tanks, Long Duration, Low Thrust Navigation and Guidance Analysis, Stage Thrust Vector Control Techniques, Closed Loop Dynamics of the Stage with Large Solar Arrays, Stage Central Computer and sequences (CCS) Requirements Analysis, Stage Navigation Sensors, Versatile Thermal Control System for the Stage, Environmental Protective Device for Stage Payloads, SEPS Structural Analysis, Survey and Classification of Low-Thrust Trajectories, and SEPS GC&N System Definition Studies. A majority of the tasks shown will be spin-offs of ongoing inhouse efforts currently being worked.

W73-70563 **180-17-57**
Marshall Space Flight Center, Huntsville, Ala.
SOLAR ARRAY TECHNOLOGY FOR SOLAR ELECTRIC PROPULSION STAGE (SEPS)
J. L. Miller 205-453-4566

The objective of this RTOP is to insure the availability and adequacy of technology to support the solar electric propulsion stage solar array. The approach is to assess the adequacy of existing advanced solar array technology and to use that which is applicable and to develop that which is not. Specifically the GE and Hughes rollup solar array concepts will be considered along with the possibility of a different deployment scheme using the Lockheed deployable boom concept. As a backup approach or possibly a product improvement approach, the FEP teflon solar cell sandwich blanket concept under development by LeRC will be considered. The effort will be accomplished according to a 4 point work breakdown as follows: (A) Analysis of technology available in comparison to SEPS requirements; (B) Specific technology; (C) Specific application development, (D) Fabrication and test of a full scale test article.

W73-70564 **180-24-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
ENGINEERING INSTRUMENTATION
P. J. Meeks 213-354-2546

This is an applied research program designed towards developing and demonstrating electrothermal nondestructive EED test techniques, methods to efficiently and reliably function electroexplosive devices at high power levels and techniques for allowing in-flight monitoring of squib condition for long duration missions. Several techniques have been developed to nondestructively examine the condition of the critical squib bridgewire/header/pyrotechnic interface. The development of new application techniques to integrate these NDT tests into flight applications is now being addressed. Techniques to examine and analyze both unloaded squib bridgewires and the relationship between the loaded assembly and the bare wire will be developed. A second most important application of the NDT techniques will be in the determination of failure mode rates so that a failed condition can be forecast in several different environments. This application information will be directly integrated into long term mission squib monitoring technology development. Long duration missions to the outer planets and beyond necessitate squib survivability in an extended radiation and vacuum temperature cycling environment. A method to periodically monitor squib ignition reliability while a spacecraft is in-transit to the outer planets will be developed. It is presently planned to make use of the spacecraft computer, telemetry techniques and the squib firing circuit in this application. Low level electrical pulses will be periodically supplied to each bridgewire of each spacecraft squib. The electrothermal responses from the squib will be analyzed by the on-board computer for condition determination of bridgewire circuit. This information can be used to directly influence overall mission operational flexibility either by the spacecraft computer or by ground commands.

W73-70565 **180-31-02**
Goddard Space Flight Center, Greenbelt, Md.
AEROZINE 50/N2O4 AUTOGENOUS PRESSURIZATION SYSTEM
R. L. Haltermann 301-982-6113

The objective is to determine the feasibility of reducing the Delta vehicle's second stages inert weight through the replacement of the current helium cold gas propellant pressurization transfer system by an autogenous AeroZINE 50/N2O4 system. The hypergolic characteristic of this propellant combination provides the potential for such applications as: 1) studying alternate methods using the basic propellants to provide the performance given by the present pressurization system, 2) performing a systems analysis on the alternate methods to determine amounts of propellant required to provide the necessary pressurant volume; 3) developing the layout; and weight of the design hardware required for each system) 4) performing a critical failure analysis on the systems and determining the reliability of each, 5) selecting the most sensible design and performing subscale testing.

W73-70566 **180-31-07**
Goddard Space Flight Center, Greenbelt, Md.
RS-27 ENGINE LOW LEVEL THRUST QUALIFICATION
Thomas D. Stuart 310-982-5961
(680-40-02)

The maximum acceleration level on a Delta mission will occur during the end of first stage burn. This is true for all two stage missions and for three stage missions using the TE-M-364-4 solid propellant motor where the spacecraft weight exceeds 1200 pounds (700 pounds with a TE-M-364-3 motor). Reorificing the repackage Delta H-1 (designated RS-27) engine to lower the thrust is a straightforward method of reducing the maximum acceleration. The proposed thrust reduction to 160,000 pounds would reduce the maximum acceleration, during the last seconds of first stage burn, by 25 percent.

W73-70567 **180-31-51**
Lewis Research Center, Cleveland, Ohio.
THERMAL SYSTEMS MANAGEMENT
J. R. Barber 216-433-6441

The general objectives of the programs to be conducted under this RTOP are to provide the technology required for effective design, fabrication, maintenance and operation of thermal protection systems for use with cryogenic propellants in launch vehicles and upper stages. Experimental and analytical studies will be conducted to (1) evaluate multilayer insulation performance, emphasizing the effects of critical features (such as seams, overlaps, gaps and penetrations), insulation preconditioning and surface temperatures, (2) investigate the influence of outgassing on insulation performance, including the effect of perforations, (3) optimize multilayer insulation by selectively varying thickness and shield emissivity, (4) investigate the concept of a lightweight vacuum jacket, and (5) evaluate a lightweight cryogenic refrigeration system for long-term space operation.

W73-70568 **180-31-52**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
LIQUID PROPULSION TECHNOLOGY
P. J. Meeks 213-354-2546
(757-53-30; 503-24-26)

A primary objective is to design a Dual Mode Propulsion System which will be ready for use by 1977 flight projects. System requirements for the next decade and existing and projected capabilities will be reviewed. Coordinating closely with related OAST R/AD RTOPS, component improvements, technology deficiencies, and other new approaches will be identified. Another major objective is to demonstrate and evaluate a flight-configuration bimodal (combination monopropellant/bipropellant) rocket engine for unmanned planetary spacecraft applications. The engine will be passively-cooled and operable, upon command, in either the monopropellant or bipropellant model. It will burn the earth-storable propellants N2O4 and N2H4 and be capable of operating continuously for at least 1000 seconds at a 4500-N (approximately 1000 lbf) thrust level for orbit-insertion or plane-change maneuvers, and at a reduced thrust of about 1500-N (approximately 340 lbf) with monopropellant N2H4 for orbit modification or trajectory correction maneuvers, all with a single thrust chamber. A third objective is to advance understanding of the chemical and mechanical processes occurring within a bed of Shell 405 catalyst during monopropellant decomposition, with special emphasis on the phenomenon known as "washout". The experimental work will be extended to pulse-mode washout, and a mathematical correlation will be developed to predict and control washout.

W73-70569 **180-32-51**
Langley Research Center, Langley Station, Va.
SOLID ROCKET PROPULSION SYSEMS
C. H. Nelson 703-827-2893

A review will be made of the criteria and methods of analysis used in the design, processes, and techniques used in the fabrication of solid fuel rocket motors, particularly those used in the Scout vehicle, and identify those areas where the design and/or process controls are inadequate. A study will be performed to define the extent and severity of the solid rocket motor outgassing. Optimum motor case materials and/or fabrication techniques will be selected. An investigation will be conducted to determine and verify by tests a technique for predicting the aerodynamic coefficients of control surfaces immersed in a rocket exhaust flow external to the nozzle. A study will survey the existing motors, define an optimum configuration for an upper stage motor, and select one or more candidates as the starting point for development of the optimum motor. The Apollo standard initiator will be qualified to a delay initiator assembly in a modular concept. In this concept, the Apollo standard initiator shall be used to function higher level hermetically-sealed pyrotechnic assemblies. Separate motor delay initiator assemblies will be developed to meet three different specified conditions. An investigation will be made to evaluate the effectiveness of radiographic and ultrasonic nondestructive test methods currently used for determining the acceptance of solid propellant motors. Methods for upgrading the quality of nondestructive test acceptance criteria, through improvements in existing equipment and procedures, and/or the use of advanced techniques will also be investigated. A development program will be conducted to determine the selection of an improved material to replace graphite materials currently used for nozzle throat inserts on solid propellant motors. A program will---

W73-70570 **180-32-52**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
SOLID AND HYBRID PROPULSION TECHNOLOGY
Paul J. Meeks 213-354-2546
(758-56-47; 502-24-06)

The objectives are to determine the requirements, the applicability, and the effectiveness of solid and hybrid propulsion systems in meeting future earth orbit, planetary spacecraft, and probe missions; identify optimum propulsion configurations; and determine areas of technology advancement required to support future use of such propulsion. Standardization of certain classes of propulsion systems for multi-mission applications will be sought. The major effort will be on the Spacecraft Energetic Propulsion (SCEP) concept, propulsion within planetary atmospheres, and demonstration firings of graphite epoxy motor chambers. Motor reliability of conventional apogee and small upper stage solid motor applications will be examined to determine where reliability improvements may be achieved. User requirements, analyses, development and motor fabrication techniques and user flight data and experience relative to post flight failures will be assessed. Flight instrumentation and motor NDT improvements will be stressed. Recommendations for reliability improvement will be provided for future flight program usage.

W73-70571 **180-32-52**
Langley Research Center, Langley Station, Va.
DELTA HYBRID TECHNOLOGY DEMONSTRATION
C. H. Nelson 703-827-2893
(113-32-01)

The objective of this work is to complete the technology for a high energy (flox/lithium-lithium hydride) hybrid propulsion system so as to allow initiation of a development of a new third stage for Delta using this system. The approach will be a contracted program in which the primary effort will be a design

and demonstration at full scale in heavyweight hardware of (1) a suitable fuel configuration using an already developed fuel formulation, and (2) a suitable nozzle which will survive the required extreme temperature and chemical environment for 100 seconds. Secondary emphasis will be on altitude performance verification and on demonstration of the benign nature of the fuel in response to cracks, separations, etc.

Planetary Exploration SR&T

W73-70572 **185-47-51**
Goddard Space Flight Center, Greenbelt, Md.
ABSOLUTE PRESSURE, ATOMIC OXYGEN, AND ENERGETIC BEAM CALIBRATION FOR MASS SPECTROMETERS
H. B. Niemann 301-982-4706

The objective of this work is to develop laboratory techniques and construct test facilities for the testing and calibration of instruments to measure the neutral particle composition and temperature in the atmosphere. The large pressure range over which the instruments are required to operate and the different chemical properties of the various atmospheric constituents make it necessary to build several separate systems each with a limited range and flexibility which together satisfy the test requirements. An absolute pressure calibration system has been constructed for mass spectrometer calibration with non-reactive gases, i.e., N2, O2, CO2, H2, etc. A dual chamber system with liquid helium cryogenic pumps and sputter ion pumps is used in order to provide for large pumping low ultimate pressure and hydrocarbon free operations. Pressure measurement with reference manometer and high speed computer compatible data recording assures improved measurement accuracy and high efficiency. For the evaluation of spectrometers with chemically active gases, i.e., O and H, substantial improvements are planned for the use of both (1) thermal dissociation beam system which produces atomic constituents by means of dissociation induced by a heated filament; and (2) the satellite energy sputtered beam system which produces medium energy atomic beams by means of energetic ion sputtering of vacuum deposited gas layers. With further development, complementary studies to be carried out with these systems will include (1) calibration of sensor response to active gases of high concentrations, with very low background pressures, and (2) an evaluation of the effect of beam velocity upon gas surface interactions influencing the eventual optimization of gas detector designs.

W73-70573 **185-47-52**
Goddard Space Flight Center, Greenbelt, Md.
DEVELOPMENT OF NEUTRAL MASS SPECTROMETERS FOR PLANETARY ATMOSPHERE EXPERIMENTS
H. B. Niemann 301-982-4706

This research plan is concerned with the overall improvement of neutral gas composition measurements planned for the atmospheres of the Earth and of the planets. In general, improvements are sought in two basic areas, (1) sensor concept and application, and (2) optimization of basic instrument parameters in anticipation of restrictive mission constraints. In the first area, sensor development will be directed toward (a) the improvement of ambient gas sampling techniques for high velocity probes into high density atmospheres (e.g. the Jovian Turbopause Probe), (b) the design of more efficient ion sources of both the open type which provides side-energy focusing, and the closed type which increases the thermalization of the gas being measured, and (c) development of a neutral particle retarding potential analyzer for high velocity probes. In the second area, neutral spectrometer system development will be directed toward optimizing existing techniques in view of rigorous requirements anticipated in forthcoming Earth and planetary flight opportunitites. This work will concentrate on (1) development of smaller, lighter, higher resolution, less expensive analyzers using hyperbolic rods; (2) improvement of ion current detectors applicable to digital systems, emphasizing accuracy, sensitivity, and stability; and (3) development of improved digital logic and on-board data processing sub-systems. Periodic Earth atmosphere flight tests will be performed to evaluate developments in the ion source area and in the on-board data processing system under true flight conditions.

W73-70574 **185-47-53**
Goddard Space Flight Center, Greenbelt, Md.
DEVELOPMENT OF ION MASS SPECTROMETER FOR PLANETARY ATMOSPHERIC EXPERIMENT
H. A. Taylor, Jr. 301-982-6610

The Bennett Radio Frequency Ion Mass Spectrometer instrument is being prepared for future planetary flight opportunities, including both entry probes and orbiters. The objectives of the experiments to be performed with these instruments will be the direct in-situ measurement of ambient thermal positive ions distributed in the planetary ionosphere. The Bennett ion spectrometer instrument has been proven through repeated successful earth flight tests on both rockets and satellites. The most economical preparation of this instrument concept for planetary application is that of optimizing existing measurement techniques so as to provide the simplest, least expensive, and least demanding instrument capable of returning significant direct measurement results on the exploration of an unknown planetary ionosphere. To realize this objective, further refinement of the Bennett spectrometer instrument is planned in the following areas, namely (1) improvements in the selection and testing of ultra light non-reactive sensor insulators, (2) optimization of noise suppression and isolation techniques, and (3) earth atmosphere test flights of prototype instruments. The first two tasks involve electro-mechanical design enhancements, emphasizing a controlled and reliable extension of present technology. The third task provides for a continuing program of earth flight testing involving cooperative participation on existing and planned Javelin rocket payloads.

W73-70575 **185-47-54**
Goddard Space Flight Center, Greenbelt, Md.
EXPERIMENT DEVELOPMENT FOR THE DETERMINATION OF VENUS CLOUD PARTICLE COMPOSITION
H. B. Niemann 301-982-4706

The objective of this work is to develop a practical technique for the determination of the composition of cloud particles in the lower atmosphere of Venus. Although the complexity of the Venus cloud structure, which is expected to be at least equal to the complexity of the terrestrial cloud structure, requires a study of many different techniques, the relatively straightforward and laboratory proven method of mass spectrometers for the composition determination of solid materials and condensibles will be adopted for space flight applications. The major effort will be extended in the area of miniaturization, weight reduction and efficiency in power consumption.

W73-70576 **185-47-55**
Goddard Space Flight Center, Greenbelt, Md.
SPECTROSCOPY AND PHOTOCHEMISTRY OF PLANETARY AND COMETARY MOLECULES
L. J. Stief 301-982-2529

The objectives of this program are to measure the optical and chemical properties of atoms and molecules which are

important in understanding the composition of planetary atmospheres and comets. Emphasis is placed on those problems which are of immediate concern for interpreting the results of rocket and satellite observations. In these investigations the well known techniques of optical spectroscopy and of photochemistry are applied under well defined experimental conditions. Sophisticated techniques have been developed for data reduction and for handling the small signal levels which are usually encountered. Cross sections have been measured for producing the CO Fourth Positive Band System and O resonance line emission from photodissociation of CO2. Excitation cross sections were measured in the vacuum ultraviolet for electron impact on NO. A flash photolysisresonance fluoresence apparatus has been constructed to directly measure quantum yields for primary phtotochemical processes. Laboratory evidence for formation of C3 in photodecomposition of methylacetylene (CH3C equals CH) has led to the suggestion that the latter may be the parent molecule for formation of C3 in comets The reactions HO2+CO and HO2+NO are being investigated

W73-70577 **185-47-56**
Goddard Space Flight Center, Greenbelt, Md.
NEGATIVE IONS IN PLANETARY ATMOSPHERES
A. C. Aikin 301-982-4913

The objective is to determine the altitude distribution and species of negative ions present in planetary atmospheres such as Venus and Mars. Since negative ion formation and species will depend on the presence of minor neutral atmospheric constituents such as molecular oxygen and water vapor, identification of negative ions can be used as a tracer of these neutral constituents. The present study will simulate the lower ionosphere of a CO2 atmosphere with trace neutral constituents and identify species of negative ions. A negative ion detection system for sampling in planetary atmospheres will also be developed. This system will initially be utilized for the Earth's atmosphere. The research has application to the manned and unmanned exploration of the Martian surface, since it defines the electrical environment in which systems operate. It has application to meteorology in that negative ions found in the mesosphere can be utilized as tracers to determine factors involved in large scale circulation and interaction between the stratosphere and mesosphere.

W73-70578 **185-47-61**
Manned Spacecraft Center, Houston, Tex.
SPECTROSCOPY OF PLANETARY ATMOSPHERES
R. D. Hudson 713-483-4981

The objective of this program is to provide, by infrared and ultraviolet spectrometric techniques, both in the laboratory and by means of sounding rocket probes, ground based telescopes, high altitude aircraft, or space vehicle platforms, fundamental data, which can be used to develop and explore the feasibility of space flight experiments for the determination of the *temperature and composition of planetary atmospheres. This* will be achieved by (1) laboratory studies of the absorption of ultraviolet light by atmospheric gases at high resolution (delta lambda is less than 0.04 angstroms), (2) laboratory studies of the chemical reactions that lead to the production of airglow, (3) use of rocket probes, high altitude aircraft, and space platforms to study atmospheric composition, temperature, dissociation rates and airglow, and (4) telescope studies of the atmospheres of Mercury, Venus, Mars, Jupiter, and Saturn, in the infrared at high spectral resolution.

W73-70579 **185-47-66**
Ames Research Center, Moffett Field, Calif.
ATMOSPHERIC CHEMICAL PHYSICS - RESEARCH STUDIES OF PROCESSES IN PLANETARY ATMOSPHERES, COMETS AND INTERSTELLAR SPACE
Glen Goodwin 415-965-5065
(185-47-67)

The objective is to determine products, rates, and yields of energy transfer reactions in planetary atmospheres, comets, and interstellar space. Solar and galactic radiations interact with the atmospheric constituents to produce excited and ionized species and free radicals, which then react to form other ionized and excited species, and/or neutral unexcited species, and/or reradiate spectral energy. Insight into the nature of planetary atmospheres, comets and interstellar matter can be obtained from studies of these processes under controlled conditions. The recombination of CO and O to produce CO2 will be investigated under conditions simulating the CO2-rich atmospheres of Mars and Venus. The recombination process in the presence of Cl will also be investigated to assess the effectiveness of Cl in catalyzing the recombination reaction. This study is relevant to the CO2 photochemistry on Venus in view of the presence of HCl in its atmosphere. The ultraviolet photolysis of CH4, NH3 and H2 will be investigated and the fluorescence emission cross-sections determined. These studies will contribute to our understanding of the photochemistry of Jupiter and will provide scientific support for future Jupiter missions. The equivalent widths of the Schumann-Runge absorption bands of O2 will be determined under various pathlength-pressure conditions to assess the role *of pressure broadening and its possible importance in attenuation of ultraviolet radiation in O2-rich atmospheres.*

W73-70580 **185-47-67**
Ames Research Center, Moffett Field, Calif.
STRUCTURE OF PLANETARY ATMOSPHERES
Glen Goodwin 415-965-5065
(185-47-66)

The basic goal is to connect atmospheric observations with theory. Immediate objectives are: 1) structure of the ionospheres of Venus, Mars and Jupiter; 2) stability against photolysis on Mars and Venus; 3) interactions of ionospheres with planetary magnetospheres and solar wind; 4) nature and genesis of Martian dust storms; 5) runaway greenhouse on Venus; 6) temperature structure of Jovian planets and Titan; and 7) mean particle sizes and optical depth of Saturn's rings. The abundance and distribution of ions, electrons and minor constituents on Mars and Venus are being computed, using estimates and available data from atmospheric observations and laboratory measurements. The role of kinetics, mass transport, and stratification is being considered in the problem of stability of the CO2 atmospheres of Mars and Venus. The interaction of the solar wind with the atmospheres of Mars and Venus will be studied, as well as the Cytherean ionosphere. Using Mariner 9 photographs of the dust storm on Mars the mean particle size and temporal variation of the optical thickness will be determined *In the greenhouse effect on Venus the temperature structure of* the atmosphere will be determined from a computer program and combining this with an evaluation of the photodissociation of water vapor in a photochemical model the history of water will be studied. The same basic computer program will be applied to the Jovian planets and Titan in deriving the top of the convection zone and the temperature structure. The role of *pressure-induced transitions of CH4 in greenhouse effects will* be studied. To estimate the particle size of Saturn's rings comparisons will be made of the infrared absorption bands of ice with multiple scattering calculations.

W73-70581 **185-47-68**
Ames Research Center, Moffett Field, Calif.

PLANETARY ATMOSPHERES - STRUCTURE AND COMPOSITION

Alvin Seiff 415-965-5685

(186-68-60; 186-68-63)

Exploratory missions to other planets will in some cases employ atmosphere-entry probes for the purpose of making measurements of the atmosphere during descent as well as from the surface. Comprehensive studies have resulted in the definition of measurement techniques of this type and instrumentation suitable for Mars's atmosphere. Such instrumentation will be part of the 1975 Viking mission payload. The Planetary Atmosphere Experiments Test, supported in part by this RTOP, was performed to demonstrate and confirm in the Earth's atmosphere the soundness of this concept. The flight data obtained demonstrated the validity, accuracy, and usefulness of the techniques developed. Studies have also been performed and will be continued as needed in response to needs of the Viking Project Entry Science Experiment, to evaluate effects of proposed changes or to modify approaches to the planned experiments for the lander vehicles. Current emphasis is required on adaptation of the experiments to Venus probes, as planned in the Pioneer Venus Phase B studies. Further work will also be devoted to determine implementation requirements of these or similar experiments for entry into Saturn and Jupiter.

W73-70582 **185-47-71**

Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.

ATMOSPHERIC EXPERIMENT DEVELOPMENT

Donald P. Burcham 213-354-3028

The purpose of this work is to define in detail the key investigations to be conducted in studying the atmospheres of the planets. In FY'73 special emphasis will be placed on Jupiter and Saturn, although the results will have relevance to other cloudy or hazy planets (including Venus and Earth). Principal objectives are the definition and recommendation of techniques and instrumental concepts to be developed for both space-flight and supporting Earth-based investigations. Theoretical and laboratory investigations of crucial features of new concepts are also to be undertaken and error analyses performed. These include (1) new methods in radiative transfer theory for cloudy atmospheres (2) inversion and interpretation of radiometric (broadband) and spectroscopic measurements (3) definition of relationships between practical instrument parameters and feasibility of objectives (4) spectroscopic properties of atmospheric gases and cloud constituent under Jovian conditions and at long wavelengths. Preliminary studies of techniques for the investigation of the outermost regions of the atmospheres of Jupiter and Venus from orbiters are to be initiated. A new program of studies in atmospheric dynamics is proposed in support of the above.

W73-70583 **185-47-72**

Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.

THEORETICAL STUDIES - PLANETARY ATMOSPHERES

Donald P. Burcham 213-354-3028

A broad program of experimental and theoretical studies related to planetary atmospheres will be conducted, with the following objectives: 1. Understanding the properties and determination of the parameters of planetary atmospheres. 2. Application of laboratory experimental data to understanding and interpretation of spectral features of complex planetary atmospheres. 3. Applying these findings towards design of ground based and spacecraft experiments. 4. Interpretation of above data as well as other observations to aid in the evolution of valid planetary atmospheric models. This program contributes to NASA planetary missions both in its direct research relevance to planetary atmospheric science and in the maintenance within JPL of a staff of specialists who may evaluate and define scientific objectives and experiments for planetary flight projects. The studies to be conducted in FY'73 pertain to: A. Photochemistry of planetary atmospheres. B. Theoretical studies, planetary atmospheric models and radiative transport theory C. Microwave spectral studies of planetary atmospheres. D. Volatile evolution. E. Electron ionization and collisions in planetry atmospheres.

W73-70584 **185-47-91**

Langley Research Center, Langley Station, Va.

PLANETARY ATMOSPHERIC PROCESSES AND MEASUREMENTS

C. H. Nelson 703-827-2893

Properties and processes of the earth's upper atmosphere as well as the atmosphere of other planets will be studied using ground-based and satellite measurements, laboratory simulations and theoretical studies. Earth aeronomical measurements employing various techniques will be compared with drag measurements of the NASA-Langley Air Density Explorer satellites to obtain a more comprehensive picture of our thermosphere and exosphere. The vertical distribution of ozone in our atmosphere will be determined spectrophotometrically earth's shadow Mariner 9 tracking data may be analyzed to determine the Martian radio refractivity profile, to develop consistent Martian atmospheric models and to verify the techniques for future measurements of Mars. Mariner 9 solar occultation data may be analyzed to deduce neutral atmospheric conditions near the surface of Mars and to possibly confirm, or deny, the reality of an apparent diurnal variation in the surface pressure of Mars suggested from Mariner radio refractivity data. A study will be performed of the possible effect of helium and other upper atmospheric consituents on the density of the Martian exosphere which in turn controls the orbital decay of Mariner 9, Mars 2 and 3, and future Viking spacecraft. Design studies and formulation of design criteria for possible instruments, measurement techniques and spacecraft to further our understanding of planetary atmospheric processes will be continued.

W73-70585 **185-47-94**

Wallops Station, Wallops Island, Va.

EXPERIMENTAL AND THEORETICAL STUDIES OF PLANETARY ATMOSPHERES

Shardanand 703-824-3411

The objective of this RTOP is to carry out an integrated experimental and theoretical study aimed at improving our understanding of the optical properties of planetary atmospheres including the effect of aerosols on slant path visibility through the atmosphere. Special emphasis will be placed on (1) developing and improving model atmospheres for use in remote sensing, (2) development of instrumentation for measuring optical parameters of the atmospheres, (3) improving existing theoretical models of radiative transfer through the atmospheres containing significant amounts of particulate matter (i.e. haze, dust, ice crystals, fog droplets).

W73-70586 **185-50-50**

Goddard Space Flight Center, Greenbelt, Md.

GEOPHYSICAL PROCESSES RELATED TO ORIGIN AND EVOLUTION OF THE PLANETS

L. S. Walter 301-982-2282

The basic purpose of this research will be twofold. a) To develop and evaluate theories concerning the composition and structure of the planets - especially Mars, Venus and the Earth. b) To conceive definitive flight experiments which would serve

to establish the validity or disprove the theories. The several segments under this research plan pertain to a broad variety of disciplines: a) Petrology and Impact Studies; b) Chemical; c) Astronomical; d) Planetary Body Studies.

W73-70587 **185-50-60**
Ames Research Center, Moffett Field, Calif.
PLANETOLOGY: GEOMORPHOLOGY AND SURFACE PROCESS OF PLANETARY BODIES
Glen Goodwin 415-965-5065

One objective of this program is to study the relative importance of volcanic and impact process on the production of surface features of planets and satellites of planets and to apply these results to interpretation of the geologic history of the body. For example, meteorite impact appears to be of greater importance for the production of craters on the moon than is volcanism. However, volcanic process may be more important in explaining surface features on much of the planet Mars. It may be interpreted from this that Mars is more active than the Moon. A second objective is to determine the variable response of planets and satellites to the same flux of impacting bodies. One example is a recent study of Mars doublet craters. Twin craters on Mars could have been produced from breakup of impacting meteoroids due to stresses from the gravitational field of Mars. However, the theory predicts that breakup would be less extensive for the Moon and separation of fission products would be smaller on the Moon than on Mars. Therefore crater structure would be different. An experimental impact program has shown that under these conditions crater types result that are similar to those we see on the Moon. Thus different planetary bodies exposed to the same flux yield different crater types and different crater distributions. Mariner 9 has recently revealed the presence of Martian calderas and rilles that are much larger than those observed to date on other surfaces of planetary bodies. Thus, an integral part of this program, the study of terrestrial volcanic structures, will be helpful in interpreting the different response of each planetary environment to the same basic endogenetic processes.

W73-70588 **185-50-61**
Ames Research Center, Moffett Field, Calif.
LUNAR AND PLANETARY STUDIES
Glen Goodwin 415-965-5065

The objectives are to analyze and interpret theoretical calculations of the composition and thermal history of planetary bodies, planetary surface phenomena, the process of planetary formation and planetary magnetism; and to investigate electromagnetic heating as a possible factor in the evolution of planetary bodies. Electromagnetic heating is pursued by computer modeling which combines this heating with radionuclide and other sources, including models for early solar evolution and planetary accretion. Other investigations make use of Mariner 9 surface images of Mars for interpretation of surface features. Related theoretical analyses have been made concerning Jupiter and the planetary system of Barnard's star.

W73-70589 **185-50-71**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
PLANETOLOGY STUDIES
D P. Burcham 213-354-3028

This program is devoted to the development of experimental techniques, instrumental configuration and method of data analysis for the in situ measurement of planetary surface composition. X-Ray Diffraction/Fluorescence: the objective of this task is to develop a flight-configured engineering model of a combined X-ray fluorescence spectrometer and diffractometer for use in determining the elemental and mineralogical content of planetary materials. The instrument will be miniaturized and capable of ruggedization X-Ray Fluorescence Analysis of Planetary Surfaces Using Solid-State Detectors The main objective of this program is to develop a solid-state X-ray detector system of high resolution that can be flown on instrumented spacecraft missions for the chemical analysis of planetary surfaces. Solid-state detectors offer a great improvement in resolution relative to gas-filled proportional counters Likely applications of a flyable solid-state X-ray detector include: (1) use in an X-ray mode of an alpha-scattering instrument for chemical analysis of the Martian surface, and (2) use in a combined X-ray diffraction/spectroscopy experiment for Martian surface analysis. Planetary Frost and Ice Studies A program will be carried out to investigate the optical properties of frosts, ices and ice silicate mixtures of suspected relevance to the atmospheres and surfaces of the outer planets. Spectral measurements will be made in the laboratory as well as the field.

W73-70590 **185-50-90**
Langley Research Center, Langley Station, Va.
REMOTE DETECTION OF SURFACE PROPERTIES OF PLANETS
C. H. Nelson 703-827-2893

The objective of this research is the investigation of planetary surface properties through analyses of the photometric and polarimetric characteristics of solar radiation that has been reflected from the planet and is detected by planetary orbiters or earthbased instruments. Included among the soil properties to be studied in this manner are chemical composition, particle sizes, particle phase functions (i.e., individual scattering laws), interparticle relationships, degree of multiple scattering, and types of large-scale surface topographies. The theoretical part of the research involves rigorous derivations of photometric functions, quantitative treatments of polarization phenomena, and studies of the effects of rough topographies on brightness measurements. A variety of photometric and polarimetric experiments on laboratory soil samples will serve to check, refine, and supplement the theoretical expressions, which can then be used to interpret existing planetary measurements.

Planetary Exploration SR&T Advanced Technical Development

W73-70591 **186-68-51**
Ames Research Center, Moffett Field, Calif.
HEAT SHIELD EVALUATION FOR JUPITER PROBE MISSIONS
Glen Goodwin 415-965-5065
(502-27-01)

The objective is to develop the heat-protection technology so that heat-protection systems for unmanned probes entering the atmosphere of Jupiter can be designed with a minimum weight, thus, maximizing the scientific payload capability. Candidate heat shield materials will be selected, screened, and tested under conditions that simulate the high heating rates typical of those to be expected at Jovian entry velocities of 50 km/sec. The tests will be conducted in electric-arc-heated streams and high-intensity argon arc and laser radiation fluxes both singly and in combination. Analytical techniques for predicting the characteristics of the heat-shield materials will be developed concurrently with the experiments. The development of a pulsed constricted-arc facility capable of duplicating Jupiter entry heating conditions will continue. This technology is required to permit the design of heat protection systems for unmanned probes entering planetary atmospheres at velocities of 50 km/sec

W73-70592 **186-68-52**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
SCIENCE SUBSYSTEM TECHNOLOGY FOR OUTER PLANET MISSIONS
Rob R. McDonald 213-354-6186
(115-24-06; 185-50-71)

A need exists in planetary exploration for a long life, reliable vidicon television instrument which has broad spectral capabilities and high sensitivity. The objective of this effort will be to improve the capabilities of a Mariner type television instrument, using a silicon vidicon, in the areas of instrument lifetime, spectral coverage, and sensitivity. The approach will initially be to modify existing Mariner electronics and support equipment to the extent necessary to operate with a silicon vidicon. This approach will provide a foundation for development of a flight instrument in subsequent years which would have the lifetime for eight to ten year missions using a minimum of new development from existing Mariner technology. Future work will be directed toward improving the instrument's capabilities both in terms of performance and lifetime through redesign of those areas where new technology can significantly alter the capabilities of the instrument. The development will also be directed to taking maximum advantage of the inherent capabilities of a silicon vidicon, e.g., broader spectral coverage and higher sensitivity.

W73-70593 **186-68-53**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
TELECOMMUNICATIONS TECHNOLOGY FOR OUTER PLANET MISSIONS
R. R. McDonald 213-354-6186
(186-68-56; 186-70-51)

The general objective of this work is to advance radio device and system technology of the JS'77 spacecraft to provide increased lifetime for missions to the outer planets in 1979 and beyond. The plan for FY'72 and FY'73 contains two types of activities. (1) the development of an advanced radio for use on either the JS'77 mission or a subsequent outer planet mission and (2) radio effort required only for subsequent missions such as a JUN. The current JS spacecraft utilizes a Viking Orbiter radio system augmented with X-band TWTAs. Weight, power and reliability advantages of the advanced radio are sufficiently attractive that the JS'77 Project plans to hold this option open by supporting the radio development. Decisions on the JS radio are pending cost effectiveness analysis. The radio was chosen for emphasis in FY'72 and FY'73 because of reliability and cost problems experienced with Mariner radios and because of the large improvements desirable for the JS'77 mission. A micromin transponder breadboard obtained from a vendor will be augmented, evaluated, and tested. The unit incorporates digital modulation and tracking. Also, solid state power amplifiers will be developed, with attention to stable circuitry and life test preparation. An X-band power amplifier will be sought for nine year life, taking into account raw power fluctuations over the lifetime of RTG spacecraft power sources. In addition to these radio hardware developments, companion radio systems developments and analyses will be conducted to understand the digital implementation of radio functions and to determine the effect of the high doppler environment near Jupiter on the possibility of maintaining radio tracking accurate enough to do a 2 or 3 planet mission.

W73-70594 **186-68-53**
Ames Research Center, Moffett Field, Calif.
PLANETARY TELECOMMUNICATIONS
John V. Foster 415-965-5083
(186-68-65; 186-68-60)

The objective is to develop detailed analytical models of planetary atmospheres to determine atmospheric effects on communications from atmosphere probes direct to earth or via a spacecraft relay. Primary emphasis will be on Venus and Saturn. The approach will be to take existing data and develop analytical atmospheric models for evaluation of turbulence, absorption, attentuation, etc.

W73-70595 **186-68-54**
Jet Propulsion Lab., Calif Inst. of Tech., Pasadena.
GUIDANCE AND CONTROL TECHNOLOGY FOR OUTER PLANET MISSIONS
R. R. McDonald 213-354-6186
(502-33-91)

The objective of this RTOP is to develop an advanced long-life image dissector tube to meet the requirements of star trackers for future long-term missions. The planned performance improvements over current image dissectors include: (1) increased operating lifetime, (2) higher reliability, (3) reduction of magnetic field susceptibility, (4) high sensitivity, (5) more uniform sensitivity, and (6) higher temperature capability. The design and fabrication of the improved image dissector tube is being accomplished under contract. The emphasis of this task will be to fabricate a sample quantity of the tubes and to perform evaluation testing and qualification testing of the tubes during FY'73. The advantages of this improved image dissector are sufficiently attractive that the Mariner Jupiter Saturn Project (MJS'77) plans to hold this option of its use open and is jointly supporting this contracted effort.

W73-70596 **186-68-55**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
G AND C TECHNOLOGY FOR MARS ROVING VEHICLES
R. R. McDonald 213-354-6186

The work proposed under this RTOP will provide technical assistance and direction to two NASA Headquarters university research contracts at Cornell University and Rensselaer Polytechnic Institute. These contracts provide for research and advanced development in the area of Mars surface exploration. In particular, the work is directed toward developing subsystem and component technology for an unmanned Mars roving vehicle.

W73-70597 **186-68-56**
Jet Propulsion Lab, Calif. Inst. of Tech., Pasadena.
SPACECRAFT DATA-SYSTEM TECHNOLOGY FOR OUTER-PLANET MISSIONS
R. R. McDonald 213-354-6186
(502-33-93)

The goal of this work is to advance the spacecraft data-system technology of the MJS' 77 class spacecraft to provide increased lifetime for missions to the outer planets in 1979 and beyond. The data system is comprised of three distinct subsystems: spacecraft measurement subsystem, central computer subsystem, and data-storage subsystem. Designing these for a longer mission lifetime presents a unique set of problems. A combination of new system architecture, improved component technology, and the elimination of mechanical wearout mechanisms will be the basis for realizing the improvements needed. The MJS'77 subsystems will be assessed to determine possible ways for improving reliability and to determine the limitations of those designs. The results of these evaluations will then direct the efforts in FY'73 to making those changes in design, or system architecture, that are deemed necessary for

extending the lifetime to an 8-to-10 year mission. These efforts may require a significant departure from MJS'77 technology. In that event, the FY'73 activities will be oriented towards providing suitable feasibility demonstrations in FY'74, to the extent that manpower and resources permit. An important part in system reliability is that of the component technology that is applied. A modest level of effort will be devoted to evaluating the impact of new component technology on the subsystem designs, and to acquiring applications data so that reliability, cost, and power, weight and volume estimates are credible.

W73-70598 **186-68-59**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
OUTER PLANETS ENTRY PROBE HIGH SPEED BRAKING SURVIVAL ANALYSIS
Rob R. McDonald 213-354-6186
(502-07-03)

In the present task, research results will be applied to analyze and optimize the performance of outer planet atmospheric entry probes through flow-field analysis, parametric trajectory studies, and trajectory dynamic analysis. The result of this task will be to feedback to and to guide the research effort now going on in the OAST-sponsored task and to furnish preliminary estimates of thermal protection-system requirements, optimum body shapes, and structural loads. In the entry trajectory analysis we will compute those variables required by the flow-field analysts and at the same time judge the relative severity of a planetary entry. In flow-field analysis we will investigate the interaction of the shock-layer gas with the ablation layer gas and compute ablation rates and mass loss. The flow-field analysis will be done both in-house and through consultants. The high ablation rates are expected to have several effects on the probe angular motion - those effects will be studied by means of a 6-deg of freedom computer program.

W73-70599 **186-68-60**
Ames Research Center, Moffett Field, Calif.
VENUS ENTRY PROBE TECHNOLOGY
J. V. Foster 415-965-5083
(186-68-63)

The objective of this effort is to define and optimize on a system and subsystem basis the selected technologies and design concepts required for the proposed Venus Pioneer missions. The approach will take the existing studies as a baseline and perform additional system analysis and tradeoff studies in all spacecraft/probe areas for the purpose of defining one optimum choice for each subsystem and system required to support the mission objectives. The spacecraft and probe areas to be studied include: The definition of the total probe and spacecraft subsystem vs. the mission objectives, solid state attitude sensors, battery studies, spacecraft data handling subsystem, antenna subsystem designs, probe descent thermal control designs, probes aerodynamics studies, probe acceleration test studies, low bit rate modulation and coding studies, stable oscillator and transponder designs, communication propagation effects of Venus atmosphere, detail design of critical structural subsystems, mission analysis, maneuver and navigation studies.

W73-70600 **186-68-62**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
PROPULSION AND PYROTECHNIC TECHNOLOGY FOR OUTER PLANET MISSIONS
R. R. McDonald, Jr. 213-354-6186

The purpose of this plan is to provide material and propellant compatibility information for application to outer planet missions. The overall objective of this plan is to determine which materials are acceptably inert for use in the construction of propulsion subsystem components, in contact with liquid propellants for long duration missions. Material test specimens immersed in earth storable propellants will be utilized to generate test data. The test program involves continuing actual specimen storage tests in a controlled environment using the compatibility test facility at the JPL Edwards Test Station. Detailed chemical and physical analyses of specimens and propellants will be performed after specific storage periods and a rating assigned for design purposes.

W73-70601 **186-68-63**
Ames Research Center, Moffett Field, Calif.
VENUS PIONEER SCIENTIFIC INSTRUMENT DEVELOPMENT
J. V. Foster 415-965-5083
(186-68-60)

The objective of this effort is to facilitate the selection and development of scientific instruments for the Venus Pioneer 1976/77 dual multiprobe missions. The approach to be taken is to conduct vital instrument technology studies to initiate advanced development of certain instruments requiring long lead planning and feasibility studies to insure readiness to meet program integration and launch schedules, and to initiate conceptual design and interface definition of all instruments selected for development, in support of the system definition design studies.

W73-70602 **186-68-65**
Ames Research Center, Moffett Field, Calif.
PIONEER FOLLOW ON MISSION TECHNOLOGY
John V. Foster 415-965-5083
(186-68-60; 186-68-53)

The objective is to develop basic spacecraft and probe configurations, using existing technology, as close as possible to Pioneer F/G and PAET configurations respectively, consistant with specific mission requirements. This will provide the basis for the realistic estimates of performance, costs, reliability, and scheduling so vital to project definition and decision making. This can only be accomplished by understanding the required technology, subsystems, and the respective interfaces. The approach is to concentrate on the most critical areas first; understand the technology requirements, evaluate alternatives, and investigate the most attractive but unproven concepts. Emphasis will be placed on obtaining experimental data. Evaluation and application of existing technology will have the highest priority. All efforts will be primarily hardware oriented and related to specific missions.

W73-70603 **186-68-66**
Langley Research Center, Langley Station, Va.
ADAPTIVE SCIENCE LABORATORY TECHNOLOGY
C. H. Nelson 703-827-2893

The purpose of this work is to provide studies of an Adaptive Science Laboratory (ASL) to determine the feasibility and technology requirements associated with the use of an ASL by planetary missions. These studies include analyses of science and associated instrument requirements, mission mode studies, conceptual spacecraft design studies, and cost studies. Because sample return missions are quite complex and, therefore, expensive, it is desirable to analyze an ASL concept as a possible alternative to a sample return mission. In any event, a mission whose scientific capacity lies between the Viking (about 75 lb of science) and a sample return mission is a desirable mission and should be studied thoroughly to determine its feasibility and technological implications. Studies will be a

combination of in-house and contractual activities and will concentrate on the application of adaptive systems and instruments to Mars exploration. Trade-offs will be made of the additional flexibility of the adaptive systems versus the less complicated conventional systems in terms of science return, cost, etc. The use of small rovers to augment sample collection will also be studied.

W73-70604 **186-68-69**
Jet Propulsion Lab., Calif. Inst of Tech., Pasadena.
ENVIRONMENTAL REQUIREMENTS AND SIMULATION FOR OUTER PLANET MISSIONS
R. R. McDonald 213-354-6186

This plan provides for the generation of environmental definition and effects information, the evaluation of life limiting elements or characteristics of Mariner type spacecraft and the development of radiation test technology. The emphasis in these tasks is focused on the critical planetary environments and the long life implications on outer planet missions utilizing Mariner based techonology. More specifically, the following tasks will be addressed: a) Improvements to the upper limit model of Jupiter's trapped radiation b) Development of radiation effects information and radiation test technology. c) Improvements to Saturn's ring model. d) Identification of life limiting elements/characteristics of Mariner subsystems. All are continuations of FY'72 efforts except task D which is new for FY'73.

W73-70605 **186-68-70**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
COMPUTER ANIMATED MISSION DESCRIPTION FILMS
R. R. McDonald 213-354-6186

The objectives of this RTOP are to aid NASA in describing future planetary missions by effectively utilizing computer animated films. Toward this end the following activities will be undertaken: Develop planetary or small body encounter trajectory data for selected missions. Missions to be selected will be the subject of discussion of Headquarters SL/Advance Programs Office and JPL personnel Using the trajectory data, generate motion pictures that will illustrate mission profiles. These films should be similar to those that have been made for the Outer Planets Missions. Improve the technology for making computer generated trajectory films.

W73-70606 **186-70-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
ELECTRONIC PARTS AND PACKAGING FOR OUTER PLANET MISSIONS
R. R. McDonald 213-354-6186
(186-68-53)

The long-range objective of this work is to develop the necessary electronic parts and packaging technology which will enable upgrading of the MJS77 spacecraft for eight to ten year outer planet missions. Specific objectives in FY73 include supporting the microminiature radio development tasks (186-68-53), evaluation of life and performance improvements which could be achieved through application of hybrid microelectronics techniques to the MJS power conditioning electronics and investigation of radiation susceptibility together with methods of radiation hardening for certain MJS electronic devices and subsystems. Investigations of areas that have a potential of resulting in lower cost electronic packaging will also be performed. The work will primarily be performed in-house although the development of high resistance value beam-leaded hybrid resistor network having application in the microminiature radio development task is being conducted via a contract.

W73-70607 **188-36-55**
Ames Research Center, Moffett Field, Calif.
MAGNETOSPHERIC PHYSICS - PARTICLES AND PARTICLE/FIELD INTERACTION
Glen Goodwin 415-965-5065

The objective of this RTOP is to provide for investigation of techniques to improve space plasma and magnetic field measurements and to improve understanding of space plasma and magnetic field observations and their relation to the sun and the interstellar medium. Techniques to improve the lifetime, reliability, sensitivity, sampling rate, dynamic range and resolution of space plasma experiments are studied. Means for improvement of measurement resolutions for the individual plasma parameters, the temperature, density, velocity vector and temperature anisotropy, and investigation of techniques for improvement of calibration procedures and calibration data analysis are included. Theoretical studies provide designs of plasma analyzers for testing in the laboratory. The number and position of flux collectors, position and attitude of particle multipliers, suppression of secondary electrons, shapes for apertures, post-analyzer electric field requirements and optimum electric field configurations for both the energy to charge analyzer section and deflection plates for sampling a range of incident directions are covered. Laboratory sources of simulated space plasmas and calibration beams are prepared. Verification of instrument performance is accomplished using these sources. Computer controlled calibration of flight experiments is performed. Calibration data is processed by computers at the Ames Computation Center. A variety of charge collection techniques and single particle counting devices are tested. For space magnetic measurements, new fluxgate drive techniques and core compositions and arrangements for minimum noise are evaluated. Theoretical studies of models of the solar plasma have been accomplished.

W73-70608 **188-36-55**
National Aeronautics and Space Administration, Washington, D.C.
MAGNETOSPHERIC PHYSICS - PARTICLES AND PARTICLE/FIELD INTERACTIONS
E. R. Schmerling 202-755-3674
(188-36-51; 188-36-52; 188-36-53; 188-36-54)

The objective is to investigate the processes occurring in the magnetosphere of the earth and in interplanetary space through a study of energetic neutral and charged particles and their interactions with magnetic and electric fields. Areas of investigation include trapped and auroral particles, the magnetopause, geomagnetic tail and solar wind. The processes which result from the arrival of solar particles near the earth, and the consequences of variations in the incident flux are to be investigated. Instruments for measuring neutral and charged particles from several eV to several tens of MeV will be developed; DC magnetic fields from below 0.1 gamma to several Oersted; electric fields and VLF wave activity. The theory needed to understand the magnetosphere, the auroras, the solar wind, the interplanetary regions and the observed boundary effects, down to roughly the plasmapause will be developed.

Physics and Astronomy SR&T

W73-70609 **188-36-55**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
STUDIES OF JUPITER'S MAGNETOSPHERE
Donald P. Burcham 213-354-3028

Exploration of Jupiter's magnetosphere is an important

scientific goal, consistent with NASA's planetary program. The work in this task is directed toward obtaining a deeper understanding of the structure of Jupiter's magnetosphere and of the important physical processes taking place in it. In the initial phases of the work, a study of Jovian decametric emissions will be pursued with the aim of identifying and explaining the physical mechanisms in the magnetosphere responsible for these emissions. This study will be based on the recent theoretical work by Smith, Wu, and Zmuidzinas, which has provided natural explanations of some long-standing puzzles in the area of Jovian decametric emissions. The initial studies will serve the important role of providing a theoretical framework for interpreting the anticipated Pioneer data on the Jovian magnetosphere when they become generally available. Later phases of the work will utilize the Pioneer data, in conjunction with existing radio observations and theoretical analyses, in an attempt to build a coherent model of Jupiter's magnetosphere. It is anticipated that the work in the task will eventually lead to definitions of new and critical radio and space-probe experiments designed to explore specific features of the magnetosphere.

W73-70610 **188-36-55**
Goddard Space Flight Center, Greenbelt, Md.
MAGNETODYNAMICS - NON THERMAL PLASMAS
K. W. Ogilvie 301-982-5904

The object of this research is to increase the knowledge and understanding of non-thermal plasmas occurring in nature, and also to improve the theoretical description of their properties. This requires a concomitant improvement in measurement techniques, and interpretation of appropriate space and laboratory experiments.

W73-70611 **188-36-56**
National Aeronautics and Space Administration, Washington, D.C.
MAGNETOSPHERIC PHYSICS - PARTICLES AND PARTICLE/PHOTON INTERACTIONS
E. R. Schmerling 202-755-3674
(188-36-57)

The objective is to investigate the absorption of solar photons and particles in the earth's upper atmosphere, the processes by which the absorption products are dissipated, and the effects which arise therefrom. Included are the collisional, photochemical and electromagnetic interactions which are found in the upper atmosphere, the ionosphere and the inner magnetosphere. Instruments for the direct and indirect measurement of near-thermal plasmas, electric and magnetic fields will be developed. Coordinated investigations are to be conducted for cause-and-effect studies, together with the development of the appropriate theories. The region covered extends roughly from the lowest ionosphere to the plasmapause.

W73-70612 **188-36-56**
Goddard Space Flight Center, Greenbelt, Md.
MAGNETOSPHERIC PHYSICS - PARTICLES AND PARTICLE/PHOTON INTERACTIONS
James P. Heppner 301-982-4797

The objectives are: (a) to conceive, design, develop and test new techniques for space measurements of electric fields, magnetic fields, auroral particles, trapped particles, solar-interplanetary particles, plasma waves, wave-particle interactions, photon-particle interactions, plasma composition, electron density and atomic and molecular collision processes with particular emphasis on magnetospheric and ionospheric regions, and (b) to analyze problems and conduct theoretical studies in magnetodynamics, plasma physics, and atomic and molecular interactions. The approach includes detector and supporting electronics, design, laboratory and contractor fabrication and testing, and theoretical studies of field and particle phenomena and distributions in space. This effort is expected to produce: (a) flight instrumentation having the capability to make measurements that previously have not been possible, particularly in areas where there are significant gaps in our knowledge as a consequence of there being few or no measurements, (b) accurate models of fields in space which have both scientific and technological utility, (c) indices which describe the instantaneous degree of disturbance in the ionosphere and magnetosphere, and (d) advances in the understanding of plasma instabilities and other field environment.

W73-70613 **188-36-56**
Ames Research Center, Moffett Field, Calif.
MAGNETOSPHERIC PHYSICS - PARTICLES AND PARTICLE/PHOTON INTERACTIONS (AERONOMY)
Glen Goodwin 415-965-5065
(185-47-67)

The objective is to investigate the physics of the earth's topside ionosphere and plasmasphere and the coupling of these regions with the magnetosphere and solar wind. Theoretical studies of the thermal charged-particle composition, density and temperatures are being performed. Computer programs are being coded based on the continuity, momentum and energy balance equations appropriate to these regions. Data from the Alouette, ISIS and other satellites will be used as boundary conditions. Special correlative studies are also being performed to investigate the global nature of certain anomalous features, e.g., the plasmapause and ionospheric troughs. The results of these efforts are vital to the understanding of the earth's charged particle environment, and have application to communications between terminals immersed in these media. The theory and techniques involved are applicable to the studies of atmospheres and ionospheres of other planets. Preliminary efforts are being initiated to investigate the charged particle environment of the Venus and Jupiter ionosphere.

W73-70614 **188-36-56**
Marshall Space Flight Center, Huntsville, Ala.
MAGNETOSPHERIC PHYSICS - PARTICLES AND PARTICLE/PHOTON INTERACTIONS
James O. Ballance 205-453-3431

The objective is to develop more representative models of the earth's upper atmosphere for use in vehicle development programs. The theoretical studies of traveling ionospheric disturbances will provide a greater insight into the coupling between the lower (is less than 90 km) and upper (is greater than 90 km) atmospheres, between the charged and neutral atmospheres, and the solar-terrestrial relationships. The airglow research will provide us with data on the dynamics of the lower thermosphere, the chemical and physical processes occurring there, and how all of these processes control the earth's upper atmosphere.

W73-70615 **188-36-56**
Langley Research Center, Langley Station, Va.
MAGNETOSPHERIC PHYSICS
C. H. Nelson 703-827-2893

The overall objective of this work is to accurately measure the constituent number density of the terrestrial thermosphere. (100 to 300 km) The approach centers on the development of a unique molecular beam mass spectrometer system which virtually eliminates gas-surface interactions and makes possible the accurate measurement of reactive gases such as atomic

oxygen. The feasibility of this instrument design for measurement of reactive gases in the atmosphere has been demonstrated by theoretical and experimental work. This work has included design and tests of engineering models of the primary instrument components such as, the ion source, mass separator, and ion collector system. Studies of vehicle requirements for flight measurements with this instrument have also been initiated, and these preliminary studies indicate that all vehicle requirements can be met by using the 3rd stage of the Scout vehicle or the 2nd stage of a Delta vehicle with only modest modifications.

W73-70616 **188-36-56**

Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.

MAGNETOSPHERIC PHYSICS

D. P. Burcham 213-354-3028

Advanced Magnetometer: The major objective is to develop the vector helium magnetometer for use on space missions where extremely weak interplanetary or interstellar fields are to be measured and where intense planetary fields may also be encountered. Tests and experiments will be carried out to understand the underlying principles of operation and to develop improved components, a more optimum design and new or more optimum modes of operation. Spectral Analysis: It is of major interest to examine the power spectral density of the solar wind at frequencies up to and beyond the proton gyro-frequency. Workers in the field of radio scintillation have interpreted their data to indicate the existence of an anomalously high number of electron density fluctuations or blobs of scale size 100-200 km. This claim has been disputed. Because of the high data acquisition rate of OGO-5, it is now possible to extend the power spectrum to frequencies corresponding to a scale size of less than 100 km. Hopefully this will shed light on the question of blobs. Even if blobs are not found, the high frequency spectrum is of intrinsic interest to determine the behavior of solar wind phenomena in the neighborhood of the proton gyro-frequency.

W73-70617 **188-36-57**

Goddard Space Flight Center, Greenbelt, Md.

SHUTTLE APPLICATIONS OF IONOSPHERIC PLASMA EXPERIMENTS

H. A. Taylor 301-982-6610

The Space Shuttle Program provides an unique opportunity for performing both pure and applied ionospheric plasma-aeronomy experiments In this research plan, a series of theoretical and experimental studies are proposed with the objective of (1) more completely defining the methods and capabilities of several theoretical and experimental research concepts, and (2) adapting existing experimental techniques to best interface with the manned operation concept of such missions. The research studies are in two related areas, namely, plasma diagnostics, and sensor-plasma interactions. In both areas, the potential applicability of anticipated research results to the earth science problems of high latitude communication, and the coupling of energy from the solar-wind/magnetosphere to the lower atmosphere will be particularly emphasized. The research area of plasma diagnostics will include both a study of the plasma environment characteristics anticipated for a typical Shuttle configuration, as well as a series of related wave-particle interaction studies, based upon both natural and man made perturbations of the ambient ionosphere. In the area of sensor-plasma interactions, problems of fundamental plasma physics will be explored emphasizing methods which cannot be adequately simulated in an earth laboratory. These problems are inherent to the complete understanding of direct measurement techniques for thermal and energetic plasma detection, as well as the interpretation of both rf and lf signal transmission and reception techniques in a rarefied plasma.

W73-70618 **188-36-57**

National Aeronautics and Space Administration, Washington, D.C.

MAGNETOSPHERIC PHYSICS - RADIO SCIENCE

E. R. Schmerling 202-755-3674

(188-36-56)

The objectives are: to investigate the interplanetary medium, the environments of the earth, the moon, the planets and the sun, as well as celestial mechanics and relativity, by the propagation or scattering of radio waves; to develop techniques for interpreting the refraction, scattering, polarization rotation and phase shifting of radio signals occurring naturally or generated artificially in terms of physical properties of the intervening medium; to develop instruments for generating electromagnetic waves in space and measuring the effects of the medium, together with the appropriate theory; and to model, in the laboratory, the plasma interactions and resonances observed in space, and to test the theories developed to explain them.

W73-70619 **188-38-01**

Goddard Space Flight Center, Greenbelt, Md.

NON-THERMAL SOLAR X-RAY OBSERVATIONS SOLAR PHYSICS - SHUTTLE PAYLOAD DEVELOPMENT

J. C. Brandt 301-982-4701

The nature of particle acceleration in a solar flare is among the most important and fundamental problems of the physics of a solar flare. Indeed it has been claimed that the acceleration mechanism is the fundamental flare process; all other flare manifestations are derived from it. By studying the temporal, spatial and energy history of this process in the sun, we will gain insight into the triggering and energy release mechanisms of a solar flare.

W73-70620 **188-38-02**

Goddard Space Flight Center, Greenbelt, Md.

SOLAR PHYSICS - SHUTTLE PAYLOAD DEVELOPMENT - SOLAR POINTING INSTRUMENT

J. C. Brandt 301-982-4701

Definitive observations of the fine scale structure, on the order of 100-1000 km in extent, of solar active regions and flare phenomena require XUV instruments larger in size than can be accommodated on present rocket and satellite missions, but could easily be fit into a shuttle mission. Research will be directed to define design criteria for components of instrumentation that would be used for such observations. Fabrication methods will be investigated with emphasis on finding the most economical means of achieving the scientific objectives. Methods for measuring the polarization of hard X-rays during flare events will also be investigated.

W73-70621 **188-38-03**

Goddard Space Flight Center, Greenbelt, Md

SOLAR PHYSICS - SHUTTLE PAYLOAD DEVELOPMENT - SOLAR POINTING INSTRUMENT

J. C. Brandt 301-982-4701

The Laboratory for Solar Physics, GSFC, proposes to study, design and build under contract, and test an integrated solar pointing instrument to obtain from orbit spectral line profiles in the UV and XUV and also x-ray and GAMMA ray spectra originating in the solar chromosphere, transition region, and corona, over both quiet and active regions The main scientific purpose of this experiment is to study the physical structure and associated dynamics of these solar atmospheric regions, including the solar wind at its origin in the low corona. The

phase of development of this experimental package covered by this RTOP would terminate with test and evaluation of the instrument, but the instrument will be designed to fit into the Shuttle Sortie Module and will be constructed so as to be as flight ready as possible, pending evaluation of the tests.

W73-70622 **188-38-51**
Goddard Space Flight Center, Greenbelt, Md.
DEVELOPMENT OF EXPERIMENTS AND HARDWARE FOR SOLAR PHYSICS RESEARCH
J. F. Osantowski 301-982-5861

The objective of this research program is to develop or improve critical technology items principally, but not exclusively, for solar physics research and to supply critical data required by scientists in designing and/or proposing advanced instrumentation for space or program based observations. Specifically, the development of specialized optical components, the development or improvement of optical instrumentation, and the development or improvement of various techniques of instruments for support of solar observation is included To accomplish this objective, GSFC will conduct in-house experimental and theoretical studies in the following key areas; design, fabrication and testing of glancing incidence optical systems for the 8A to 300A spectral region and various optical studies of vacuum deposited thin films and specialized multilayer film combinations as required for high efficiency reflectance coatings, band pass filters, etc. These key areas have been identified, in part, from NASA Document SP-213, "A Long-Range Program in Space Astronomy". Other technology areas may be included to support current programs or problem areas. Development and construction of a multichannel correlation receiver is proposed as part of the new instrumentation required to take advantage of the radio spectroheliograph under construction by the University of Maryland at the Clark Lake Observatory in California.

W73-70623 **188-38-52**
Marshall Space Flight Center, Huntsville, Ala.
GROUND BASED OBSERVATIONS OF THE SUN
Paul J. Schwindt 205-453-3430

The Real Time Solar Magnetograph, being built jointly by the Naval Research Labs. and MSFC, will allow studies of small scale variations of the sun's magnetic field in order to determine this role in solar activity. The system uses a narrow band filter, polarizers, and a SEC vidicon TV system to measure the Zeeman effect in chromospheric absorption lines. In direct support of the real time solar magnetograph a study will be undertaken with the objective to determine the basic phenomena involved in the eruption of solar flares by studying the interactions of the solar plasma and local magnetic fields in the active regions and to analyze basic solar data such as magnetic field and the absorption line profiles and interpret them on the basis of these interactions. The third objective of this study is to observe and investigate millimeter emissions from the sun at the shortest practical radio wavelength (i.e three millimeters) before, during, and after solar events and during the quiet sun and to correlate the results with solar magnetograph, H-alpha records and solar flare information. The results will be used to determine the correlation between millimeter emissions and solar activity for possible flare prediction and as a basis for a more complete understanding of the physical processes in the solar chromosphere through the comparison of observed data with that predicted by current solar models.

W73-70624 **188-38-52**
Goddard Space Flight Center, Greenbelt, Md.
GROUND BASED OBSERVATIONS OF THE SUN
J. C Brandt 301-982-4701

The development of an observatory to determine solar wind properties at remote locations in the solar system by recording and analyzing the properties of ionic comet tails is continuing The Zeiss filtergraph previously used to obtain supporting observations for the GSFC OSO-5 wheel experiment is dedicated to OSO-7 support, and provides live video H-alpha images to the OSO Control Center and GSFC OSO-7 experimenters. Photographic spectroscopy of active and quiescent prominences and other solar phenomena will be performed with a 24-inch reflector and universal spectrograph at Capilla Peak. A coronal photometry system, intended to obtain brightness maps of the corona during total eclipses of the sun with a high accuracy in relative point-to-point photometry is nearing completion and will be operated at the eclipses of 1972 and 1973.

W73-70625 **188-38-53**
Langley Research Center, Langley Station, Va.
SOLAR PHYSICS
C. H. Nelson 703-827-2893

The principal objective is to generate and to identify some of the visible coronal emission lines. While the majority of the observed lines have been theoretically classified as 'forbidden' transitions (forbidden in the sense that the transition violates a first-approximation quantum-mechanical selection rule) they have never been observed in the laboratory because of the high stages of ionization that correspond to these transitions. The initial lines to be investigated are 5536 Angstroms (thought to be Ar X), 6917 Angstroms (thought to be Ar XI), and 8476 Angstroms (thought to be Ar X). A second objective is to produce and identify spectral lines of highly ionized atoms of astrophysical interest in the far ultraviolet and soft x-ray regions. In particular, those elements observed in the sun will be introduced so that identification of laboratory lines will be consistent with solar spectra obtained by rocket and satellite-borne spectrographs. The thetapinch facility will be used to generate the radiating plasma. The one-megajoule thetapinch facility produces a plasma of sufficient temperature and density to produce Ar X through Ar XIII. Observation of the normal transition from those ions simultaneously with the visible line would confirm the stage of ionization involved in the emission of the visible corona lines. Theoretical intensities, oscillator strengths and the energies involved in these transitions will be calculated as needed using the wavefunctions generated by a Hartree-Fock computer program. This procedure should not only classify the transition and element but should also provide a determination of the oscillator strength. This same procedure will also apply to the identification of normal spectral lines of highly ionized atoms. Analysis of the plasma radiation depends on a knowledge of the plasma state itself. Important parameters for the characterization of the plasma state are ghe electron temperature and density. These parameters will be measured by laser scattering methods.

W73-70626 **188-38-53**
Ames Research Center, Moffett Field, Calif.
SOLAR MAGNETISM AND INTERPLANETARY FIELD
Glen Goodwin 415-965-5065

The objective is to define the underlying structure in the interplanetary magnetic field and its relationship to the rotating photospheric field pattern. The definition of the proper rotation rate of the interplanetary sector structure over the solar cycle and its significance in view of the latitude dependent photospheric rate will be considered. To compare photospheric and interplanetary field data with ground based magnetic records and develop models consistent with the observations. Spacecraft data from Ames magnetometers on Explorers 33 and 35 and

Pioneer 9 are scanned to determine interplanetary sector boundaries. In collaboration with other institutions these are compared with geomagnetic observations from Thule and Godhavn and with solar photospheric magnetic records. Statistical correlation studies are carried out by computer.

W73-70627 **188-38-53**
Goddard Space Flight Center, Greenbelt, Md.
EXPERIMENT DEVELOPMENT - LABORATORY AND THEORETICAL SOLAR PHYSICS
J C. Brandt 301-982-4701

Research toward improved systems for solar observations in the EUV, X-ray and gamma ray regions is being pursued through the development of prototype collimator systems and detectors for these wavelengths The X-ray and EUV scattering properties of surfaces produced by various polishing techniques are being studied. Research into improved hard X-ray detectors emphasizes the objective of extending the energy range of observation to 20 MeV. Use of a passive Li impregnated Bismuth shield offers a substantial improvement over existing methods. Electronics are being developed, which together with existing crystal and methanical fixtures, will produce a detector able to record the spectrum of a solar X-ray burst with 100 milliseconds resolution. Detector work begins on a multiple chamber counter capable of simultaneously recording soft, medium and hard X-rays. Design of high resolution coronal spectrometer/polarimeters for the wavelength ranges 1-20 angstroms and 1200-1500 angstroms is underway and bench testing will be carried out. COS/MOS type integrated circuits which may have reduced power needs, volume and weight will be environmentally tested in typical space solar experiment electronic units. Developmental work includes an imaging infrared up-converter for use at 5 microns. Extensive laboratory studies of ultraviolet spectra are performed to interpret observations.

W73-70628 **188-41-51**
Manned Spacecraft Center, Houston, Tex.
ULTRAVIOLET STELLAR SPECTROMETER DEVELOPMENT (ASTRONOMY)
Y. Kondo 713-483-6467

Ultraviolet Stellar Spectrometer - The objective is to observe Mg II doublet emission at 2795 Angstrom and 2802 Angstrom in various spectral type stars. Particular emphasis will be placed in the intermediate to early type stars. (In this spectral region, the Ca II doublet emissions at 3933 Angstrom and 3968 Angstrom become unobservable.) The Balloon-borne Ultraviolet Stellar Spectrometer has been designed, fabricated, and flown successfully twice in 1971. Further flights will be required to extract the full usefulness of this instrumentation. The objectives for FY 73 are to further develop the inner loop pointing system of the balloon payload and to perform two combined engineering development and scientific data flights.

W73-70629 **188-41-51**
Goddard Space Flight Center, Greenbelt, Md.
UV AND OPTICAL ASTRONOMY
Albert Boggess, III 301-982-5103

The objective is to pursue a long range program in astronomical research, with emphasis on optical observations, theoretical astrophysics, and other specific topics of special interest to NASA. The effort includes operation of ground telescopes, development of new instrumentation for ground and rocket use, data interpretation, and theoretical studies. Spectroscopic and photometric data are obtained from ground and rocket telescopes in order to analyze the properties of stellar atmospheres and the interstellar medium. Model atmospheres are being developed to compare with observation, particular attention being paid to nonequilibrium phenomena. Additional tasks include calculations of fundamental physical parameters of astrophysical interest, investigations of convective energy transport, and some stellar population problems.

W73-70630 **188-41-51**
Langley Research Center, Langley Station, Va.
UV AND OPTICAL ASTRONOMY (COMPUTATIONAL PHYSICS)
C. H. Nelson 703-827-2893

New and improved computer models will be developed to investigate the evolution and structure of various systems of astrophysical interest, such as spiral galaxies, the asteroid belt and Saturn's rings. Galaxy related problems that will be studied are the methods by which spiral galaxies transfer their angular momentum outwards. Another problem to be investigated is the density wave theory proposed to explain the spiral structure of galaxies. Computer experiments testing the density wave theory without making the approximations required in an analytical treatment will be performed. Numerical experiments on the evolution of the asteroid belt will be performed. In particular, resonant effects caused by the commensurability of asteroids with Jupiter will be investigated. Similar calculations will be made for Saturn's rings. Another problem to be investigated is the dynamics of the expansion of an artificial ion cloud released in the Earth's magnetosphere to study the geomagnetic environment Another objective is the study and extension of current cosmological theories and the correlation of the theoretical and experimental results in order to identify the correct model universe. In addition, studies will be made to determine which astronomical and astrophysical observations yielding the most significant cosmological data, are worthy of being done in a satellite and provide methods of data analysis. This work will improve the basic knowledge of the universe and establish requirements for cosmological observations and satellites.

W73-70631 **188-41-51**
Marshall Space Flight Center, Huntsville, Ala.
UV AND OPTICAL ASTRONOMY
Jean R. Olivier 205-453-3428

The objectives are to perform ground-based visible and near IR filter photometry of binary stars, long period mira variables, Seyfert galaxies and magnetic variable stars; and to perform multispectral photoelectric polarimetry to study properties of zodiacal light. The above data will be used in support of several flight experiments now under development at MSFC Multispectral photometry will be performed using equipment which is mostly already developed and on hand. The 30 and 49 cm telescopes at MSFC, and the 150 cm telescope at Tucson, Arizona will be used.

W73-70632 **188-41-52**
Goddard Space Flight Center, Greenbelt, Md.
GROUND BASED RADIO ASTRONOMY
R. G. Stone 301-982-4631

The objective of the Ground Based Radio Astronomy program is to provide a better understanding of the dynamics and composition of astrophysical plasmas in objects such as radio galaxies, quasars, supernovae, pulsars, and solar system sources such as the Sun and Jupiter through the high angular and time resolution observations of radio emission from these objects. Radio Astronomy has provided new insight into such problems which could not have been gained from observations in other parts of the spectrum such as the visible or UV region The

interpretation of source spectral and spatial distribution in terms of our knowledge of plasmas and high energy processes leads to knowledge of the evolution of the source and of the magnetic field, energetic particle composition and dynamic processes within the source. The approach taken involves the use and development of high resolution radio telescopes.

W73-70633 **188-41-52**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
RADIO ASTRONOMY
D. P. Burcham 213-354-3028

This RTOP uses the unique facilities of NASA's Deep Space Instrumentation Facility (DSIF) to find microwave spectral lines of interstellar atoms and molecules at X-band (8GHz) and K-Band (15 GHz), regions in which NASA's receiving capabilities are the best in the world. Concurrently, a laboratory microwave spectroscopy program is carried out in order to interpret the results of the observation program as to the molecular species, abundances within the source, and the Doppler shift of the source itself. DSIF equipment to be used includes the 64m Goldstone antenna; K-Band and X-Band wideband low noise feeds, masers, and receivers; a wideband digital correlator spectrum analyzer; calibrated noise sources; and programmable local oscillators. This DSIF equipment either already exists or is being developed for programs supported by the Office of Tracking and Data Acquisition (OTDA); thus, RTOP does not pay for such equipment. The spectrometer system to be used in the laboratory investigations includes a Stark Modulation Spectrometer and associated programmable digital data handling and control equipment. Fundamental questions in stellar and galactic evolution to be answered by interstellar microwave spectroscopy include the galactic molecular and isotope distribution and the isotope abundance ratios, the velocity distribution of interstellar material; and the causes of anomalous interstellar molecular spectral line intensities. Of particular interest is the location and abundance of complex interstellar molecules, because the mechanism that allows the creation and retention of such molecules is presently unknown.

W73-70634 **188-41-53**
Ames Research Center, Moffett Field, Calif.
THEORETICAL ASTROPHYSICS
Glen Goodwin 415-965-5065

The objective is to conduct theoretical studies on important fundamental problems of astronomy and astrophysics and to provide theoretical advice and support for the center program on observational infrared astronomy. Astrophysical theory and mathematical techniques will be used together with available observational data to develop self-consistent theoretical models for the investigation and interpretation of astrophysical phenomena. Application will be made to a wide range of problems including the properties of the envelopes of quasi-stellar objects, the infrared background radiation, the energy transfer mechanism in the Crab Nebula, possible IR sources for airborne observation, pre-main sequence stellar evolution and others.

W73-70635 **188-41-54**
Marshall Space Flight Center, Huntsville, Ala.
RELATIVITY AND CELESTIAL MECHANICS
James O. Ballance 205-453-3431

The objective of this activity is to develop, through a coordinated program, the technology and research required to support the flight of the gyro-relativity experiment. This experiment will be a fundamental and unique test of the general theory of relativity. The feasibility of this experiment centers around the development of gyroscopes several orders of magnitude more precise than any existing gyroscope, and the ability to maintain these gyroscopes and record their precessions, while in earth orbit, over a period of twelve months or more. This work will be accomplished by expanding the technology development programs being carried out in laboratories of the Science and Engineering Directorate, by initiating a mission definition study for the engineering test flights required to support this supporting research and technology efforts under overall MSFC program management. These activities will be administered through the Mission and Payload Planning Office of the Program Development Directorate who will assume the overall coordination and management of these activities. In-house experimental and theoretical activities will be applied to support the Stanford University SRT activities. These activities will be oriented toward resolving problems in the development of the gyroscope and other phases of the experiment.

W73-70636 **188-41-54**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
RELATIVITY AND CELESTIAL MECHANICS
D. P. Burcham 213-354-3028

To support on a consulting basis and upon call the planning activities of NASA Headquarters in the areas of space probe missions relevant to the testing of gravitational theories and the cooperative planning of these missions with ESRO. JPL technical personnel will follow and review the technical studies being conducted for the European Space Research Organization on the testing of gravitational theories in space. As required, a technical consulting team of senior personnel from several disciplines will be formed at JPL. Information obtained from ESRO will be periodically presented to the team for reaction and review. These evaluation will be forwarded to NASA Headquarters (SG). This activity will support the joint Mission Definition Group of ESRO and NASA formally agreed upon. Approximately twenty percent of the funding will be required for travel to ESRO facilities for technical interchange. Some interchange will take place at JPL.

W73-70637 **188-41-55**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
INFRARED ASTRONOMY
Donald P. Burcham 213-354-3028

The objective of this task is to obtain and analyze high resolution (better than 1 cm to minus the 1st power) spectra of selected cool stars in the 1.2 to 6 micron (1600-8000 cm to minus the 1st power) region with the JPL Mk III Connes'-type Fourier Spectrometer at the coude' focus of the 107 inch telescope McDonald Observatory. The primary aim is to aid in the understanding of the chemical composition and evolutionary state of normal and variable late-type stars.

W73-70638 **188-41-55**
Ames Research Center, Moffett Field, Calif.
INFRARED ASTRONOMY
Glen Goodwin 415-965-5065

The broad objectives of this program are (1) to obtain and interpret astronomical data in the far infrared region of the spectrum and (2) to develop and evaluate improved platforms and instrumentation for infrared astronomy. A Michelson interferometer is used with a 12 inch telescope mounted on a Lear jet to determine the spectra of galactic nuclei, HII regions, and the bright planets in the range of 30 to 300 microns. A 28 inch balloon-borne telescope is being modified to make it suitable for observations in the far infrared. Engineering test flights (probably 2) will be launched to check out guidance and control and to compare the performance of the detector and

the interferometer aboard the balloon system with that aboard the Lear Jet. Efforts will be made to obtain a spectrum of atmospheric emission from both platforms. A 30-cm aperture, cooled telescope-interferometer and associated remote guidance control, and information handling systems will be developed for use on high-altitude aircraft.

W73-70639 **188-41-55**
Marshall Space Flight Center, Huntsville, Ala.
INFRARED ASTRONOMY
Jean R. Olivier 205-453-3427

This survey will be performed with earth-based telescopes using liquid helium-cooled gallium-doped germanium and copper-doped germanium detectors. Bandpass spectral filters will be used to make use of the earth's atmospheric windows and also to give the spectral distribution of the emitted energy. The measurement will be made using a 1.5-meter infrared telescope at Tucson, Arizona. There are many stars and stellar sources which emit a sizeable portion of their energy in the infrared part of the spectrum. Surveys have been made in the near infrared but much remains to be done in determining which of the objects are detectable in the middle and far infrared. The results from these measurements will be made available to infrared astronomers so that closer study can be made on those findings that are of prime interest in understanding stellar evolution and processes.

W73-70640 **188-41-55**
Goddard Space Flight Center, Greenbelt, Md.
EXPERIMENTAL AND OBSERVATIONAL RESEARCH IN INFRARED ASTRONOMY AND INTERSTELLAR MEDIUM
Patrick Thaddeus 212-866-3618

GISS is carrying out several projects in experimental and observational physics and astronomy for the purpose of study of infrared sources, interstellar molecules and the cosmic microwave radiation. Specific aspects of this work are: Infrared Astronomy - conducting of experiments using balloons, aircraft, sounding rockets and ground-based telescopes for study of infrared sources and for improvement of techniques for infrared observation; Interstellar Molecules and the Cosmic Microwave Radiation - to obtain precise laboratory frequencies of a number of molecular transitions recently discovered in space with radio telescopes and, also to measure the frequency of lines which are good candidates for detection; to continue analysis with the GISS microdensitometer system of high resolution stellar and interstellar spectra obtained at Lick and McDonald Observatories.

W73-70641 **188-41-55**
Manned Spacecraft Center, Houston, Tex.
INFRARED SPECTROSCOPY OF COOL STARS AND PLANETARY NEBULAE (ASTRONOMY)
A. E. Potter 713-483-2071

Infrared spectra of planetary nebulae and cool stars are measured with a Michelson interferometer using infrared detectors and the 107 inch McDonald Observatory telescope. Analysis of the spectra yields information on the composition and structure of the nebular gases and the stellar atmospheres. Principal objectives of the work are to clarify the origin and nature of cool carbon-rich and oxygen-rich stars and to explore the nature of infrared emissions from planetary nebulae.

W73-70642 **188-41-59**
Goddard Space Flight Center, Greenbelt, Md
X-RAY ASTRONOMY
Elihu A. Boldt 301-982-5853

X-Ray production is a necessary consequence of energetic charged particles in space. Ultra-relativistic electrons radiate X-rays via their interactions with the ambient electromagnetic environment (e.g., magnetic fields, starlight, microwave radio). Subrelativistic energetic particles radiate X-rays via collisions with matter. highly ionized atoms radiate characteristic X-ray lines after recombining with ambient electrons. Hence, by studying the X-ray emission from stellar objects, nebulae, and interstellar space we get direct information on energetic processes over a broad range of physical conditions and astronomical scales. Observations of hard X-rays are made with mechanically collimated proportional counters of advanced design. The technical goals are large effective area, broad spectral coverage, optimum resolution, and efficient rejection of extraneous events (e.g., caused by gamma rays, electrons, radioactivity). These goals, coupled with a detailed knowledge of detector response, are being achieved via laboratory tests, balloon and rocket flights. Observations of soft X-rays may be made with the use of grazing incidence optics. Small specialized detectors are then practical, and we are investigating the use of gas jets composed of pure low atomic number elements as precision X-ray filters for identifying line emission in the soft X-ray band.

W73-70643 **188-41-60**
Goddard Space Flight Center, Greenbelt, Md.
ASTRONOMY SORTIE MODULE (ASM)
S. Sobieski 301-982-4549

The objective is to define and implement a group of associated astronomical experiments to be performed using the space shuttle operating in a sortie mode. Specific goals will be definition of scientific objectives, formulation of instrumentation requirements, establishment of operational criteria and modes, and formulation of data acquisition, management and reduction procedures. The wavelength region to be covered will be from the far ultraviolet to the near infrared (100 angstroms to 5 microns) Additional passive experiments requirements requiring pointing will be considered on an non-interference basis. Emphasis will be on experiments most appropriately performed from the shuttle, that is on those which capitalize on the shuttle capabilities for inflight experimental reconfiguration, experiment return and re-flight with updated equipment. The scientific objectives are to complement and supplement ground-based and space-based research. The results of the preliminary study will be used to configure an astronomical facility to pursue scientific programs in observational astronomy within the framework given below. Flexibility in programming and instrument configuration is to be maintained to allow redefinition of the scientific program at any time in order to maximize efficiency and scientific productivity. Experiment definition and participation by non-NASA scientists in programming and utilization will be according to conventional practice at ground-based observatories.

W73-70644 **188-41-60**
Marshall Space Flight Center, Huntsville, Ala.
STRATOSCOPE III
Tom Barr 205-453-1732

Stratoscope III is a concept for astronomical observations from a balloon supported telescope. Typical operation will elevate the telescope by balloon to 80,000 ft., which is above 90% of the atmosphere. In this manner improved observations can be made without the disturbing effect of air turbulence and contamination. This concept has been demonstrated with earlier systems (Stratoscope I and II) with good results. Stratoscope III will be a 48 in. diffraction limited, reflecting telescope. The design will be for balloon flight and adaptable to Shuttle Sortie operation

W73-70645 **188-41-61**
Goddard Space Flight Center, Greenbelt, Md.
SOFT X-RAY SPECTROSCOPY FOR SHUTTLE
Elihu A Boldt 301-982-5853
(188-41-59)

X-ray production is a necessary consequence of energetic charged particles in space. Ultra-relativistic electrons radiate X-rays via their interactions with the ambient electromagnetic environment (e.g., magnetic fields, starlight, microwave radio). Subrelativistic energetic particles radiate X-rays via collisions with matter: highly ionized atoms radiate characteristic X-ray lines after recombining with ambinet electrons. Hence, by studying the X-ray emission from stellar objects, nebulae, and interstellar space we get direct information on energetic processes over a broad range of physical conditions and astronomical scales. Observations of hard X-rays are made with mechanically collimated proportional counters of advanced design. The technical goals are large effective area, broad spectral coverage, optimum resolution, and efficient rejection of extraneous events (e.g., caused by gamma rays, electrons, radioactivity). These goals, coupled with a detailed knowledge of detector response, are being achieved via laboratory tests, balloon and rocket flights. Observations of soft X-rays may be made with the use of grazing incidence optics. Small specialized detectors are then practical, and we are investigating the use of gas jets composed of pure low atomic number elements as precision X-ray filters for identifying line emission in the soft X-ray band. We are also continuing the development of cooled Si(Li) detectors to be used for non-dispersive spectrometery with resolution even better than that obtainable from proportional counters.

W73-70646 **188-45-51**
Goddard Space Flight Center, Greenbelt, Md.
COMETS AND INTERSTELLAR MATTER
B. D. Donn 301-982-5014

This RTOP includes several programs to study interplanetary and interstellar matter. The primary objective is laboratory experiments relevant to the behavior of matter in space. Theoretical analysis of astronomical problems using this data is a second aim. A third aspect involves flight observations to obtain new data. The last phase uses ground based telescopic observations. Molecular beam and laser techniques are being used for measuring productions of atoms, radicals and ions from planetary, comtary or interstellar moelcules by impact of photons, electrons or ions. The optics, spectroscopy and chemistry of species appropriate to the study of interstellar molecules and grains will be investigated. The possible relation of cometary and interstellar molecules to chemical evolution and the origin of life will be examined. In support of other research, use of image intensifiers to study comets and interplanetary matter will be investigated.

W73-70647 **188-45-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
COMETS AND ASTEROIDS
Donald P. Burcham 213-354-3028

The asteroids very probably represent material which has existed since the origin of the solar system. They may well be planetessimals left over from the formation of the planets and if so they are very important to our eventual understanding of the origin of the solar system. It is intended to investigate the origin and evolution of small bodies in the solar system. The properties of the asteroid belt, asteroid families, and fireballs would be studied. The proposed study of asteroid families will identify which asteroids are fragments of a former body, and which appear to have survived without major disruption. The study of the asteroid belt bears on our understanding of the impact history of the surface of Mars. There are four objectives: 1) To investigate the properties of asteroid families, clusterings of asteroids, using recently derived data on presently known objects. 2) To generate proper elements, orbital elements freed of the perturbations of the planets, for newly discovered asteroirds. 3) To generate proper elements for fireball orbits and investigate their distribution and nature. and 4) To investigate the long term orbital evolution of special objects by numerical integration. These studies should illuminate the origin and fragmentation history of asteroids and will attempt to use techniques on the analysis of fireball orbits which have proved powerful for the analysis of asteroirds.

W73-70648 **188-45-51**
Marshall Space Flight Center, Huntsville, Ala.
COMETS AND ASTEROIDS
J. R. Olivier 205-453-3428

The objectives are to construct photoelectric polarimeter for ground-base visible measurements. Zodiacal light and airglow observations are to be performed. The polarimeter would be used in support of determining the correlation between ground-base and space observations.

W73-70649 **188-45-52**
Marshall Space Flight Center, Huntsville, Ala.
METEOR ASTRONOMY
J. R. Olivier 205-453-3428
(188-45-52)

Low light level television systems onboard airborne expeditions can be used to make optical, real-time, examinations of faint phenomena under the improved atmospheric conditions encountered at high altitudes. Data recorded by Secondary Electron Conduction (SEC) video cameras can provide on-the-spot support to other experiments and can be filmed or stored on video tape for analysis. Special filters allow examination to be made in selected spectral regions. Thus astronomical events (aurora, eclipses, etc.) occurring at times and places for which no real time observations are available, may be analyzed in the laboratory. Low light level television (SEC Vidicon) systems equipped with full aperture diffraction gratings will be used to obtain spectro-photomatic data on meteors. Analysis of the data will be done by using (1) photography of the TV screen, (2) use of video analysis on stop action frames of TV, (3) use of moving target video processors to isolate the moving spectra from a stationary background, a scan converter for storing the spectra, and auto correlation to identify faint spectral lines.

W73-70650 **188-45-52**
Langley Research Center, Langley Station, Va
METEOR PHYSICS - SPECTRA PATROL AND DATA ANALYSIS
C. H. Nelson 703-827-2893

The primary objective of the in-house research is to continue to obtain spectra of shower meteors; and to obtain spectra and velocity, altitude, and orbit data of sporadic meteors. Radiation studies using shock tube meteorite spectra and other radiation data will be conducted. Studies of satellite meteor ultraviolet spectroscopy of silicon, carbon and magnesium, and of airborne meteor spectroscopy will be made. A comet probe study will be undertaken. Data reduction and analysis with emphasis on element abundance determinations will continue at LRC. A secondary objective of the in-house research is to obtain spectra and related data of meteors produced by debris from comet Giacobini-Zinner on October 8, 1972. This data will be reduced and analyzed for spectroscopically accessible element abundances, and the result correlated with other meteor data. The objectives

of the contract (SAO) meteor research are: to reduce radar meteor data collected over the period 1965-1968; to finish reductions and analysis of simultaneous meteor data; and to analyze this meteor data in order to reduce basic uncertainties in flux, mass, composition, density, and ablation of meteoroids that enter the earth's atmosphere. Additional objectives of the SAO meteor research are to determine orbital distributions of sporadic meteors and meteor streams within the meteor sample, and to investigate associations of meteor streams with comets and asteroids.

W73-70651 **188-45-53**
Goddard Space Flight Center, Greenbelt, Md.
COSMIC DUST RESEARCH
Louis S Walter 301-982-2282

The objective of this research will be to understand the nature and origin of the condensed matter of the solar system. In this effort, a multidisciplinary approach will be applied which will involve: (A) Analysis of material of cosmological significance when it is returned to the laboratory. (1) Mineralogical/petrographic (including microprobe) analysis (2) Chemical analysis (both wet and trace element analysis). (3) Isotopic analysis for age determination, and for the study of short-lived radioactivities produced by cosmic ray spallation. (B) Laboratory experimentation - high-temperature experiments, under reducing conditions on silicate systems.

W73-70652 **188-45-53**
Ames Research Center, Moffett Field, Calif.
COSMIC DUST MEASUREMENTS
Glen Goodwin 415-965-5065

The objective is to perform chemical analyses of extraterrestrial material (involving major element, trace element and isotopic determinations) enabling interpretation of the nature and origin of cosmic dust and meteorites. A laser microprobe will be used in this work to excite spectral emission from cosmic dust grains, pollution particles, and meteorite minerals as a means of studying major and trace element content. Ion microprobe and electronprobe techniques will also be applied to determine isotope ratios in and major element contents of terrestrial and extraterrestrial material. A direct-reading probe (one using photomultiplier tubes) has now been designed and built and has proven to be a much more sensitive and precise method than film recording of elemental line intensities. Preamps, amplifiers, analog-to-digital converters and scalers are currently being purchased and integrated, and a completed system, capable of registering and printing out intensities of three or more elements simultaneously, is expected to be in routine operation by March, 1972.

W73-70653 **188-45-54**
Goddard Space Flight Center, Greenbelt, Md.
COSMIC DUST EXPERIMENT FOR THE SPACE SHUTTLE
O. E. Berg 301-982-5920

The objective is to prepare for use in the Space Shuttle (and other missions) an instrument which will determine the ion composition, and much more accurately measure the speed, direction, and kinetic energy of cosmic dust particles. Laboratory experiments have proved the feasibility and practicability of adjusting the position sensor techniques used in nuclear studies to cosmic dust impact studies. The experiment ensemble will incorporate position sensor techniques; ion composition techniques (already proved); and impact energy analysis techniques (from Pioneer experiments).

W73-70654 **188-46-51**
National Aeronautics and Space Administration, Washington, D.C.
LOW ENERGY COSMIC RAYS
Albert G. Opp 202-755-3689
(188-46-52)

The objective of this task is to study the composition and propagation of solar and galactic cosmic rays with energies less than 10 BeV. The primary galactic radiation represents the direct penetration of material from the galaxy into the solar system. The study of the nuclear composition and energy of this material provides direct evidence on the stellar processes which created the cosmic radiation and information on the interstellar material, through which the cosmic radiation has passed. The total energy content of the galactic cosmic ray is high, and it is believed to be a major factor in the stability of a galaxy. The observation of solar cosmic rays provides information on the abundances of different elements in the sun and information on the solar processes which accelerate the cosmic ray particles to their observed energies. Similarly, the measurement of solar neutrons will give information on thermonuclear reactions in the sun and mechanisms responsible for accelerating charged particles in solar flares. It is also necessary to be able to assess the hazard of solar flare particle bursts on astronaut operations and on the operation of radiation-sensitive spacecraft components. The cosmic ray particles considered here can be observed by solid-state detectors, scinetillators, nuclear emulsions and similar nuclear detectors. Funds provided here are utilized to conduct laboratory and balloon tests of new instrument concepts---

W73-70655 **188-46-51**
Langley Research Center, Langley Station, Va.
ISOTOPIC ABUNDANCES IN LOW-ENERGY COSMIC RADIATION
C. H. Nelson 703-827-2893

The isotopic ratios, elemental abundances and energies of cosmic ray nuclei with masses which are less than or approximately equal to 16 amu and energies which are less than or approximately equal to 300 MeV/amu will be measured from high altitude balloons at high latitude. To perform these measurements, a three-parameter time-of-flight telescope with a large geometric factor will be developed to measure charge, mass, and energy with far better resolution than achievable in present systems. The measured results will be used to study solar modulation and the origin, propagation, and age of the cosmic radiation.

W73-70656 **188-46-51**
Goddard Space Flight Center, Greenbelt, Md.
LOW ENERGY COSMIC RAYS
F. B. McDonald 301-982-4801

The technical objective of this task is the development of new detector systems to determine the properties of solar and galactic cosmic rays and the associated development of theoretical studies related to these experiments. Specific goals are enumerated as follows: (1) The development of a high resolution detector system combining superconducting magnets and nuclear emulsions to conduct experiments which would measure the separate abundance of the isotopes of the elements from Li through C in cosmic radiation in the energy region from about 100 to 400 MeV/nucleon. (2) The development of a large area detector to obtain the first measurements of the spectra of heavy (Z is more than or equal to 3) galactic cosmic rays at low energies (2 is less than or equal to E 30 MeV/nucleon). (3) The development of detectors to measure the true intensity of cosmic rays in interstellar space on deep space missions. (4) Improved measurements of the differential intensities of positive and negative cosmic ray electrons with energies from 20 MeV

to 20 GeV. Detectors will be designed, constructed, and tested in our laboratories. Detector behavior will be explored using particle accelerator beams and other devices. Balloon flights will be carried out both for the purpose of detector development and obtaining new scientific information.

W73-70657 **188-46-52**
National Aeronautics and Space Administration, Washington, D.C.
HIGH ENERGY COSMIC RAYS
Albert G. Opp 202-755-3689
(188-46-51)

The objective of this task is to study the composition and propagation of primary cosmic radiation greater than 10 BeV in energy. Cosmic rays in this energy range provide information on very high energy processes occurring in stellar reactions. The energy of some cosmic ray particles presently exceeds the energies available from ground-based accelerators. Very high energy nuclear particle interactions, which cannot be studied in terrestrial laboratories, can be studied in space. The high energy of these particles requires large sophisticated instrumentation to define the characteristics of the cosmic ray particle and to analyze the resulting interaction. These effects are studied with instruments such as ionization spectrometers, total absorption cascade detectors, transition radiation detectors, and superconducting magnetic spectrometers. The size and complexity of these instruments requires extensive development and balloon testing prior to flight on a spacecraft. Instrumentation developed under this RTOP is directed toward future flight opportunities on High Energy Astronomy Observatories and on the Space Shuttle.

W73-70658 **188-46-52**
Goddard Space Flight Center, Greenbelt, Md.
HIGH ENERGY COSMIC RADIATION
Frank B. McDonald 301-982-4801

The objective is to measure the energy distribution and the charge and mass composition of the several components of the primary cosmic radiation high altitude from balloons. These components include both electrons and nuclei from hydrogen to iron, lead, uranium, and beyond. The results will be used in astrophysical considerations concerning the origin, acceleration, and propagation of cosmic radiation. The properties of charge measuring devices, direction detecting devices and total ionization spectrometers for measuring energy will be designed, developed, fabricated, and tested. They will then be calibrated on the ground and studied at balloon altitudes. These balloon flights will provide results on the details of the cosmic ray composition at energies between 10 to the 10th power and 10 to the 12th power eV. The detectors developed will subsequently be used in satellite born detectors which will provide the long exposures required to measure the low fluxes of the particles in question.

W73-70659 **188-46-53**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
X-RAY AND GAMMA RAY ASTRONOMY
D. P. Burcham 213-354-3028

This describes the JPL part of a cooperative program with UCSD in X- and gamma-ray astronomy. The objective is to observe line spectra in extraterrestrial X-ray and gamma-ray sources in the 0.05 to 10 MeV energy range. Observation of such sources would provide important information on nucleosynthesis, galactic history and the nature of cosmic X-ray sources. Under this program, a gamma ray sensor which has been developed for lunar missions will be adapted to balloon flight systems for carrying out astronomical observations while simultaneously studying their properties and performance in a spacelike radiation environment. The specific objective for this program for FY'72 is to integrate an advanced solid state detector array, its cesium iodide shield, pulse-height analyzer, and data handling electronics into a balloon-flight system and perform a balloon flight in the last part of FY'73.

W73-70660 **188-46-53**
National Aeronautics and Space Administration, Washington, D.C.
GREATER THAN 10 KeV X-RAY ASTRONOMY
Albert G. Opp 202-755-3689
(188-46-54)

Several X-ray sources have been identified, which have spectra extending into the tens of keV energy range. In addition, a diffuse X-ray background has been identified. The background is predicted to originate from a combination of contribution from discreet sources and a contribution from the interaction of highenergy cosmic ray electrons with the 2.7 K background radiation. The spectra of the discreet sources and the spectra and celestial distribution of the X-ray background will provide information of stellar processes as well as on physical processes in galactic and extragalactic space. Solid-state detectors and large inorganic scintillators have been used for measurements in this energy region. Solid-state detectors generally must be cooled and large scintillators are relatively fragile in the space and launch environments. Technical development is required to perfect these sensors for space use. Instrumentation developed under this RTOP is directed toward future flight opportunities on the Explorer class satellites, follow on High Energy Astronomy Observatories and on the Space Shuttle.

W73-70661 **188-46-54**
National Aeronautics and Space Administration, Washington, D.C.
GAMMA RAY ASTRONOMY
Albert G. Opp 202-755-3689
(188-46-53)

Gamma-ray photons result from a number of physical processes. These processes can furnish information on the synthesis and distribution of elements in the universe, on the magnetoplasma environment of a star, on the condensation and interaction of interstellar material with radiation, as well as other astrophysically important parameters. Gamma rays, which are undeflected by magnetic fields, travel directly from their sources, and anisotropies in the direction of arrival of the photons gives information on the location of the gamma-ray sources. The high gamma-ray background of the earth and the high energy of several of the gamma rays of interest requires sophisticated instrumentation capable of absorbing high energy photons with satisfactory directionality and shielding to protect against background and to determine the direction of arrival of the photon. Instrumentation used for these investigations are spark chambers, large inorganic scintillators and Cerenkov counters. The primary objective of this task is to develop these detectors, such that unambiguous measurements of high energy photons can be made in space. Instrumentation developed under this RTOP is directed toward future flight opportunities on Explorer class satellites, future High Energy Astronomy Observatories and on the Space Shuttle.

W73-70662 **188-46-54**
Goddard Space Flight Center, Greenbelt, Md.
GAMMA RAY ASTRONOMY
C. E. Fichtel 301-982-6281

The technical objective is to develop the most appropriate detector systems for the observation of the astrophysical sources

of very energetic photons. The approach has been divided into several different parts. The first approach to the general problem of gamma-ray astronomy was the development of a large telescope using digitized spark chambers to be tested on high altitude balloons and then flown on satellites. Other approaches to detector systems are now being pursued both for the high energy gamma rays and intermediate gamma ray studies. A medium energy gamma ray detector is being designed and built. A unique feature of this system is its high time resolution which will permit the tagging of several gamma rays during a short (microseconds) pulse as might be expected from a supernova outburst Improvements in the spark chamber systems are continuing, and methods for accurate timing are being developed for a search for discrete source emission of gamma rays at pulsar periodicities. In addition, a complementary ground-based detector system is being constructed and operated to search for atmospheric fluorescence which would be generated by photon pulses. These pulses are expected to result from extra-galactic supernova, and their detection would strongly suggest that supernova are the principal sources of cosmic ray particles.

W73-70663 **188-46-55**
Goddard Space Flight Center, Greenbelt, Md.
ASTRONOMY IN THE 150 KeV TO 15 MeV RANGE
T. L. Cline 301-982-4375

The technical objective of this new research program is to carry out extensive studies in astronomy in the 0.15 to 15 MeV region, intermediate between the traditional X-ray and gamma ray domains. This scientific discipline is critical in high-energy astrophysics since many important spectral and temporal features of electromagnetic radiation are expected in this unique energy range as the signatures of certain astrophysical processes. These spectral features include the electron-position annihilation line, most nuclear deexcitation lines, and the changes in the power-law exponent of continuous spectra due to the emergence of high-energy processes. There are also the questions of the extent into the high-energy domain of various lower-energy spectral and temporal x-ray phenomena, such as pulsars and time-varying hard x-ray emitters. Not only are point sources and the diffuse background of great interest, but of timely interest are the possibilities that the extended anisotropic sources of the Gum Nebula and the galactic plane emit detectable intensities of photons in this energy interval, particularly with spectral features such as several-MeV lines. The problems of angular resolution and signal to noise are especially critical in this energy range, due to the existence of cosmic-ray secondary generation both in the environment and in the detector material itself; these problems create the need for innovative approaches to instrument design and to research studies. A new detector system is being developed which will employ energy resolution from 150 keV up to 15 MeV, directional resolution, and improved sensitivity for the expected sources. This system is radically different than those that are presently, and have been previously, employed in this energy range; it involves several technological developments, including time of flight---

W73-70664 **188-46-56**
Goddard Space Flight Center, Greenbelt, Md.
VERY HIGH ENERGY COSMIC RAY DETECTORS FOR SHUTTLE
J. F. Ormes 301-982-5798

The technical objective of the proposed experimental program is to develop detectors which can be flown on the space shuttle capable of making the following measurements in primary cosmic rays (1) To measure the energy dependence of the charge distributions of cosmic ray nuclei from protons to Fe in the range 10 to the 14th power to 10 to the 17th power eV where galactic containment starts breaking down. (2) To measure the energy distributions of V.V.H. nuclei (Z is more than 30) around 10 to the 12th power eV. These nuclei arise in the 'r' and 's' processes in S.N. explosions and other high energy non stationary environments. (3) To measure the spectra of electrons of high energy (is more than 1000 GeV) in order to study their relationship to muon-poor extensive air showers and to understand the interactions with the galactic magnetic field and photon environments. (4) To measure the direction of arrival of these particles as a function of charge and energy in order to probe the structure of galactic magnetic fields and to attempt to relate sources of cosmic rays with nearby celestial objects like the Gum nebula. These studies are essential to complement the existing astrophysical information to understand the origin of cosmic radiation and to determine whether the processes responsible are galactic or metagalactic.

W73-70665 **188-46-57**
Goddard Space Flight Center, Greenbelt, Md.
GAMMA RAY, ENERGETIC ELECTRON, SUPERCONDUCTING MAGNET, AND NUCLEAR EMULSION COSMIC RAY DETECTOR SYSTEMS FOR APPLICATION TO THE SPACE SHUTTLE PROGRAM
C. E. Fichtel 301-982-6281
(188-46-54; 188-46-51)

The technical objective of the proposed research is the development of a system of compatible detectors with diverse capabilities, which can be combined in various configurations to perform a number of important experiments in gamma ray astronomy, energetic electrons, and cosmic ray nuclei studies. The ultimate goal is to develop detector systems which can utilize the capability of the Space Shuttle to place large and/or heavy payloads in orbit. These detector developments are directed toward three broad categories of scientific objectives: 1) Gamma Ray Astronomy - Improvement of sensitivity, precise source location capability, and extension of energy range to both higher (is more than 1 GeV) and lower (is less than 50 MeV) energies; 2) Cosmic Ray Electron/Positron Studies - Refinement of measurements at low and intermediate energies (10 MeV - 10 GeV), measurements at ultra high energies (is more than 100 GeV); 3) Cosmic Ray Nuclei Studies - Measurement of isotopic composition of low energy nuclei (Z is less than 30), high resolution studies of superheavy nuclei (Z is more than 30), studies of isotopic composition of extreme relativistic nuclei (gamma is more than or approximately equal to 30). The technical developments to be pursued include the following. 1) Large area spark chambers to provide increased sensitivity in the investigations of rare components of the cosmic radiation; 2) Proportional chambers to allow better spatial resolution; 3) Superconducting magnet and cryogenic techniques for high precision rigidity measurements; 4) Total absorption high resolution energy detector for gamma ray and electron energy measurements; 5) Large area proportional counters to allow sensitive energy loss (dE/dx)---

W73-70666 **188-46-58**
Goddard Space Flight Center, Greenbelt, Md.
SHUTTLE SUPERNOVA DETECTOR
T. L. Cline 301-982-4375

The technical objective of the proposed experiment is to search for, detect, and directly measure the time structure and energy spectrum of the energetic X-ray bursts from brief, catastrophic celestial events such as supernovae, novae, X-ray flares and pulsar quakes. A new detector system is being developed with differential time resolution on the several-nanosecond scale, energy resolution in the few-keV to hundred-keV

region and sensitivity sufficient for the theoretically expected fluxes. The detection of supernova X-ray bursts and the analysis of resulting data should provide a significantly greater understanding of the fundamental, high-energy astrophysical processes. In addition, the observation of the prompt X-ray flash can be used as an alarm to predict the delayed presence of secondary, supernova gamma-ray emissions from the de-excitation of the long-lived nuclear states.

W73-70667 **188-48-51**
Marshall Space Flight Center, Huntsville, Ala.
INTERDISCIPLINARY SPACE RESEARCH
E Stuhlinger 205-453-3033

Objective is to conduct space research in various scientific and technical disciplines with a capability of directing "quick reaction" efforts toward significant problems or promising areas of research and with the over-all purpose of helping develop the in-house scientific capabilities of the Center. Under the direction of the Associate Director for Science, Dr. Ernst Stuhlinger, research is initiated in scientific and technical areas that influence the scientific missions of the MSFC. Research projects are selected that, within available resources, contribute significantly to in-house scientific capabilities and state-of-the-art advancement. These projects are then funded from the Interdisciplinary Space Research discretionary funds.

W73-70668 **188-48-52**
Goddard Space Flight Center, Greenbelt, Md.
BASIC THEORETICAL RESEARCH
Aaron Temkin 301-982-5213

The objective is to develop techniques for the solution of basic (prototype) atomic collision problems involved in processes occurring in planetary and stellar atmospheres, and in other plasmas: also for collision processes that may be used as diagnostic tools in atmospheres. Specific work implementing the above objective fall in the following general categories: 1. Study of electron impact ionization. 2. Development of techniques and calculations of autoionization states of atomic systems. 3. Calculation of electron molecule scattering techniques. 4. Study of positron-atom scattering and reactions. 5. Study of proton-hydrogen collisions. 6. Investigation of hydrogen-antihydrogen annihilation and its cosmic significance. 7. Study of photoionization processes.

W73-70669 **188-78-51**
Marshall Space Flight Center, Huntsville, Ala.
LOW GRAVITY SUPERFLUID HELIUM ADVANCED TECHNOLOGY DEVELOPMENT
James O. Ballance 205-453-3431
(188-41-54)

Several experiments are currently being developed which will require a low temperature environment for their power operation in space. Superfluid helium will undoubtedly be used for many of these applications. Immediate applications to experiments are to be found in cosmic ray, relativity, and infrared astronomy. The purpose of this task is to investigate theoretically and experimentally, where possible, the properties of superfluid helium to be expected when liquid helium dewars are flown into space. The properties of superfluid helium in this near zero gravity environment will be assessed and methods will be investigated whereby problem areas may be resolved or controlled.

W73-70670 **188-78-51**
Goddard Space Flight Center, Greenbelt, Md.
ADVANCED TECHNOLOGICAL DEVELOPMENT, GENERAL: ON-BOARD PROCESSING ELECTRONICS; SOLID STATE NUCLEAR DETECTORS
J. H. Trainor 301-982-6282

A. The technical objectives of this research project are to develop and test new on-board signal handling, data processing, storage, computing and auxillary electronic circuitry for use in energetic particle and astrophysics experiments on IMP, SAS, Pioneer, Helios, HEAO, outer planet missions, rockets balloons, etc. The growing complexity of experiments and the often corresponding increase in volume of data obtained have made signal handling, data processing and data transmission - capability limiting factors. To reduce the transmission of unnecessary data, it is necessary to increase the experiment's on-board signal handling and data processing capability. This program is approached through (1) the investigation and development of new techniques for signal shaping and handling, data processing and auxillary circuitry and (2) the modification of existing techniques by the application of advanced technology and materials including bipolar integrated circuits, MOS/LSI technology, thick film techniques, micropower circuitry and multiple chip techniques. Special techniques must also be devised in order to accurately and efficiently evaluate and test the flight systems. B. The technical objective of the research project is to conduct a program of research and development, and devise test and evaluation in the field of silicon nuclear radiation detectors with emphasis on (1) the improvement of detector technology; (2) the understanding of the radiation damage effects on device operation and lifetime; (3) the understanding of the effects on these detectors of chemicals commonly used near or on spacecraft; (4) to establish the technology for the fabrication of specialized devices not available from industry; and (5) to continue the pragmatic life testing now underway.

W73-70671 **188-78-52**
Goddard Space Flight Center, Greenbelt, Md.
MODULAR INFORMATION SUBSYSTEM DEVELOPMENT
Raymond G. Hartenstein 301-982-5410
(180-17-54; 115-23-31)

Some of the benefits which can be derived from the addition of an on-board computer to spacecraft command and data handling subsystems have been demonstrated by the On-Board Processor (OBP-I) on OAO-C which was developed under earlier phases of an RTOP supported by OTDA. The OBP-I has proven its versatility by performing tasks for virtually all of the major spacecraft subsystems simultaneously. The OBP-I on the other hand is rather large and heavy (55 pounds) and consumes 35 watts of power all of which detracts from its universality especially in the smaller satellite field. The size and weight are being improved by an item of this RTOP which is to result in an LSI logic version of the processor module in third quarter 1972. The power consumption will be greatly lessened by the use of plated wire memories and/or volatile semiconductor (C-MOS) data storage memories both of which are part of this RTOP. The plated wire memory development is near fruition with the delivery of a qualification model scheduled for second quarter 1972. The C-MOS memory program to be initiated when funds become available will result in an order of magnitude reduction in memory power along with similar size and weight improvements. In order to keep pace with the continual increase in data rates and to increase the computational capacity of the OBP, it is essential that improvements in the speed power product of the OBP logic be investigated. Essential to these efforts is the continual development of ground support hardware and software.

W73-70672 **188-78-57**
Langley Research Center, Langley Station, Va.
LARGE SPACE TELESCOPE INSTRUMENTATION
G. B. Graves 703-827-3745

The principal objective of this work is to develop instrumentation and techniques for maintaining diffraction-limited performance in astronomical space telescope system. In order to make maximum use of the space environment, the optical systems must be maintained in precise alignment and the mirror shapes must be maintained to within 1/50 wavelength. The effects of the launch environment, the stresses associated with the change from 1 g to 0 g environment, the effects of heat inputs, and the basic material stabilities make the use of a conventional passive mirror doubtful. Techniques will be developed which use control systems to actively control the shape of the mirror surfaces and the alignment of the optical elements to the accuracy required for diffraction-limited operation under the influence of varying loads and stresses.

W73-70673 **188-78-57**
Marshall Space Flight Center, Huntsville, Ala.
LARGE SPACE TELESCOPE ADVANCED TECHNOLOGICAL DEVELOPMENT
Garvin R. Emanuel 205-453-3427

The objective of the LST project is to orbit a large, high resolution optical telescope system which is international in scientific usefulness and which will significantly extend man's knowledge of the universe. A more immediate objective is to fulfill as many of the scientific and technological requirements as possible during a precursor mission that will provide mankind with astronomical analysis beyond the reach of all ground-based telescopes and, simultaneously, provide scientific, technological, and operational knowledge for a diffraction-limited LST in the early 1980's. The projects outlined in this RTOP are necessary to solve the technological problems associated with the design and development of the LST.

W73-70674 **188-78-57**
Goddard Space Flight Center, Greenbelt, Md.
DESIGN, ANALYSIS AND EVALUATION OF THE LARGE SPACE TELESCOPE OPTICAL INSTRUMENTS SYSTEM
A. B. Underhill 301-982-5101
(502-23-54; 975-84-78)

The Large Space Telescope (LST) is intended as a very high performance multi-purpose astronomical research facility. Candidate instruments for the LST include the full gamut of imaging, dispersive, photometric, polarimetric, and interferometric devices, and the fine guidance system necessary to properly necessary to properly point the telescope. The various instruments will be Lyman limit through the near infrared; they will be removable for service and, in some cases, interchangable so that the flight complement of instruments can be modified in orbit to reflect improvements in the state of the art or changes programmatic emphasis. Three types of activity will be supported under this Plan: a) development and evaluation of novel devices potentially applicable to LST instruments, b) definition and detailed design of specific instruments to meet the established performance objectives, c) development of the data handling and data reduction techniques that will be required in order to achieve the full research potential of the instrumentation. Items b) and c) are closely interactive and should proceed together. It is expected that these efforts will culminate in the fabrication of bread-board instrumentation whose performance capabilities can be verified in the laboratory and in LST engineering models.

W73-70675 **188-78-58**
Marshall Space Flight Center, Huntsville, Ala.
LARGE SPACE TELESCOPE PHASE-B STUDIES AND LONG LEAD TIME PROCUREMENT
Garvin R. Emanuel 205-453-3427

The objective of the LST project is to orbit a large, high resolution optical telescope system which is international in scientific usefulness and which will significantly extend man's knowledge of the universe. A more immediate objective is to fulfill as many of the scientific and technological requirements as possible during a precursor mission that will provide mankind with astronomical analysis beyond the reach of all ground-based telescopes and, simultaneously, provide scientific, technological, and operational knowledge for a diffraction-limited LST in the early 1980's. The objective of the Phase-B effort is to obtain sufficient information on each alternate LST project approach resulting from the Phase-A study to permit the recommendation of a single approach for LST. Further, it is to provide management with a basis for action on recommendations for follow-on project activity. Two prime contractors will be selected to conduct parallel one-year studies, each funded at 500K. The contractors will define the Optical Telescope Assembly (OTA) for the LST and prepare inputs for the LST Phase-C/D. One of these two contractors will be selected for Phase C/D without resolicitation, hence a Phase C/D start can begin in early 1974. An additional $1000K of FY-73 funds is required because of the long lead time associated with procuring a three-meter diameter mirror for the LST.

W73-70676 **188-78-59**
Marshall Space Flight Center, Huntsville, Ala.
ASTRONOMY SORTIE MISSION DEFINITION PROGRAM
Dale J. Wasserman 205-453-3430

A continued program to determine the most advantageous method of performing Astronomy Sortie Missions is proposed. This program is a natural extension of the FY-71 Astronomy Sortie Mission Definition Study. The effort will further develop methods of mounting optical telescopes and high energy arrays within the Shuttle cargo bay, develop deployment techniques, analyze observation programs, and study techniques for simplifying ground refurbishment operations. This continuing effort will also update the definition of certain optical instruments such as the 1-M Photoheliograph mounted in the Shuttle. The approach will be to examine the results of the FY-71 Sortie Mission Study; additional study will be performed on the conclusions and results. More detailed analysis will be performed on the critical items of the mission such as mission time lines, observer scheduling, equipment operations, the control and display panel concepts and the telescope operating philosophy. Detailed study should be given to the methods of operating and controlling the optical instruments.

W73-70677 **188-78-81**
Ames Research Center, Moffett Field, Calif.
INVESTIGATION TO DEFINE SHUTTLE PAYLOAD EXPERIMENT SYSTEMS FOR FLIGHTS OF OPPORTUNITY IN PHYSICS AND ASTRONOMY
J. V. Foster 415-965-5803

The objective of this investigation is to establish how physics and astronomy experiment systems for Shuttle flights of opportunity may take advantage of sounding rocket techniques and procedures to obtain the benefits, such as low cost and quick reaction, which are characteristic of sounding rocket programs. This investigation is sometimes referred to as the MPACT (Modular Physics and Astronomy Concepts and Techniques) Project. The existing experience with on-going rocket payload flight projects, such as SPARCS (Solar Pointing Aerobee Rocket Control System), will be combined with additional inputs from experimenters to establish benefits and requirements for

application of sounding rocket concepts and techniques. The results of prior work on orbital versions of rocket payloads, such as Orbiting SPARCS, will be extended to develop system concepts which take advantage of sounding rocket techniques and procedures to obtain maximum science for minimum cost. Related techniques being used for low-cost airborne experiment systems will be incorporated where appropriate. Specific concepts will be developed for attached and free-flying versions of MSPARS (Modular Solar Pointing Astronomical Research System) and MSTARS (Modular Stellar Tracking Astronomical Research System). Coordination with Space Shuttle will be used to establish payload interface requirements. A program plan will be developed to further define and to implement the recommended payload concepts, techniques, and procedures.

Planetary Biology

W73-70678 **192-55-61**
Ames Research Center, Moffett Field, Calif.
CHEMICAL EVOLUTION
H. P. Klein 415-965-5094
(192-55-62)

Chemical evolution encompasses the study of the evolutionary path of carbon and its compounds from the primal fireball, through interstellar dust clouds, to formation of galaxies, solar systems, and planets, to the first stirrings of life in the Earth's primative oceans. In the laboratory, the syntheses of organic compounds related to terrestrial biochemicals are explored in experiments which simulate the putative environments of interstellar dust clouds, cooling solar nebulae and primordial and extant planetary atmospheres and surface. The study is relevant to understanding the prebiological chemistry of the solar system which led in the case of Earth to the formation of organic compounds and the origin of life, but which on extraterrestrial bodies and environments may have taken divergent paths. The study provides an experimental basis for the hypothesis that the origin of life, on Earth and possibly elsewhere, was preceded by a period of organic chemical evolution in which simple compounds containing the organogenic elements C,N,O,S,P,H were converted by abiotic processes into the complex organic molecules which are direct precursors of the macromolecules essential to life.

W73-70679 **192-55-62**
Ames Research Center, Moffett Field, Calif.
ORGANIC GEOCHEMISTRY
H. P. Klein 415-965-5094
(192-55-61)

The objective of organic geochemistry is to study the abundance, fate, and distribution of organic carbon compounds in contemporary environments and in recent and ancient (Precambrian) rocks. Modern organic geochemistry also includes the study of extraterrestrial material such as lunar samples and meteorites. In this work highly refined laboratory techniques will be used to isolate organic matter from a mineral matrix and to identify its constituents. Chemical criteria will be used to distinguish between the biological or non-biological origin of the organic matter found in geological samples.

W73-70680 **192-55-63**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
LIFE DETECTION
Donald P. Burcham 213-354-3028

In preparation for missions to the planets, research is required to define and develop scientific strategies for flight experiments which will detect and identify extraterrestrial life and organic molecules characteristic of past or present life. Under this program are eight separate tasks which entail a wide variety of disciplines from organic chemistry, geochemistry, biochemistry through various types of molecular spectroscopy: Metabolism and Photosynthesis, Geochemistry of Biomolecules, Reaction mechanisms in Thermal Decomposition, Volatile derivaties of Organic Compounds, Analytical Technique in Mass Spectrometry, Advanced Techniques in Organic Analysis, Kerogens of Harsh Environmental Soils, Biospheric Recycling Processes.

W73-70681 **192-55-63**
Ames Research Center, Moffett Field, Calif.
LIFE DETECTION
H. P. Klein 415-965-5094

Those attributes of life which can be used for the remote detection of life are being studied. Techniques are being developed for the detection of active extraterrestrial life, for the detection of organic molecules unequivocally related to life, and for the determination of the nature of extraterrestrial life.

W73-70682 **192-55-64**
Ames Research Center, Moffett Field, Calif.
BIOLOGICAL ADAPTATION
H. P. Klein 415-965-5094

Objective is to study terrestrial microorganisms which have adapted to life under extremes of environment, as models for organisms which may have evolved and continue to live on other planets. Environments on the other planets include low and high temperatures, low water concentration, intense radiation, and probably high salt concentration. Microorganisms have been collected from various localities on earth which resemble those conditions, and are being studied to determine the mechanisms by which they adapt to such extremes. This information will lead to better predictions of the possibilities for evolution of life on other planets, the characteristics to be expected of such life, and properties which can be utilized in a search for the living forms.

W73-70683 **192-55-64**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
BIOLOGICAL ADAPTATIONS
Donald P. Burcham 213-354-3028

The results from the study of the ecology and biochemistry of organisms which can survive and grow in extreme environments are important for planning and interpreting the results of the planetary biology experiments. One area of study in this task is the ecology of microorganisms that exist in extreme environments, especially desert soils. The desert soils of Antarctica constitute our best model of Martian ecology. By studying the ecology of the microorganisms and their enzymes, a better understanding of the survival and growth of life in such environments can be obtained. the current work continues microbial, physical, and chemical analyses of soils and microbial isolants from harsh environments, viz., the Antarctic dry valleys, Transantarctic Mts., and from Don Jaun Pond. Measurements of metabolic activities will be continued on soils recently collected in Antarctica. Based on relationships between the occurrence of organisms and environmental factors established in our field work and recent MM'71 results, an attempt will be made to develop descriptive criteria for selection of the most promising areas to search for active or past biology on Mars. Because of the aridity of Mars, it is appropriate to investigate halophilic microorganisms since they are uniquely adapted to an environment of limiting water. The two proposed areas are under study with the halophiles:

the characterization of intracellular enzymes and the mechanisms for uptake of extracellular substrates. Understanding these processes may provide some insight as to how Martian life-forms perform metabolic transformations in the arid environment.

W73-70684 **192-55-65**
Ames Research Center, Moffett Field, Calif.
BIOINSTRUMENTATION
J. V. Foster 415-965-5083

The broad objective of the effort is to develop instrumentation and techniques for planetary exploration in the field of exobiology. The primary emphasis of the program is directed at the exploration of Mars, but consideration will be given to application of the instrumentation to other planets. The work ranges from the continued development of a complex wet-chemical processor for the isolation and identification of soil compounds such as amino acids, to feasibility studies of experiments involving stable isotope tracers, mass spectrometry and other advanced concepts. The approaches are: to design, fabricate, and test in breadboard form, specific critical components of the wet-chemical processor; establish feasibility and perform preliminary breadboard design of a metabolic gas analysis system for Mar's life detection, establish feasibility of integration of flight type mass spectrometer with wet-chemical analysis.

W73-70685 **192-55-65**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
BIOINSTRUMENTATION
Donald P. Burcham 213-354-3028

In this task a major effort will be made to develop fully wet chemical analytical techniques and instrumentation needed to insure the successful conversion of potential post-1976 candidate experiments for detection of active biology and biomolecules into flight experiments. It is expected that such experiments will be proposed by extra-JPL NASA-supported scientists and might be expected to originate from several SRT tasks presently in progress at JPL. Careful attention will be given to means by which the existing Viking GC/MS technology can be incorporated into these future potential flight experiments involving wet chemical front ends and atmospheric trace constituent analysis schemes. Every attempt will be made in this task to bring together the scientific investigator and the development engineer early in the conceptual phase of potential experiments. By making careful engineering evaluations and supplying appropriate engineering support at an early stage, alternatives which will lead to more feasible automation and remote data acquisition should be implemented. Such a strategy can be expected to result in a more ready development of a scientific concept into a scientific breadboard or engineering prototype stage than has traditionally taken place.

Planetary Quarantine

W73-70686 **193-58-61**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
STERILIZATION TECHNIQUES
John W. Lucas 213-354-4530
(193-58-62; 193-58-63)

The objectives of this RTOP are to perform analytical and experimental studies in the area of planetary quarantine to develop understanding of potential contamination events of future missions. Specifically, these studies will include: (1) an analysis of planetary quarantine constraints for Jupiter-Saturn fly-by missions, Saturn's rings encounter, and atmospheric probes; (2) studies to determine the effect of the natural space environment on the survival of microorganisms. These studies are being conducted to identify planetary quarantine constraints for future missions to better understand the requirements and to develop the procedures and methodology by which flight programs can reliably satisfy these requirements. Existing JPL facilities will be used to conduct these studies and a multidisciplined team will be used to perform analysis for advanced missions. This team will include support for the definition of the natural space environmental parameters, spacecraft flight environments, mission analysis and microbiology.

W73-70687 **193-58-62**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
MICROBIAL ANALYSIS
John W. Lucas 213-354-4530
(193-58-61; 193-58-63)

The objectives of this RTOP are to develop analytical tools and perform experimental studies in order to estimate the recontamination hazard for spacecraft hardware. All physically significant parameters and processes are to be analytically modeled and experimentally verified, where possible, to obtain a reasonable level of confidence in the results. A combined discipline approach will be used to: (1) perform tests in existing JPL facilities in order to obtain data for the verification of the analytical models; (2) perform analytical and empirical correlation studies and (3) to perform mission strategy analyses to assess their impact on recontamination phenomena.

W73-70688 **193-58-63**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
CONTAMINATION CONTROL
John W. Lucas 213-354-4530
(193-58-61; 193-58-62)

The objective of this RTOP is to further develop and refine the methodology and procedures for the reduction and probability estimation of microbial burden on an assembled spacecraft at the time of encapsulation or terminal sterilization or during flight. This technology is required for: 1) design of the sterilization process for a planetary lander or probe; 2) estimation of the probabilities of contamination associated with contaminating events identified in the mission prelaunch analysis; 3) the reduction of microbial burden on spacecraft components for the purposes of either decreasing planetary contamination probabilities for an orbiter or minimizing the duration of the sterilization process for a lander. The work will provide mathematical tools for the estimation of microbial survival probabilities on spacecraft and needed information concerning cleaning techniques that could significantly reduce microbial burden on spacecraft hardware. This RTOP contains a work unit which provides direct support to the NASA headquarters Planetary Quarantine Office as requested.

Lunar Science SR&T

W73-70689 **195-42-50**
Ames Research Center, Moffett Field, Calif.
IMPACT CRATERING IN GEOLOGIC MATERIALS
Glen Goodwin 415-965-5065
(383-09-52)

The Vertical Gas Gun (VGG) and the Electrostatic Microparticle Accelerator (EMA) Ranges will be used to study cratering in unconsolidated materials of low cohesive strength

and in massive rock. The effects of material strength and gravitational forces will be examined over a wide range of crater sizes. Previously developed techniques will be exploited to model and study other geologically significant formations for lunar and planetary applications. Results of studies will be combined with RTOP 383-09-52 'Lunar Data Analysis' for interpretation of the lunar surface morphology and evolutionary processes The VGG will be used in studies of crater formation and of ejecta trajectories in gravitational fields of 1 to 0 'g'. Experiments on the EMA will focus on cratering efficiency (i.e., the ratio of eroded mass to projectile kinetic energy), effects of oblique impact, residual projectile material in craters, comminution of small particles, and calibration of micrometeorite detectors. Because the cratering process is controlled primarily by material strength and/or gravitational forces depending on crater size, target media will vary from unconsolidated material through bonded particulate material to massive rock in order to simulate to cratering of different scales and ascertain material strength effects With the VGG, high speed photographic and stereoscopic techniques will be used to study crater formation and ejecta trajectories in gravity fields from 1 to 0 'g'. Modeling techniques that have been developed will be exploited to explore scaling laws for large craters and study geologically significant deformations and structures.

W73-70690 **195-42-51**

Ames Research Center, Moffett Field, Calif

CHEMICAL AND ISOTOPIC STUDIES OF METEORITES AND ABLATION PRODUCTS

Glen Goodwin 415-965-5065

(188-45-53)

Chemical analyses via the electron microprobe permit determination of coexisting mineral composition in meteorites, terrestrial analogs and lunar samples. Knowledge of mineral composition, together with textural studies, is needed to determine more precisely the physicochemical conditions of their origin, post-solidification thermal histories and shock events. Experiments will be devised to determine the feasibility of forming meteorites from a 'cold' beginning. In addition, a study of the concentrations of the cosmogenic radionuclides in meteorites provides information regarding their pre-atmospheric entry size in their exposure age. Concentrations of such nuclides in meteorites are a function of chemical composition, meteorite size and exposure age. Thus comparisons can then be made among meteorite and terrestrial mineral assemblages for establishing more precise limits on meteorite parent body size, crystallization process, and postparent body breakup histories. Also, characterization of reactions and fractionated products will define the types of material being ablated from bodies during entry into the earth's atmosphere. This will enable new criteria to be developed for identifying debris ablated from sources such as meteoroids Hence, it will be possible to identify extraterrestrial debris ablated from meteors and fireballs found in glacial ice sediments. Analyses to be conducted on specimens will include: optical mineralogy, petrography, density, X-ray diffraction, X-ray fluorescence, electron microprobe scanning electron microscopy.

W73-70691 **195-42-53**

Ames Research Center, Moffett Field, Calif.

THEORETICAL STUDIES OF THE MOON AND METEORITE PARENT BODIES

Glen Goodwin 425-965-5065

The objective is to obtain a better understanding of the structure, composition and evolutionary history of the moon by means of theoretical investigations employing the results of lunar and ground based experiments. Theoretical knowledge, physical insight and mathematical modeling techniques are used, together with astronomical and geological data, to construct self consistent mathematical descriptions of lunar and meteorite processes and structure. Analysis and interpretation of the results of these model calculations are applied to such topics as: the composition and thermal history of the moon, solid state convection in the lunar interior, the electrical conductivity profile in the moon, interpretation of rare gas studies of meteorites and lunar samples and radar scattering properties of the lunar surface.

W73-70692 **195-42-55**

Jet Propulsion Lab., Calif. Inst of Tech., Pasadena.

GEOLOGY AND MINERALOGY

D P. Burcham 213-354-3028

The Geology and Mineralogy program is a coordinated group of researches directed at understanding the surface and subsurface properties of the Moon, the evolutionary history of this body and its relation to the origin of the solar system. The specific tasks involved are: (1) Analysis of lunar gravity and associated lunar structures. (2) Analysis of electromagnetic techniques for lunar interior exploration. (3) Thermal and thermoelastic histories of the body, based on previous investigations of lunar thermal history. (4) Investigations of thermal deformation as a mechanism for modification of lunar surface features. (5) Studies of the reflectance and radiative properties of rocks and rock-forming minerals, and their use in interpretation of telescopic and spacecraft observations. (6) Irradiation of known composition targets to observe induced gamma ray spectra as a supplement to interpretation of Apollo 15 and 16 gamma ray spectroscopy data. (7) Study of the relation between lunar surface rock (or particulate) sizes and radar back scattered energy, using by-product data from the Apollo Lunar Sounder Experiment. (8) Produce a radar map of the Moon at 7.5 m wavelength from data previously obtained at Arecibo Observatory. (9) Obtain new magnetic resonance data on terrestrial and meteorite, as well as lunar samples, to further our basic understanding of the nature of lunar materials.

W73-70693 **195-42-57**

Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.

PARTICLE TRACK COSMOCHRONOLOGY

D. P. Burcham 213-354-3028

This work is undertaken to expand our understanding of the mineralogic settings and differentiation histories of planetary heat sources. Improved understanding of these settings and histories will lead to clearer interpretation of isotopic chronology studies and will provide constraints for models of planetary evolution. Planetary heat sources uranium and thorium are mapped on a microscopic scale by fission track mapping in lunar, meteoritic, and terrestrial materials. Sites of these species are studied geochemically and petrologically.

W73-70694 **195-42-59**

Manned Spacecraft Center, Houston, Tex.

GEOCHEMICAL RESEARCH (GEOCHEMICAL RESEARCH OF LUNAR MATERIALS).

P. R. Brett 713-483-2781

Geochemistry research is being conducted in 3 major areas of interest at MSC. TASK 1. Isotopic and chemical analysis of lunar rocks, meteorites and terrestrial basalts and ultramafic rocks using mass spectrometer, x-ray fluorescence, atomic absorption, rare gas analysis by mass spectrometry and gamma counting. TASK 2: Mineralogy, petrography, and mineral chemistry of lunar rocks, meteorites, and terrestrial basalts and ultramafic rocks, using the techniques of optical and electron

microscopy, x-ray crystallography, the electron microprobe and ion microprobe. TASK 3: Phase equilibria studies in order to determine the conditions of formation (temperature, pressure, volatile fugacity, elemental distributions) in lunar rocks, meteorites, and terrestrial igneous rocks. Analysis of volatile contents (excluding noble gases) in lunar rocks, terrestrial volcanic rocks and meteorites using thermogravimetric analysis, differential thermal analysis and mass spectrometric techniques.

W73-70695 **195-42-60**
Manned Spacecraft Center, Houston, Tex.
GEOPHYSICAL RESEARCH
D. W. Strangway 713-483-5891

Geophysical research is being conducted in two areas of interest. TASK 1: Geophysical Properties of Materials: (a) Magnetic Properties: To study magnetism in materials--in particular lunar samples--to help understand the evolution of the moon, in particular whether it had a fluid core. A cryogenic magnetometer representing the state of the art has been delivered. Contracts will be let to continue modifications and ensure that we can make maximum use of the device. We also plan to let contracts to develop furnaces and alternating field demagnetizers to be part of this instrument. (b) Electrical Properties: To measure the electrical properties of materials that might represent lunar and planetary interiors as a function of temperature and pressure. The equipment for this is largely in operation or is in procurement permitting measurements to 300 C and 30 Kbars. Synthetic samples of pure materials and crystals need to be procured for this work. This work relates to the temperature determination in planetary interiors by transient sounding. Measure the properties of a soil as a function of confining stresses representing the top kilometer of a planet. (c) Thermal properties: To measure the thermal diffusivity of lunar and other soil samples under high vacuum conditions and varying confining stresses to represent the top kilometer or so of the moon or planets. This information is useful in understanding the heat flow of the moon and the thermal balance at planetary surfaces. A contract---

W73-70696 **195-42-63**
Goddard Space Flight Center, Greenbelt, Md.
ORIGIN AND STRUCTURE OF THE PLANETS AND THE MOON
L. S. Walter 301-982-2282

The objective of the in-house research is to gain an understanding of the nature and origin of the condensed matter of the solar system. More specifically, activities will focus on time and mechanism of formation of the terrestrial planets, the moon and meteorites and subsequent modification of these bodies since formation. This includes, for example, development of the earth's core and formation and movement of the continents; development of the surficial topography of the moon by vulcanism and meteorite/cometary impact and comparison of magnetic differentiation processes of the moon and the earth. The approach will be multidisciplinary, involving the following areas: 1. Analytical geochemistry - major, minor and trace element analysis, 2. Geochronology - rubidium/strontim and potassium/argon age determinations, 3. Radiochemistry - determination of cosmic-ray spallation products, 4. Mineralogy/petrology - mineral compositions and textural relations, 5. Crystallography - analysis of crystal structures, 6. Experimental petrology - duplication of natural conditions in the lab, 7. Geologic investigations - in situ (e.g., terrestrial craters) and photographs (e.g., Lunar Orbiters; earth satellites), 8. Theoretical study of lunar origin. The objectives of the out-of-house research are: 1) to determine the state and magnetic moment of iron in tektites and meteorites (especially achondrites) and to---

W73-70697 **195-42-68**
Goddard Space Flight Center, Greenbelt, Md.
HALO-ORBIT UTILIZATION STUDIES
R. W. Farquhar 301-982-6724

Previous studies under this RTOP have demonstrated the importance of halo orbits about libration points in future space missions. The principal goal of the current effort is the development of a computer program that could be used for a wide variety of mission analyses of possible halo-orbit operations. This computer program will be mainly directed towards the trajectory and control requirements associated with these operations, but other mission constraints will also he taken into account. It would be applicable to all types of libration-point missions including an upcoming GSFC mission (IMP-K'). Many of the required subroutines for this type of program have already been developed at GSFC and could easily be incorporated into the mission analysis program. It is intended that all hardware-related program elements will be represented by general parametric relationships. This specification should increase the program's flexibility, and at the same time, forestall early obsolescence.

W73-70698 **195-43-51**
Goddard Space Flight Center, Greenbelt, Md.
LUNAR RANGING EXPERIMENT LASER SYSTEM
T. S. Johnson 301-982-4835

The objective is to develop, build, test, install, and evaluate high energy, short pulse laser transmitter systems for the Lunar Ranging Experiment (LURE). Experiment uses retroreflectors which were placed on the moon by Apollo 11, 14, and 15. By measuring distance precisely to each reflector from several stations on Earth, we can study lunar orbits, lunar precession, earth rotation variations, polar motion, continental drift, ard relativistic effects. Present NASA installation at the University of Texas McDonald Observatory uses system with resolution of one nanoseconds (15 cm). Experiment requires a second station in Hawaii and a system resolution of 0.2 nanoseconds, as well as an improvement in the economy of the operation. The ruby laser transmitter developed and installed by GSFC at the McDonald Observatory in 1969 has a typical pulse duration of 3 to 4 nanoseconds and pulse energy of 3 to 5 joules, operating once per 3 seconds. New laser materials and techniques indicate that Neodymium (Nd) lasers (using host crystals of Yttrium Aluminate or Yttrium Aluminum Garnet) can produce pulses less than 200 picoseconds long with energies up to 2 joules at pulse rates of 5 to 10 per second. In this RTOP, such a laser will be developed, tested, and integrated into a second station being built in Hawaii. The improved divergence of the transmitted beam, the increased pulse rate, and the shorter wavelength of Nd radiation will also improve the efficiency of the system, making possible the use of smaller cheaper telescopes and shorter operating periods. Telescopes, detectors, electronics, facilities, and operations are not part of this RTOP, but responsibility of other members of LURE team. Data resulting from experiment will be analyzed at GSFC and at other participating organizations.

Planetary Astronomy SR&T

W73-70699 **196-41-12**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
SUPERCONDUCTING INFRARED DETECTORS
D P. Burcham 213-354-3028
(134-03-03)

The objective is to develop an improved type of detector for radiation in the microwave and far infrared region of 3 mm to 100 microns, for use in both earth- and spacecraft-based astronomical observations. The detector is expected to have a sensitivity on the order of 10 to the minus 15th power watt/Hz to the minus 1/2 power, a response time of 10 to the minus 9th power sec or better, and to be narrow-band and tunable. The detector will make use of a thin-film superconducting structure similar to a Josephson junction. In developing the detector the main obstacle to be overcome is that of efficiently coupling the superconducting structure to external radiation. This problem will be approached first at 10-20 GHz, where the equipment and superconducting samples are more tractable; the results will then be transferred to 100 GHz (3 mm) and above. Coupling and sensitivity will be maximized by manipulating geometrical factors and composition of the structure. Frequency response and sensitivity will be determined in the range of 10-100 GHz and above, and noise measurements will be made at microwave frequencies. Instrumentation will be developed for use with the superconducting device. Close cooperation in this project will be maintained with members of Dr. James Mercereau's Low-Temperature-Physics Group at Caltech. Members of this group were responsible for the invention and initial development of the type of superconducting structure to be studied. Outside of JPL, this is the only other place where this structure is being studied. A portion of the funds will be used to support their contributions to this task.

W73-70700 **196-41-50**
Goddard Space Flight Center, Greenbelt, Md.
GROUND-BASED INFRARED ASTRONOMY
R. A. Hanel 301-982-4528

The scientific objective is to determine information on the atmospheres and surfaces of the planets from ground-based infrared measurements, obtained with high spectral resolution, of the planets thermal emission spectrum. A double-beam Michelson interferometer has been used to obtain high quality spectra of Venus in the regions of the terrestrial atmospheric 'windows' at 450-500/cm, 800-1000/cm and 1100-1200/cm with a spectral resolution of 0.25/cm. Similar data but of lower quality and lower spectral resolution (0.5-1.0/cm) have been obtained for Mars. Attempts to measure the thermal emission spectrum of Jupiter have not been successful to date due to its very low infrared signal. Improvement of the present instrumentation and data acquisition electronics will allow further valuable planetary observations to be obtained. These observations include obtaining some spatial resolution for Venus, measurement of the thermal emission spectrum in the 2000/cm terrestrial atmospheric 'window' for all of the planets and obtaining higher quality spectra of Mars and Jupiter for all the terrestrial 'window' regions.

W73-70701 **196-41-51**
Goddard Space Flight Center, Greenbelt, Md.
RADIO AND RADAR PLANETARY STUDIES
J. K. Alexander 301-982-5461

The objective of the Jupiter Monitor program is to obtain continuous synoptic observations of the decameter-wave radio emissions from Jupiter in order to facilitate reliable studies of the morphology of the emission phenomenon and its relation to dynamical processes in the Jovian magnetosphere. To meet this need a world-wide network of five observing sites has been established in order to monitor Jupiter with identical instruments at each site and thus obtain a homogeneous body of data for analysis. Each site consists of a two-element interferometer operating at 16.7 and 22.2 MHz. These are located at Goddard Space Flight Center, at Clark Lake Observatory in Borrego Springs, Calif., and at MSFN stations in Kauai, Hawaii; Carnarvon, Australia; and Grand Canary Is., Spain. The network is providing important data on the Jovian radio emissions that can not be obtained from a single, isolated observatory or from combination of data from various dissimilar observatories.

W73-70702 **196-41-52**
Goddard Space Flight Center, Greenbelt, Md.
ADAPTATION OF MARINER MARS IRIS BREADBOARD FOR SPACE SHUTTLE MISSIONS
R. A. Hanel 301-982-4528
(196-41-50; 160-44-54)

The objective of this RTOP is to prepare instrumentation eventually suitable for several tasks in atmospheric research to be performed from the space shuttle. The instrument will be designed to record a substantial portion of the thermal emission spectrum (200 to 1600/cm) with a spectral resolution adequate to resolve individual spectral lines of many atmospheric constituents (0.25/cm). The approach is to upgrade the breadboard instrument of the Mariner 9 infrared interferometer and to demonstrate the above performance in the laboratory. The new breadboard instrument to be constructed can then serve as a convenient prototype for instrumentation to be flown on sortie missions of the space shuttle.

W73-70703 **196-41-66**
Ames Research Center, Moffett Field, Calif.
AIRBORNE PLANETARY ASTRONOMY
G. Goodwin 415-965-5065
(188-41-55)

This RTOP is to provide high-altitude platforms for infrared observations of the planets. The experiments will be flown at altitudes which put them above most of the atmospheric water vapor, which is the chief absorber of infrared radiation. This program of airborne planetary research will provide much needed information on the extent and composition of planetary atmospheres and the composition of planetary surfaces. This information will be of assistance in the design of manned and unmanned systems for missions to the planets.

W73-70704 **196-41-67**
Ames Research Center, Moffett Field, Calif.
PLANETARY ASTRONOMY AND SUPPORTING LABORATORY STUDIES
G. Goodwin 415-965-5065

The abundance, temperature, and pressure of certain constituents of planetary atmospheres can be determined by spectroscopic observations from ground-based and from airborne observatories. Such data are necessary for the preparation of model atmospheres that are needed to evaluate the possibilities of life on the planets and to design systems for exploratory missions. The objective of this work is to make airborne and ground-based observations of planetary spectra, to obtain in the laboratory the spectroscopic parameters needed to analyze the observatory spectra, and to develop the analytical and computational techniques needed to interpret the spectra in terms of real planetary atmospheres. The spectroscopic parameters such as absorption intensity and line widths and their temperature and pressure dependences will be obtained using long path gas cells, cooled gas cells and high resolution spectrometers and interferometers operating primarily in the infrared.

W73-70705 **196-41-71**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
GROUND BASED OPTICAL ASTRONOMY

Donald P. Burcham 213-354-3028
(196-41-74)

The objective of this task is the comprehensive study of solar system bodies through ground-based telescope observations. Principal emphasis is devoted to high-resolution spectroscopic observation of Mars, Venus, Jupiter, Saturn and Uranus. The principal instrument used in this task is the high-dispersion coude spectrograph and its ancillary equipment at the coude focus of the Table Mountain Observatory 24-inch telescope. Specific objectives for FY 73 include completion of the analysis of the Venus superior conjunction CO2 data, completion of the analysis of the H2 abundance on Saturn, analysis of CH4 and NH3 on Saturn through observation of the 3 nu sub 3 and 3 nu sub 1 bands at 1.1 micron respectively, observation of CO2 band strengths during Venus inferior conjunction, observation of the H2 abundance on Uranus, compilation of a library of solar comparison spectra for Table Mountain, construction of an image tube scanning system for the coude spectrograph, and construction of an image stabilizer and guidance system for the coude spectrograph.

W73-70706 **196-41-72**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
GROUND-BASED INFRARED ASTRONOMY
Donald P. Burcham 213-354-3028
(196-41-74)

The objective of this task is to obtain and analyze high resolution spectra of the planets at infrared wavelengths. The principal instrumentation employed is a Connes'-type Fourier spectrometer at the coude focus of the 107 inch telescope, McDonald Observatory, University of Texas. During FY'73, we plan to continue our observing program on Venus in order to elucidate the role of the clouds in the anomalous phase effects observed both in the continuum and in the HC1 bands. We shall also continue our efforts to make a positive identification of the cloud material. We also plan to continue our successful exploration of the spectrum of Jupiter and to commence observations on Saturn.

W73-70707 **196-41-73**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
RADIO AND RADAR PLANETARY STUDIES
Donald P. Burcham 213-354-3028

The objective of this task is to conduct a comprehensive program in ground based planetary radio and radar astronomy. Radio astronomical observations provide data on the properties of planetary atmospheres, magnetospheres, and surfaces. Radar astronomy provides data on the properties of the atmosphere, surfaces, and dynamical motions of the planets. A microwave radiometer development program is conducted to provide support for the observational radio astronomy program. The support objectives are to design, construct, test, and maintain advanced microwave radiometer systems for use at Table Mountain, Goldstone, and Owens Valley radio observatories. Equipment used in the course of this task includes the facilities and test equipment of the Table Mountain Observatory and the Deep Space Network. The facilities include the 18-foot millimeter wave antenna at Table Mountain, and the 85-foot, and 210-foot antennas at the Goldstone Tracking Station. Observations at other observatories are carried out as required by the specific needs of the program.

W73-70708 **196-41-74**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
INFRARED SPECTROSCOPY
Donald P. Burcham 213-354-3028
(196-41-71; 196-41-72)

The objective of this activity is to support astronomical and spaceflight studies of planetary atmospheres by obtaining spectra of gases under suitable conditions. There are two main functions, namely: (1) to furnish quantitative band or line data chiefly at infrared wavelengths, and (2) to provide direct aid in verifying identifications of features observed in planetary spectra The primary facility employed in this task is the Spectroscopy Laboratory which contains spectrometers covering the visible, near and middle infrared spectral regions and absorption tubes capable of providing path lengths of up to 1 kilometer at pressures up to 20 atmospheres.

W73-70709 **150-22-20**
Goddard Space Flight Center, Greenbelt, Md.
TRACKING AND DATA RELAY SATELLITE TECHNOLOGY DEVELOPMENT
George Q. Clark 301-982-6331
(164-21-55)

The two objectives are: (1) To provide for the definition of a Tracking and Data Relay Satellite System to be used for support of NASA missions, and (2) To provide for the orderly development of the technology required for implementing a first-generation TDRSS by 1977 Various studies will be performed to establish the criteria for a TDRSS, while other studies will look for solutions to problems inherent in the system. In addition, technology will be developed as required for a first-generation TDRSS.

OFFICE OF TRACKING AND DATA ACQUISITION

Tracking and Data Acquisition

W73-70710 **150-22-21**
Goddard Space Flight Center, Greenbelt, Md.
NETWORK INTEGRATION AND DEVELOPMENT PLANS
James P. Shaughnessy 301-982-2357

This task addresses the total scope of problems which are related to the technical integration of the STADAN and the MSFN into the STDN and the development of plans, programs, and techniques required to update the network. This task will emphasize those areas which maximize the effectiveness of the support provided and increase the cost effectiveness of the total network. Advanced and state of the art techniques will be identified and their potential impact upon the network will be evaluated along with their mission support capabilities. Specific objectives of this task which will affect all elements of the network including remote sites, control centers, and data handling centers are identified in the following broad areas: (A) Integration of MSFN and STADAN networks; (B) Network Control; (C) TDRS impact on the Network; (D) Advanced network system support/cost trade-off data.

W73-70711 **150-22-22**
Goddard Space Flight Center, Greenbelt, Md.
GODDARD TRAJECTORY DETERMINATION SYSTEM
W. D. Kahn 301-982-4554

The Goddard Space Flight Center (GSFC) Operational Trajectory Determination System currently in use for definitive and operational orbit determination must be improved in order that accuracies on the order of one meter can be attained. Such orbital accuracies are to be commensurate with anticipated tracking system accuracies resulting from improved RF Systems (ground based and spacecraft borne), Operational Laser Systems,

and Very Long Baseline Interferometer Systems which will be available in the mid 1970's In order to support the upcoming Radio Astronomy Explorer (RAE-B) Lunar Mission, the Goddard Trajectory Determination System (GTDS) is being modified and augmented under the concept of a series of major subsystems in the areas of orbit determination, trajectory control, attitude determination, and attitude control. The aforementioned Trajectory Determination System will have the capability to function as unique subsystems or as an integrated computing system in both a real time and non-real time environment. Flexibility in the overall design of the GTDS will be maintained to assure that application of this system to future space missions such as IMP K' which will be located in an orbit in the vicinity of the libration point (L1) between the sun and the earth (i.e. distance of .01 A.U. or 1.5 X 10 to the 6th power km) is accomplished in an efficient and timely manner.

W73-70712 **150-22-23**
Goddard Space Flight Center, Greenbelt, Md.
NETWORK SIGNAL QUALITY AND TIMING ACCURACY IMPROVEMENT
T. S. Golden 301-982-4297

This program conducts studies and develops software and hardware technology to improve signal quality for satellite-to-ground telemetry and tracking. Quality enhancement will be achieved through. (1) analysis of phenomena and delineation of techniques to alleviate ionospheric propagation anomalies; (2) investigation of techniques to improve network time synchronization to meet the plus to minus one microsecond requirement imposed by approved satellite experiments. Emphasis is placed on satisfying known present and future deficiencies in the operating networks. Software models will be developed where appropriate. Experimental or engineering models of some hardware will be built and tested in semioperational or operational environments. A single worldwide time synchronization system to meet the network requirement is being investigated. Hardware receiver development for the system is expected to be completed in FY 72. A field test of the system capability will be conducted in FY 73.

W73-70713 **150-22-24**
Goddard Space Flight Center, Greenbelt, Md.
WIDE BAND STATION DATA HANDLING EQUIPMENT
Henry J. Franks, Jr. 301-982-2649

The Wide Band Station Data Handling Equipment research program will investigate concepts for demodulating, synchronizing, decommutating, and recording spacecraft telemetry data at rates up to 300 megabits per second. In the demodulator the main emphasis will focus on investigation to optimize the intermediate and local oscillator frequencies and the number of conversions. The primary study will be on quadraphase modulation with later studies on other modulation techniques for comparison and trade-off considerations. In the synchronizer and demodulator primary emphasis will be placed on test techniques to ascertain error rate performance in environments perturbed by noise, jitter and baseline variations. Attention will be devoted to pattern sensitivity problems such as experienced with the 15 Mbs ERTS system. Experimental recording systems utilizing magnetic tape, electron beam, laser and holographic techniques presently exist in contractor laboratories. A study will be initiated comparing the performance of these systems and ascertaining their suitability for use in the field at stations of the Space Tracking and Data Network Primary emphasis will be placed on a system to meet the 30 MBs requirement for project EOS with later emphasis on the 100 to 300 MBs range of data rates.

W73-70714 **150-22-25**
Goddard Space Flight Center, Greenbelt, Md.
AUTOMATIC COMPUTER PROGRAM DOCUMENTATION
E. P. Damon 301-982-5478

Through numerous cursory investigations and a symposium on Automated Methods of Computer Program Documentation held at GSFC on November 2 and 3, 1970, a study contract has been awarded which will identify within the various compilers, assemblers, and loaders presently in existence where information for automatic program documentation can be obtained It will further provide designs of special programming that will generate information not presently available. It will also attempt to present an improved format for computer program documentation that will be more easily understood by other programmers and management personnel. This effort is aimed at the implementation of the applicable techniques recommended by the study contract stated above. This implementation will include the detailed design, production, and documentation of one or more computer programs which will contribute to the automatic documentation of other computer programs.

W73-70715 **150-22-26**
Goddard Space Flight Center, Greenbelt, Md.
TRACKING DATA AND TRAJECTORY ANALYSIS
J. L. Colley 301-982-5671

The objectives are: to provide computational techniques for metric tracking data, trajectory, guidance and maneuver analysis for space flight missions and tracking experiments scheduled for the mid 1970's era, such as Radio Astronomy Explorer, Synchronous Meteorological Satellite, geodetic and geodynamic satellites, and satellite-to-satellite tracking experiments, to develop computer programs and analysis procedures for improving the quality and usage of tracking data including pre-flight calibration, real-time analysis and post-flight evaluation; to conduct evaluation studies to isolate and identify tracking data error sources; to develop computational and procedural techniques which enhance the utilization of present and future tracking data; and to develop techniques and computer programs to study the interrelationship between the tracking data, the on-board guidance system, and the mission to determine trajectory and navigation requirements. This RTOP covers four tasks: (a) Trajectory and Data Analysis Techniques; (b) Geodetic Tracking Data Processing and Analysis; (c) Mission Analysis; and (d) Development of Wideband Filter.

W73-70716 **150-22-31**
Goddard Space Flight Center, Greenbelt, Md.
A GROUND ANTENNA FOR WIDE BAND DATA TRANSMISSION SYSTEMS
A. F. Durham 301-982-4973

A future advanced spacecraft system will transmit data to the ground at rates much higher than that of current operational systems. The Earth Observation Satellite (EOS) will transmit high resolution color TV either directly to a ground station or via a Tracking and Data Relay Satellite (TDRS). The TDRS will transmit signals from EOS and other satellites which required total TDRS bandwidths approaching 1 GHz. Existing NASA ground stations are not equipped for such data rates. Future wideband communication by TDRS, EOS and other projects, require use of frequencies at which the necessary bandwidth can be allocated. A wide band (approximately 1 GHz) system requires a high performance ground antenna system. Emphasis on overall system efficiency will be essential to an economically feasible ground station. In particular, techniques and components will be developed which yield high efficiency antenna systems, feed systems and low noise preamplifiers. In addition, dichroic subreflector techniques permitting simultaneous and efficient

operation of an antenna at different frequencies without degradation of overall performance or flexibility will be refined. Analytical procedures and design tools will be further developed to support the specific requirements of these advanced antenna systems and the general antenna development program.

W73-70717 **150-22-32**
Goddard Space Flight Center, Greenbelt, Md.
HIGH RELIABILITY CONTROL SYSTEMS FOR ANTENNAS
N. A. Raumann 301-982-6579

Concentration of data acquisition responsibilities and increasing data bandwidths resulting from reduction in the number of network stations are placing greater loads on the network links. Thus, the cost of link down time is increased, requiring a corresponding increase in link reliability. The antenna control system is one of the few components to which redundancy cannot be economically applied. In addition, link down time due to alignment requirements and routine maintenance has to be minimized. At the same time a reduction in maintenance and operation (M and O) manpower is highly desirable. Above objectives are met by the tasks in this RTOP. The computer controlled antenna system has demonstrated a potential for marked reduction in (M and O) manpower and the functions of several equipments have been successfully integrated. This system is operating experimentally at the Network Test and Training Facility (NTTF) and prototype design has begun for FY 73 operation. It will support the STADAC system at NTTF to be installed in the same time frame. The acoustical analysis equipment for detecting and identifying incipient failures in hydraulic and mechanical systems is being or has been installed on ten network antennas. In addition to direct support to the network, these installations will provide field data for further evaluation and analysis technique development under this RTOP. Study efforts in progress will define the design characteristics for a high accuracy control system which is required for future antennas operating in the Ku-band such as the ground station in support of the Tracking and Data Relay Satellite (TDRS).

W73-70718 **150-22-35**
Goddard Space Flight Center, Greenbelt, Md.
FUTURE NETWORK UTILIZATION AND SUPPORT ANALYSIS
James P. Shaughnessy 301-982-2357

The objective is to investigate support requirements of future manned and unmanned missions such as Shuttle, Large Space Telescope, Space Station, TDRS, EOS, HEAO, IMP K, K', L, and M, which are presently being programmed for the 1975 to 1980 time frame, and define the impact of these support requirements on network receiving and transmitting systems, the Network control centers, and remote site computer systems. Studies will be performed to identify new technology and support capability that can be used to upgrade or augment existing network capability. Studies will also be performed to determine the degree and complexity of computational services required of the Network and control center computers to provide efficient and cost effective automated central control of network resources. Operational concepts and rationale will be investigated to determine their feasibility and applicability to the following functions: (A) Scheduling; (B) Network/site equipment reconfiguration; (C) Data flow verification; (D) Mission simulations; (E) Equipment and data quality monitoring; and (F) Data handling.

W73-70719 **150-22-36**
Goddard Space Flight Center, Greenbelt, Md.
AUTOMATIC DATA HANDLING
John C. Rogers 301-982-4189

Improvements to meet the large increases in support requirements demanded by NASA's future space programs specifically include a higher level of automation for Goddard Space Flight Center (GSFC) facilities resulting in increased data and information exchanges between the various GSFC facilities. This RTOP shall study methods of handling data and information within GSFC and shall result in two end products (1) a variable exercisable computer simulation of the future data handling and processing capability at GSFC, and (2) the design of an automatic information management system with the necessary capability to input, store, retrieve, and distribute the increased information and data traffic resulting from increased real time operations at GSFC. The computer simulation will aid in determining the requirements and design of systems to handle and process the data at GSFC. The simulation will also be an evaluation tool to determine where bottlenecks occur and what effect alternate changes have on the overall data handling system. The simulation can also be used in the evaluation of equipment proposals. The information management system shall interface with the M and DOD computer facilities and NASCOM concentrating on the particular problems inherent in information and data transfer, data coordination and accountability among the GSFC facilities including NASCOM. Studies shall specify equipment and software requirements, equipment configuration, formats and procedures needed to interface the system to the GSFC facilities and NASCOM and to perform the specified tasks.

W73-70720 **150-22-37**
Goddard Space Flight Center, Greenbelt, Md.
STDN INTERFACE COMPUTING SYSTEMS, CONTROL AND APPLICATIONS STUDY
James P. Shaughnessy 301-982-2357

STDN future planning includes integrating the former STADAN and MSFN systems into a unified network with all stations having manned and unmanned support capabilities and continuing the current level of mission support with reduced station facilities. The remaining station will have increased capabilities requiring more automation in areas of testing, scheduling, configuration control, data handling, and status and performance monitoring in order to permit efficient utilization of their assets. The planned STDN facility reduction also places added emphasis on station availability. The ensuing improvement of network support efficiency will impact its interface computing systems operational policies and procedures and their hardware and software configurations, both at remote stations and GSFC. This RTOP shall provide an assessment of these impacts with emphasis on the following: (1) determining the current and long range effect on the STDN central computing system configuration (software and hardware); (2) determining the feasibility of utilizing the central computing systems to provide simulations between the STDN and spacecraft control centers; (3) determining techniques for minimizing or improving non-real time data handling between STDN stations and spacecraft control centers; and (4) developing a STDN central computing system control and application plan for the 1975 to 1980 time period. STDN/spacecraft control center simulation and STDN non-real time data handling techniques study thrusts will be directed toward improving station availability and/or support efficiency. The STDN interface computing system control and application studies will be directed towards developing management planning and budgeting guidelines for the future STDN central computing systems which include the NOCC/NST support computers, GRTS, and the NASCOM switching computers located at GSFC.

W73-70721 **150-22-38**
Goddard Space Flight Center, Greenbelt, Md.
DATA PROCESSING SYSTEM

Philip B. Pease 301-982-6276
(150-22-39)

The objective of this RTOP is to provide cost-effective means for processing high data rates (more than 30Mbps) and high data volumes and for distributing this data to the users. A secondary objective is improving the speed, reliability, and cost of current Mission and Data Processing Operations at GSFC. The work proposed falls into three categories: (1) Storage System Evaluation - To evaluate the characteristics of storage systems with respect to operating performance and archival properties; also to investigate new technologies which may make archival storage of large data volumes (more than or equal to 10 to the 15th power bits) practical. (2) Data Processing System Studies - To identify the high data rate processing requirements and to evaluate possible processing system architectures to meet these requirements. (3) Remote Terminal Studies - To investigate the use of remote terminals to reduce the quantity of data collected, processed, and/or distributed in high data volume conditions and to improve Mission and Data Processing Operations. In each category, the initial phase consists of in-house problem formulation by GSFC personnel. This may be followed by in-house implementation or a problem oriented study contract or grant. Implementations of solutions for a particular application are supported directly by the appropriate project

W73-70722 **150-22-39**
Goddard Space Flight Center, Greenbelt, Md.
IMAGE PROCESSING FACILITY PERFORMANCE EVALUATION AND IMPROVEMENT
John Y. Sos 301-982-2841

The NDPF has been designed primarily to handle ERTS data. The facility can be modified, however, to handle such future earth observation systems as EOS. It is proposed to conduct a study of the requirements for modifying the NDPF to handle EOS data. The ERTS NASA Data Processing Facility (NDPF) is required to produce a large volume and variety of products of extremely high quality. This requirement places a very stringent demand on the equipment performance in the NDPF. It also limits for reasons of economy the number of types of standard products that can be generated. These products then do not necessarily satisfy the requirements of all the users. To assure achievement of high performance it is necessary to develop efficient performance monitoring techniques, parameters to characterize product quality, and obtain instruments to implement the techniques in conjuction with existing NDPF hardware. It is also necessary to study methods for generating image products that could be more useful to the user community This plan proposes to develop efficient and accurate methods for monitoring and controlling performance of equipment, and assuring the quality of products produced in the NDPF. It also proposes to investigate the utility of new presentation such as stereo pairs, and products that would make human (rather than machine) interpretation easier. The plan proposes to implement an Image Display and Manipulation System (IDAMS) for support of above activities.

W73-70723 **150-22-46**
Goddard Space Flight Center, Greenbelt, Md.
UNIFIED SPACECRAFT RADIO FREQUENCY SUBSYSTEM DEVELOPMENT
A. F. Block 301-982-4158

This program provides improved tracking, telemetry, and command equipment for space flight programs. It develops designs which, due to versatility, are applicable to large spacecraft requiring high power, wideband transmitters as well as smaller payloads having modest size, weight, and power budgets. This is achieved by: (1) Developing new components to provide extended communication abilities. Power transistors for high frequency are an example; (2) Improving circuit design or circuit effectiveness through fabrication technique and component application. Power amplifiers, frequency multipliers, linear phase modulators, and stabilized oscillators are typical of this effort; (3) Designing complete systems. This is exemplified by the present effort which will produce a transponder with command, telemetry and tracking capability into the NASA networks. These systems will incorporate the most frequently required parameters of equipment planned for future spacecraft missions. This design will employ many subassemblies and components developed previously on this task. The design and prototype transponder will be done for the most part in-house. In addition to the S-band, a transistor development for a five watt, 4 to 5 GHz will be contracted by the end of FY 72.

W73-70724 **150-22-60**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
NAVIGATION ACCURACY ANALYSIS
D. W. Trask 213-354-4878
(150-22-61, 150-22-62; 150-22-63; 150-22-64)

Those DSN Tracking System uncertainties which limit spacecraft navigation capability now and in the future will be determined. Methods of removing these limitations and more effective uses of existing tracking stations such as the two-station tracking techniques needed by missions to the outer planets will be analyzed. Demonstrations to prove the advantages of two station tracking techniques including S/C VLBI, and differential VLBI with Mariner IX in configurations which simulate MVM73/VK75 navigation will be planned and executed in anticipation of MJS 77 requirements. The relative contributions of DSN tracking system error sources to orbit estimation will be examined in the presence of single and multi-station radio metric data types, both to develop and refine models of tracking system errors and to determine where better equipment/calibration techniques are needed. Currently the main thrust includes developing better practical techniques to calibrate the effects of the transmission media (troposphere, ionosphere, and space plasma) on radio metric data and to reduce the platform parameter (DSS location, polar motion, Universal time) uncertainties. It is planned for the transmission media to demonstrate radio metric monitoring of water vapor as a tropospheric calibration and to develop techniques to extract the charged particle information in the S/X radio metric data for the MVM73 demonstration In the area of platform parameters it is planned to demonstrate both the feasibility of routinely providing platform parameter measurements using VLBI techniques with existing DSN equipment and that the accuracy of the polar motion and UTL determinations are at least competitive with determinations obtained by present optical techniques.

W73-70725 **150-22-61**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
INSTRUMENTATION FOR NEW TRACKING DATA TYPES
R. Bruce Crow 213-354-3291
(150-22-60; 150-22-62, 150-22-63; 150-22-64)

This RTOP develops the support equipment necessary to generate the tracking data types required for deep space missions of the next decade. The data types of interest include simultaneous S and X down links as well as two-station tracking. Simultaneous S/X down links will lead to calibration of the charged particle medium and two-station tracking will provide microradian angle and angle-rate data on spacecraft position The new tracking data types are needed for example for navigation of the Venus-Mercury '73 and Jupiter-Saturn '77 spacecraft. Due to

increased tracking accuracy, there will be a savings of on-board fuel requirements An improved sequential component ranging system will be demonstrated with the Venus-Mercury '73 S/X-band experiment. In conjunction with the ground-based hardware, there will be an X-band S/C transmitter developed for V-M '73. Microsecond precision time synchronization for use in the two-station tracking will be demonstrated using signals from radio stars. Third-order phase locked loop technology will be utilized in the design of the Block IV Subcarrier Demodulator Assembly (SDA) to permit tracking of high residual doppler rates. Computer control and monitor will be designed into the SDA as well as the Block IV Ranging Demodulator Assembly (RDA). Ultra stable dual frequency receivers, increasingly necesaary as space probes go farther from earth, will be designed and developed. The Coherent Reference Generator (CRG) utilizing a new universal wideband distribution amplifier will be designed to provide and distribute ultra-stable dual frequency reference signals. A stable S/X receiver/exciter will be demonstrated in the V-M '73 S/X experiment, with the new reflex dichroic feed. This feed will be designed to retain high-efficiency low noise performance at both bands simultaneously.

W73-70726 **150-22-62**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
S-BAND RANGE AND DOPPLER QUALITY
R. L. Sydnor 213-354-2763
(150-22-61; 150-22-63; 150-22-64; 150-22-66)

The planetary tracking requirements of the DSN tracking stations over the next decade involve greater distances, higher accelerations due to gravitational fields, higher data rates, and the necessity for improved S-band range and Doppler quality in order that the required improvements in radio navigation and radio science be met. Calibration of the DSN tracking stations as a precision measuring system and accurate differenced range versus integrated Doppler (DRVID) measurements for calibration of the propagation path will be required for the more demanding navigational and science needs of these missions. In order to achieve this required performance, the work under this RTOP is concerned with stable generation and control of frequencies, stable phase and group delay in the DSN tracking system, and with means for obtaining and maintaining stable one and two way unified communication and tracking with spacecraft. To these ends this RTOP will. 1) develop reliable, high power, phase stable transmitters with high spectral purity for increasing the signal-to-noise ratio in the spacecraft receiver and thus improve the quality of the down-link signal; 2) develop digital oscillators for removing the high loop stresses in the up-link and down-link during high gravitational acceleration and thus minimizing the consequent doppler and telemetry degradation; 3) develop reliable hydrogen masers for ultra stable frequency generation for improving Doppler and range data over the long round trip light times, maintaining time synchronization between sites, and for use in very long baseline interferometry (VLBI) to determine tracking station locations accurately, improved radio navigation in outer planet missions, planetary orbiters, and entry missions, and 4) develop techniques for improving the signal delay stability through RF modules and cables to improve ranging calibration and precision.

W73-70727 **150-22-63**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
RADIO SCIENCE
C. Stelzried 213-354-3838
(150-22-60; 150-22-61; 150-22-64; 150-22-62)

The objective of the Radio Science RTOP is to extend the capability of the DSN tracking stations to meet long range radio science goals for planetary spacecraft and provide pre-project planning information by support of propagation medium research. Techniques will be developed to perform radio propagation experiments utilizing the spacecraft-earth communications link. The goal is to obtain information in a cost effective manner (utilization of existing link) which not only contribute to our knowledge of the Solar system but also provide data needed to design an optimum communication link for future space probes. The approach is to provide DSN co-investigators for approved propagation medium experiments. These include Pioneer 10 and G Occultation (measure structure of Jovian atmosphere and ionosphere and Solar corona effects), Mariner '71 Occultation (measure structure of Martian atmosphere, and ionosphere and physical properties of the planet), Pioneers 7 and 9 and Helios (measure Faraday rotation in the Solar corona); Mariner Venus/Mercury '73 and Viking '75 S/X Experiment (measure interplanetary and planetary ionosphere electron densities and demonstrate X-band as a NASA frequency). The occultation experiments require both open and closed loop ground receiving systems The closed loop and open loop S-band receivers are operational at all stations. Simultaneous S/X capabilities will be provided for Mariner '73 at DSS-14 and extended to the overseas 64-m antennas for Viking '75. These experiments require measurements of phase path, group path, plane of polarization, and spectral broadening. Data has been obtained from Mariner '71 and Pioneers 7 and 9.

W73-70728 **150-22-64**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
X-BAND RADAR DEVELOPMENT
C. P. Wiggins 213-354-6016
(150-22-60; 150-22-61; 150-22-62; 150-22-63)

This RTOP develops an X-band radar capability to obtain operational experience at this frequency and to prepare for a possible spacecraft X-band uplink. A gain of up to 7db over S-band will be achieved on targets without dense atmospheres. Thus, better experiments can be done on Mercury, Mars, the Jovian Moons, and asteroids. The wide bandwith available at X-band allows finer range gates, which can be used to improve mapping and altitude resolution and obtain better ephermerides as well. During FY'73 design of the X-band radar will continue and procurement of parts and fabrication will be started. This effort will continue in FY'74 with installation and checkout in FY'75. The radar transmitter will be installed on DSS-14. It will use the existing H. V Power Supply and coolant system. Minor mods to the control system and extension of the coolant pipes are required. The X-band klystrons are being procured in FY'72. A new X-band power amplifier will be designed and installed. A new X-band microwave feed will be procured in FY'74 and installed in FY'75. Waveguide components will be designed, procured and installed starting in FY'73 and continued through FY'74 and FY'75. The X-band exciter will be a design modification to an existing S-band exciter. The design and procurement will be in FY '74. The X-band receiver subsystem is presently in use at DSS-14 and will be used for the X-band radar development. The receiver subsystem includes an X-band low noise TWM.

W73-70729 **150-22-65**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
ANTENNA SYSTEMS DEVELOPMENT
H. P. Phillips 213-354-4743
(150-22-66; 150-22-67)

This RTOP develops and calibrates DSN ground antennas to meet the DSN commitments to the NASA planetary program and improves their performance, flexibility and operational availability for maximum economy in telecommunications with spacecraft. Improvements are developed in the areas of RF optics, antenna structural and mechanical design, control systems,

measurement and calibration techniques, and the evaluation of engineering and economic problems involved in the larger or higher gain antennas required in future planetary missions such as Mariner 73, Viking 75, Mariner 77 and the ongoing Pioneer program. Engineers assigned to the development tasks are those directly responsible for the design of the operational equipment, maintaining a continuity of responsibility from development through prototype installation, calibration, and operational usage. Development efforts are carried on in house at JPL, and occasionally under contract from JPL in other laboratories having unusual abilities in specific fields of interest. Contact is maintained with other laboratories and institutions doing work of interest applicable to the DSN antenna systems.

W73-70730 **150-22-66**
Jet Propulsion Lab., Calif. Inst. of Tech , Pasadena
RADIO SYSTEMS DEVELOPMENT
W. H. Higa 213-354-4240
(150-22-67)

The objective of this effort is to optimize the spacecraft-to-ground communications link in order to meet the future data rate requirements of the planetary exploration program. The Viking '75 mission to Mars, for example, will require simultaneous communications with as many as two orbiters and two landers. Future missions to the outer planets, e.g., Mariner-Jupiter/Saturn will require sophisticated communications for navigation, telemetry, and high resolution television. This effort seeks to meet these requirements by improving equipment, by optimizing the use of avilable RF equipment; and by utilizing the DSN communications system in the most efficient and cost-effective way. Hardware improvement for the DSN tracking stations refers specifically to broadband traveling wave masers operating in superconducting magnets at X- and K-bands to meet future needs of MJS '77 for data dump telemetry and ground antenna calibration. Diplexed use of antennas is practicable provided the transmitter does not interfere with the receiver functions; this means that the reflector panels of the antenna must not arc at the joints during high power transmissions. Optimum use of antennas requires measurement and calibration of antenna gain, pointing accuracy, and noise performance to reduce pads which must otherwise be included in flight project design control tables. Efficient use of the DSN tracking stations requires investigation of techniques such as multiplexed transmitters for simultaneous transmissions to multiple spacecraft and of wideband data-dump telemetry for rapid transfer of information from spacecraft to ground. The latter requires a study of weather dependent characteristics of X-band and K-band propagation through the atmosphere.

W73-70731 **150-22-67**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
DIGITAL SYSTEMS DEVELOPMENT
R. A. Winkelstein 213-354-3843
(150-22-65; 150-22-66)

In order to enhance communications between planetary spacecraft and the DSN tracking station in a timely and cost effective manner, this RTOP will provide development of technology and construction of equipment needed to handle the extremes of telemetry data rates being planned for missions in the next decade. Multiple Frequency Shift Keying (MFSK) receiving equipment will be constructed and demonstrated at rates up to 20 symbols per second. This phase incoherent method of communication is required for the difficult transmission paths through absorptive and turbulent planetary atmospheric media encountered by the expected Pioneer Venus Multiprobe and possible Jupiter probe spacecraft missions. Telemetry analog signal predetection storage and processing equipment will be developed to permit data recovery for certain spacecraft failure modes. A recording bandwidth of 500 KHz will allow post-mission processing of both low rate MFSK telemetry or phase coherent high rate telemetry. In addition, this recording technique will provide synchronization protection in the case of limited magnetic tape information dropout thus permitting two station tracking of spacecraft by providing a low cost synchronization method between data received at independent stations. Digital filter theory and design will be developed as a cost-effective alternative to large valued analog filters required in narrow bandwidth phase locked loop reception of phase coherent telemetry with low signal-to-noise ratios. Narrowing the receiver loop bandwidth permits a corresponding increase in telemetry signal modulation index while still maintaining the loop carrier signal-to-noise ratio. Digital filters are also needed as a preprocessing element for spectral analysis required for narrow loop signal acquisition and MFSK reception.

W73-70732 **150-22-68**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
STATION MONITORING AND CONTROL TECHNOLOGY
G. Morris 213-354-2745
(150-22-69)

The general objective of this work is to increase the number of tracking station control and monitoring functions performed automatically without operator intervention. The general approach is to use digital mini-computers to perform these functions. The plan for FY'73 and FY'74 contains three types of activities: (1) the standardization of interfaces between the station and the mini-computers, between mini-computers, and between mini-computers and the Network Control System; (2) the development of specific digital control and monitoring subsystems such as precision signal power measurement, PN coder controller, and antenna controller; and (3) the integration of several of these devices into a system such as planetary radar interferometer to demonstrate two station tracking under realistic conditions with a complex system using small tracking crews and a high level of automation. The interface between the mini-computers and the station has been studied and a standard proposed. The interface between station computers is currently under investigation with a demonstration system soon to be in operation. The study of the larger problem of computer-computer communications and communications with the Network Control System will be started in FY'73. The Precision Signal Power Measurement technique has been demonstrated and several improvements will be made in FY'73. The PN coder controller is already in the construction phase. The antenna controller will be started in FY'73. The demonstration of a highly automated two station radar interferometer radar will take place in early FY'73 with several improvements proposed during FY'73 and FY'74.

W73-70733 **150-22-69**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
TRACKING STATION OPERATIONS TECHNOLOGY
E. Jackson 213-354-3898
(150-22-68)

This RTOP provides a non-mission committed station and evaluation techniques for testing and demonstrating the efficiency and reliability of new tracking station subsystems, configurations, and operations control techniques. It also provides ephemeris predictions for DSN Development radar demonstrations. The Venus Station, with no mission commitments evaluates new communications and tracking concepts prior to flight project commitment, thus avoiding costly late fixes. A spacecraft signal source which can be freely manipulated for test purposes is desirable for development testing; in the absence of such test

sources, planetary radar experiments are performed at Venus Station and DSS-14 (Mars) together and separately. As a by-product of such testing, valuable planetary data necessary for pre-project planetary modeling and mission planning are obtained. Development of the two station (VLBI) tracking mode, wherein spacecraft angle positions are obtained with micro-radian precision, can be supported, inasmuch as Venus is equipped with receive capability at the spacecraft downlink frequencies. Station automation, starting at the subsystem level and working up, is demonstrated at Venus Station. Inexpensive enlargement of antenna size and DSN utilization of the shaped antenna concept for performance improvement will be demonstrated at Venus Station. In addition to providing the inhouse and contractor personnel and services required for Venus Station and the Microwave Test Facility, this RTOP also provides a small permanent contractor staff at DSS-14 to coordinate the support required by DSN Development activities. In the area of DSN management information, mathematical models of inventory, shipping, spares stockage, maintenance activity and scheduling, and reliability will be developed and tested against simulated and actual DSN logistics data, to minimize costs while maintaining the current high level of equipment availability.

W73-70734 **150-22-70**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
NETWORK DATA STREAM PERFORMANCE MONITORING AND CONTROL
R. J. McEliece 213-354-7058
(150-22-71; 150-22-72)

The work units covered in this RTOP have as goals the analysis and improvement of the communication channel represented by the Ground Communication Facility. First, current GCF transmission reliability data will be gathered, and then a statistical model of some kind (perhaps a Markov compound channel) will be sought which adequately represents the channel. Special emphasis will be placed on the problem of determining the effective memory of the channel noise, since the size of this memory will determine whether or not forward error-correction will be a practical method of improving GCF performance. In any event, once a reasonably accurate channel model has been developed it should be possible to utilize the well-developed techniques of information theory to improve the overall computer-computer/GCF link performance. For example, if it is found that an important part of the channel noise comes from symbol-error bursts of relatively short duration, than, as mentioned, forward error-correction could prove to be a practical method of significantly decreasing the overall bit-error probability on the GCF. On the other hand, if most of the channel noise comes in the form of very long bursts, some sort of a error-detection and retransmission request would probably be best. In any case, once a particular scheme has been decided upon, it will then be necessary to develop efficient algorithms for performing the necessary computations.

W73-70735 **150-22-71**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
NETWORK CONFIGURATION MONITORING AND CONTROL
John R. Smith 213-354-4768
(150-22-70; 150-22-72)

The objective of this activity is to define and develop techniques of automated monitoring of the performance and operable status of the Deep Space Instrumentation Facility. These techniques will be used in the Network Control System to monitor the network performance, control and record the configuration of the stations in the network, and generate simulated data for use in testing the station equipment, training the station operators, and performing the tracking activities assigned to the DSIF. This will improve the reliability of the network, improve the capability of the network to adapt to future flight project requirements, and reduce operations costs through a reduction in required personnel. Equipment required for the NCS will be fabricated with a standard packaging technique to reduce maintenance and logistics problems and reduce costs through the use of hardware available from multiple sources. The I.C. logic modules used will also be procurable from multiple sources and will be screened for improved reliability. The facilities of the NCS and DSIF will be used to create a computer network for common access to a central data base for network maintenance and logistics data which will improve the operating efficiency of the DSN.

W73-70736 **150-22-72**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
NETWORK CONTROL DATA PROCESSING
J. W. Layland 213-354-2757
(150-22-70; 150-22-71)

The objective of this RTOP is to develop the techniques necessary for the effective and efficient application of computational resources to the jobs of the DSN. Computational Complexity theory is extended toward the development of a yardstick against which to measure the effectiveness of task implementation within DSN computers. This same theory will be used to guide the study of resource allocation for the DSN Information Network, with the objective of defining an optimum structure, and of optimally sizing both the data transmission rates between elements of the DSN and the required computational capability at the DSN Tracking Station or Control Center. The allocation of data handling functions to software tasks and the allocation of tasks to processors within a computer network is also considered in this development. A technique is sought for the rigorous specification of complex software/hardware systems which will permit the implementation of such systems to be managed in a systematic and cost-effective manner. Alternatives in standardization of computer-based systems at the interface, software, or total hardware level are developed and an estimate is made of their impact on DSN logistics requirements. A programming support system is being developed on the Sigma 5 computer for development of Minicomputer software in a standardized real-time language. Primary emphasis is placed upon the portability of working software modules between dissimilar minicomputer, this helping to provide an alternative to total standardization of DSN computers. The design of a potential DSN Standard Minicomputer will be undertaken to determine the feasibility and desirability of providing a standard computer which can be procured to DSN Specification.

OFFICE OF MANNED SPACE FLIGHT

Advanced Development

W73-70737 **909-41-02**
Manned Spacecraft Center, Houston, Tex.
EOS/SPACE STATION - THERMAL CONTROL
James A. Smith 713-483-3676
(908-42-02)

Heat pipe systems offer promise for use in the thermal control of manned spacecraft because of their high heat transfer capability, near isothermal operating characteristics and passive thermal control features with resulting long life potential. Studies for space station thermal control systems in FY'70 resulted in identifying potential advanced concepts through the use of heat

pipes. It is the objective of this RTOP to provide a follow-on effort to perform in-depth testing and analysis on heat pipe applications defined from contract NAS 9-10436. Prototype fabrication and testing will be performed over the range of flight thermal environments experimenced by earth orbital spacecraft for large capacity heat pipe applications. The objectives of the analytical development are to pursue improved thermal analysis computer program techniques which make use of latest computer capabilities, development of thermal control systems performance subroutines, and upgrading thermal radiation and structural interface computational techniques commensurate with advanced systems analysis requirements. The approach to the thermal control analysis techniques development will be to make utilization of existing baseline thermal programs from which improved analytical capabilities can be developed. This approach insures preservation of program compatibility and is consistent with the generalized thermal program approach for all industry and NASA use

W73-70738 **909-41-07**
Manned Spacecraft Center, Houston, Tex.
EOS/SPACE STATION COMMUNICATIONS
H. J. Moorehead 713-483-4117
(977-41-07)

This RTOP covers (1) optimum digital modulation, (2) on-board command generation, and (3) color TV camera reliability improvement. (1) Projected communication systems will require the digital techniques of source and channel coding in order to operate effectively. In-house tests using the DTS (digital test set) developed under FY-71 RTOP funding have indicated certain optimization procedures that will be required to realize the theoretical improvements promised by digital communication theory. These procedures will be further investigated to establish specific parameters, after which modifications to the DTS will be designed and installed, giving the DTS a capability to further evaluate the techniques proposed. This will lead to a firm hardware base from which to specify spacecraft systems. (2) Shuttle and space station operations will involve other orbital vehicles and detached satellites. These will be controlled by commands generated on-board the parent ship. At present, there is no spacecraft equipment available, which is equivalent to the command generator in remote sites or the MCCH. Further, there may be a requirement for the spacecraft unit to operate with multiple formats. For this purpose a command generator with formats stored for rapid switching and verification is desirable This task will lead to the design of such a unit. (3) The present spacecraft color TV camera uses a mechanical color wheel to generate sequential color fields. This arrangement has limited lifetime and is subject to wear on long missions. It appears feasible to replace this mechanical arrangement with a solid---

W73-70739 **909-41-18**
Manned Spacecraft Center, Houston, Tex.
EOS/SPACE STATION CHECKOUT
A. E. Lightsey 713-483-5096

The ETC/LSS is a flight prototype model based on a six man crew with provision for variations in crew size from 2 to 6 men. The system is designed for an earth orbital mission with resupply of expendables and spares at 180 day intervals. It will be packaged within two 13 foot by 29 foot long test modules simulating modules of a shuttle launch space station. The ETC/LSS consist of three major functional groups; atmosphere revitalization, liquid heat transport, and water and waste management. One of the 13 x 29 foot test modules is utilized as a Control Center Module (CCM) and houses the Atmosphere Regeneration and Liquid Heat Transport group equipment. The second module simulates a Crew Quarters Module and contains the Water and Waste Management group equipment. The ventilation flow, which controls CO2, humidity, and trace contaminant concentrations is also being sized for two additional modules, the Experimental Module and the Habitability Module. The SSP flight prototype ETC/LSS will require a checkout tool and MSC Lab facility to fully evaluate and study the checkout techniques, control and monitor function and system concept of the ETC/LSS and its interfaces. All aspects of the ETC/LSS sensor requirements and signal conditioning, signal sample rates, control requirements, redundancy requirements, etc. will be analyzed. A detailed analysis of checkout participation in system start up/shut down sequences, expandable loading/unloading, checkout system/GSE interplay, redundancy control and inline/offline maintenance concepts will be evaluated. The ETC/LSS interface study will include signal description list, signal types, sample rates, operating limits and programmable limits requirements.

W73-70740 **909-51-02**
Marshall Space Flight Center, Huntsville, Ala.
THERMAL CONTROL
J. L. Vaniman 205-453-3821
(114-03-50; 124-09-28; 124-09-31)

The 3 tasks covered by this RTOP are directed toward providing technological solutions to thermal control problems introduced by new spacecraft requirements for long term high reliability operation in space for periods up to ten years. Long term tests of thermal control surfaces and coatings will be performed to provide resolution and circumvention of limited heat rejection capability imposed by radiation blockage of contiguously docked modules and by surface optical property degradation/contamination resulting from prolonged exposure to the space environment Heat pipe system studies and hardware development will be continued to assure efficient highly reliable long life thermal control system technology is available for module design. Studies to evaluate design techniques for radiation cooling of spacecraft electronics will be initiated. Projected time to complete the objectives of this RTOP is 6 years.

W73-70741 **909-51-04**
Marshall Space Flight Center, Huntsville, Ala.
SPACE STATION ATTITUDE CONTROL PROPULSION SYSTEMS
L. W. Jones 205-453-3814
(908-51-04)

This plan is to establish the attitude control propulsion system (ACPS) design operational methodology and component requirements to satisfy the manned space station requirements and demonstrate the necessary component, system and operational technology. This effort is necessary to provide the capability to meet the long duration and large impulse needs of the space station with a minimum of crew activity for refurbishment and resupply. These objectives will be accomplished by a logical sequence of requirements definition and analysis, component and system design and trade-off studies, and experimental demonstration of breadboard components and systems. The ACPS repair, resupply and maintenance contracts begun in previous fiscal years have been completed. The "Evaluation of the Trash Rocket Concept" task, which has examined the potential of the hybrid ACPS using nonfecal solid wastes as the fuel, will terminate, by recommendation of the EOST Guidance and Control Subpanel. Because of the limited amount of investigation top dated the trash rocket system has demonstrated potential for Space Station application, but is not yet sufficiently mature to be considered in future Space Station propulsion trade studies. During FY'73 it is planned to formulate new propellent grain compositions using 'Space Station Wastes'

and to test them for performance. Additionally improved ignition systems and techniques will be developed and tested.

W73-70742 **909-51-05**
Marshall Space Flight Center, Huntsville, Ala.
EARTH ORBITAL SYSTEMS ELECTRIC POWER TECHNOLOGY
C. B. Graff 205-453-4560
(908-51-05; 113-60-21)

This RTOP consists of 4 tasks, which will be separately summarized and discussed. Task 1 - Solar Array Stack Development : To investigate the nature of cell to cell and cell to substrate problems and to develop cell stack technology for Space Station application with highest reliability and longest lifetime including cell interconnection, bonding techniques, matrix design leakage and avalanche and thermal capacitance. Task 2 - Power Conditioning Analysis and Development : To bring power conditioning technology to the status where system tradeoff and selection can be made. Several areas of development technology are required in the field of electric power conditioning. Task 3 : Brayton Cycle Power Systems Tests - Continuation of effort. Primary FY 73 is to conduct engineering evaluation of inherent technology embodied LeRC Brayton BRU Systems. Task 4 - Switch Gear and Circuit Protected Development : To develop superior design concepts for high voltage DC (120 VDC) solid state switches, remote power controllers, improved electromechanical relays, power contactors, and circuit protection devices.

W73-70743 **909-51-07**
Marshall Space Flight Center, Huntsville, Ala.
COMMUNICATIONS
D. O. Lowrey 205-453-1578
(909-41-07; 974-41-33)

To develop an electronically steerable microwave phased array at S-Band capable of operating on earth orbital systems and other space vehicles. The array will provide a high data rate, telecommunications capability with simultaneous or separate transmit, receive and tracking functions. The narrow beam, high gain signal will automatically scan and track within a 120 degree cone. It will be capable of operating in either the retrodirective self-focusing or programmed mode. The active electronics modules of the array will utilize 100 percent microwave and digital integrated circuitry, and microcircuitry techniques to achieve high efficiency, wide bandwidth, long operating lifetime, small size, and light weight system. The array will contain all the electronic circuitry and antenna elements in an integral package to perform the transmit, receive and beam pointing control functions. High redundancy and graceful performance degradation will be achieved through the use of the individual electronic modules, each of which contains complete transmit, receive and logic electronics that are frequency coherent with a master frequency control module. Low power levels generated by each module are radiated by their individual associated antenna element to form the composite radiated signal. Techniques will be developed for production of microelectronic circuitry to achieve low cost modules. Empirical design equations developed for the active electronically steered phase array will be made available to aid in the design and development of active electronically steered phased arrays at higher frequencies.

W73-70744 **909-51-33**
Marshall Space Flight Center, Huntsville, Ala.
EARTH ORBITAL SYSTEM COMPUTING (IMS)
H. Garrett 205-453-4070
(908-51-33; 502-23-31)

The objectives of this effort are to perform research and development of advanced space computer hardware, software, and computer peripheral device technology. Also research and development of computer/scientist languages and interactions will be performed. This effort will lead to the development of an advanced space multiprocessor, a generalized software executive, advanced peripheral devices and programing techniques yielding high reliability programs. Included under this effort are research and development of advanced space computers, multiprocessors, and multicomputer systems, and the associated software; research and development of advanced computer peripheral devices such as display, history plotters, keyboards, hardcopy devices, and mass storage units will be performed; research and development of high level computer/scientist languages to facilitate man-machine interaction The research areas support future information management systems and data management systems such as those anticipated for the Space Station. During FY'73: Design of the SUMC Multiprocessor will be continued and development of the prototype unit initiated. Development of the Executative Software will be continued with completion of the First Generation Programs planned for late FY'73. Development of Higher Order Language Compiler and Controller Programs will be continued.

W73-70745 **909-71-21**
Langley Research Center, Langley Station, Va.
EXPLOSIVE WELDING FOR EARTH ORBITAL FABRICATION
C. H. Nelson 703-827-2893

The primary objective of this program is to apply the explosive welding technology conceived at NASA-Langley to accomplish fabrication requirements such as space station docking, assembly, and repair for Earth orbiting systems. This explosive welding concept is unique in that it uses relatively small amounts of explosive in a ribbon configuration to produce continuous, narrow, airtight welds. In addition, it has the physical flexibility to be molded to complex shapes. The approach for this effort would be to build on the initial in-house conceptual demonstrations to show the feasibility of using this welding concept on Earth orbiting systems, based on their particular mechanical and environmental requirements. In-house work would expand the explosive welding capabilities and initial contracted work would clearly define physical parameters of the welds, such as shear, tension, and fatigue properties.

W73-70746 **909-81-08**
Goddard Space Flight Center, Greenbelt, Md.
CONTROL COMPONENTS FOR EARTH ORBITAL SYSTEMS
H. E. Evans 301-982-5194
(908-71-08)

This task covers design, test and evaluation of prototype drive motors and speed reducer systems for Space Station support. Work includes establishing reliability through life testing programs. Where appropriate, new designs will be undertaken to meet Space Station control system requirements. Goals for this program are component and systems design that meet 10 years operation in the space environment. Initial efforts cover design, development, and evaluation of components for CMG spin motor and gimbal torquers utilizing brushless dc motor drives and unique speed reducing assemblies. Test programs will include simulated CMG loads, duty cycles, and load disturbances Electronic circuitry required to provide control over the duty cycle range will be designed and evaluated in a simulated space environment. Close coordination will be maintained with related efforts at LRC, MSFC and MSC to insure program compatibility.

W73-70747 **909-42-02**
Manned Spacecraft Center, Houston, Tex.
SPACE SHUTTLE THERMAL CONTROL
J. A Smith 713-483-3676
(114-09-31; 908-41-02)

The overall vehicle thermal management systems for the shuttle must be flexible and adaptable enough to accomodate changes in missions and configurations and must efficiently utilize available heat sources and sinks. The multi-mission requirement for the shuttle presents particular design problems in thermal control due to: (1) life-cycle considerations, and (2) the wide range of required operating conditions varying from those similar to conventional aircraft, to spacecrafts subjected to boost, orbital and reentry thermal conditions. The objective of this RTOP is to develop candidate thermal control concepts which offer potential solutions for shuttle design problems and develop improved analytical techniques for more effective design and evaluation. Heat pipe thermal control systems offer the potential for long life and trouble free heat transport and rejection at low weights for space shuttle equipment cooling applications. Design and testing of prototype thermal control systems applicable to the unique space shuttle environment and reuse applications will be pursued to provide thermal control design options for the shuttle vehicle. Vehicle complexity and use of advanced components requires improved analytical methods and extensive vehicle level analysis for design support and mission planning. The analytical techniques development program is directed towards developing computer programs for use as analytical tools for the shuttle program.

W73-70748 **909-42-07**
Manned Spacecraft Center, Houston, Tex.
SPACE SHUTTLE COMMUNICATIONS
W. E. Zrubek 713-482-3669

The Shuttle will be required to rendezvous with various spacecraft such as scientific satellites, sortie modules, the RAM, the tug, the Space Station, and disabled or powered-down vehicles. In each case, some form of rendezvous aid will be required. In some cases, a cooperative RF tracking mode can be established. In others, such as disabled satellites, the shuttle must derive rendezvous parameters on its own. This will require a noncooperative rendezvous radar. Two parameters are of interest in rendezvous activity - range and angle. The primary emphasis of this task will be to modify existing radar types (specifically Apollo) to allow them to operate in a noncooperative skin track mode and still have the capability for beacon tracking. Nonflight hardware will be used to demonstrate success of modifications, which will include increased RF transmission power and gain, reduced receiver noise, and changing to an interrupted CW mode. As a secondary task, techniques similar to those used on Gemini radar antennas will be investigated to provide angle tracking information. These techniques involve multiple flush mounted antennas forming an RF interferometer. However, where Gemini antennas rotated, the desired approach will use fixed antennas with the objective of minimizing the effects on Shuttle external structure.

W73-70749 **909-42-08**
Manned Spacecraft Center, Houston, Tex.
SPACE SHUTTLE - STABILIZATION AND CONTROL
K. J. Cox 713-483-3254

The objective of this task is to advance the conceptual development and technology of boost guidance and control systems for a class of launch vehicles (including the Space Shuttle). In particular, means to minimize the effects of wind disturbances on asymmetrical vehicles lateral dynamics will be sought. Investigations of liftoff control in the presence of severe ground winds, of lateral control, load relief, and dynamic stability in regimes of maximum aerodynamic pressure will be made. Wind statistics will be reviewed, and design concepts for utilizing a priori wind information will be developed.

W73-70750 **909-42-10**
Manned Spacecraft Center, Houston, Tex.
SPACE SHUTTLE - GUIDANCE AND NAVIGATION
K. J. Cox 713-483-3254

The objectives of this study are to identify what design factors contribute to an optimal sampling rate structure for digital flight control systems, and to develop techniques which can be utilized for the analysis of such systems. The digital control technology developed for Apollo will be extended to encompass control problems peculiar to the atmospheric flight regime with special emphasis on multi-rate sampled data techniques. The overall task will consist of a control requirements analysis, the establishment of structural response models, control system definitions and comparisons for uniform and multi-rate sampling, and development of techniques for evaluating stability margins in multi-rate sampled data systems.

W73-70751 **909-52-31**
Marshall Space Flight Center, Huntsville, Ala.
OPERATIONS, MAINTENANCE AND SAFETY
Henry E. Attaya, Jr. 205-453-1121
(908-52-46; 908-52-47; 908-52-37)

The objective of this RTOP is to provide the required technology for design, development and operation of the Space Shuttle (S.S.) in the following areas: (1) Cryogenics, (2) Upper Atmosphere Pollution Due SS Operations, and (3) Environment for Design, Test and Mission Analysis. This effort will provide consistent design criteria and concepts for efficient utilization and control of on-board cryogens; and will establish the data to insure minimum performance deviation of SS elements due to extended operational life and reuse. These will be accomplished through analysis, preliminary design and testing. This effort will also provide technology covering environmental design data requirements and guidelines in consistent engineering terms from the earth's surface to orbital altitudes for all elements, Government and industry, involved in development of the shuttle vehicle. This will be accomplished through environment models, test support planning operational analysis, environmental hazards environment, specific design study interpretation and definition and specialized/selective data acquisition. The established base for this effort must be continued to avoid costly errors on environment inputs to the SS development and its future operations. The work for FY'73 is a continuation of effort in FY '72 under RTOPs 908-52-37, 908-52-46 and 908-52-47.

W73-70752 **909-52-39**
Marshall Space Flight Center, Huntsville, Ala.
SPACE SHUTTLE AEROTHERMODYNAMICS
Werner K. Dahm 205-453-1092
(976-30-39; 908-52-39)

The objective of this RTOP is to provide support for the aerodynamic and thermodynamic development of the Space Shuttle vehicle. The tasks listed are of analytical and experimental nature. They involve the development of criteria and methods in those areas where adequate knowledge or prediction tools exist for the definition of aerothermodynamic environments or design values. The following items listed below have been selected because of their critical impact on the shuttle design: (1) Aerodynamic Study of Space Shuttle Vehicle Concepts, (2)

Shuttle Load Distributions, (3) Booster Staging Environment, (4) Ascent Base Heating, (5) Launch Configuration Shock Interference Heating, (6) Engine Plume Induced Effects on Ascent Aerodynamics, and (7) Booster Reentry Heating Studies.

W73-70753 **909-62-47**
John F. Kennedy Space Center, Cocoa Beach, Fla.
ENVIRONMENTAL QUALITY
W. H. Lee 305-867-3152
(909-62-31)

The objective of this work is to determine the effect of Space Shuttle exhaust on the ecosystem of the Kennedy Space Center and environs. The solid propellant vertical launch assist rocket and the turbojet horizontal flight engine exhaust products include hydrogen chloride, carbon monoxide, unburned and chlorinated hydrocarbons, carbon dioxide, hydrogen, water and other vapors and gases, and aluminum oxide and other particulate matter. Some will react with each other and the atmosphere producing other compounds. They will eventually fall to the earth's surface or become dispersed in the atmosphere. Their environmental fate and effect must eventually be determined. The initial concern is for hydrogen chloride gas. Its toxic effect on humans is well-known and exposure limits are established; however, this is not so for other significant species of the ecosystem. The technical approach is the straight-forward application of life sciences standard toxic effects determination methods by a systematic program of controlled exposures (time and concentration) of live specimens from the ecosystem to exhaust products of concern. The management approach is to establish a working arrangement among elements of public and private institutions having locally available capabilities in biology, toxicology, bio-chemistry, and ecosystem effects analysis.

W73-70754 **909-72-31**
Lewis Research Center, Cleveland, Ohio.
SHUTTLE CRYOGENIC TECHNOLOGY
J. R. Barber 216-433-6441
(180-31-51)

The work conducted under this RTOP will provide the technology required for the effective design and fabrication of cryogenic thermal protection and storage systems for the Space Shuttle Vehicle. This work will be conducted on storage systems designed to meet the problems of ground hold, launch ascent, reentry through the earth's atmosphere, and reuse. The use of internal, gas barrier type insulation will be evaluated for the ascent tanks. Work on a unique self-evacuating multilayer insulation system concept will be continued, for the particular requirement of the on-orbit LH2 tank of the orbiter. Rigid vacuum jacket concepts will also be studied for this application. As part of the cryogenic storage work, efforts will be conducted to evaluate the use of composite materials for the fabrication of plumbing lines, both uninsulated and vacuum-jacketed. System designs will be evaluated to provide lines that are light weight, have low heat flow, and show improved flow quality vs. time parameters when compared to all-metal lines. In addition to the storage system work, investigations will be conducted on zero and reduced-gravity fluid behavior as applied to propellant orientation, propellant transfer, heat transfer phenomena and interface control utilizing surface energy forces.

W73-70755 **909-72-47**
Langley Research Center, Langley Station, Va.
SHUTTLE SONIC BOOM STUDIES
C. H. Nelson 703-827-2893
(117-07-01)

The work under this RTOP will provide a firm technology basis for understanding of Shuttle sonic boom signatures. Existing sonic boom technology, as developed for aircraft, applies primarily to steady, level flight of high fineness ratio vehicles at low angles of attack at altitudes of less than 100,000 feet, and at Mach numbers less than 3.0. The Shuttle's unique characteristics of relatively low fineness ratio vehicles at large attitudes, steadily decelerating from an altitude of about 400,000 feet with initial Mach numbers in excess of 25, establishes the need for a concentrated technology development program to provide the means of obtaining realistic predictions of Shuttle boom signatures. Once this capability is available, operational studies will be conducted to define techniques for alleviating the overpressure levels and/or controlling the location of the boom footprint within restricted areas. Detailed analysis of sonic boom signatures obtained during Apollo 15 and 16 missions and comparisons with preflight predictions will aid in the development of prediction capability for Shuttle and verification of the prediction techniques. Additional, more detailed, measurements will be obtained during the Apollo 17 mission. Controlled studies of the overpressure characteristics in foci or caustic regions will be conducted to increase the basic understanding of the focal region occurring during Shuttle ascent.

W73-70756 **909-72-48**
Ames Research Center, Moffett Field, Calif.
SPACE SHUTTLE: FLIGHT INVESTIGATION OF ORBITER HANDLING QUALITIES DURING APPROACH AND LANDING
Leonard Roberts 415-965-5066

NASA is developing a handling qualities criteria for manual control of the Space Shuttle Orbiter during the terminal area, approach and landing phases of flight. The NASA operating centers have defined a requirement for the orbiter to be manually controlled with a minimum SAS. To meet this requirement, it becomes necessary to investigate and define the minimum acceptable vehicle handling qualities during atmospheric flight phase. The program required to satisfy this need includes analysis, simulation and flight test. In FY 72, an analysis and simulation were conducted in-house to aid in development of handling qualities criteria. The procurement of the SSV-Flight Test System (SSV-FTS) to be installed in the NASA CV-990 aircraft for simulation of the SSV orbiter, will be completed by July 1972. The program for FY 73 uses the CV-990 to study the handling qualities of several candidate vehicle and control system configurations. For these studies, the shuttle trajectory, displays and performance from 40,000 ft to touchdown will be duplicated as closely as possible by the CV-990 aircraft. The SSV-FTS will provide the variable stability capability required to investigate the orbiter handling qualities.

W73-70757 **909-44-02**
Manned Spacecraft Center, Houston, Tex.
SPACE SYSTEMS - THERMAL CONTROL
W. W. Guy 713-483-2351

The objective of the proposed effort is to develop a modular, self-contained, inflatable radiator system that can be easily deployed in orbit from standard docking ports in order to minimize radiator area availability problems of future spacecraft. The approach will include an analytical investigation and a feasibility test of candidate inflatable radiator concepts. This effort will utilize the technology base established by Echo balloons and other inflatable structures to develop a lightweight, inflatable radiator system.

W73-70758 909-44-04
Manned Spacecraft Center, Houston, Tex
SPACE SYSTEMS ATTITUDE CONTROL PROPULSION
Henry O. Pohl 713-483-4971

The objective of this RTOP is to investigate key areas of propulsion systems technology in which new data and discoveries have major payoff potential in future space system attitude control systems programs. The programs comprising this RTOP are focused on advancements in propulsion materials technology and on advancements in analytical capabilities. Both of these areas, historically, have been pacing items in the advancement and success of major propulsion programs. In the analytical area, a program will be initiated to extend and improve computer programs for transient RCS engine analyses In the materials area, programs will be initiated to study N204 corrosion inhibitors, to study metal nitride formation inhibition in monopropellant hydrazine engines, and to parametrically study high temperature oxidation resistant coatings durability for amine/N204 bipropellant engine applications.

W73-70759 909-44-07
Manned Spacecraft Center, Houston, Tex.
SPACE SYSTEMS COMMUNICATIONS
J. G. Sheppard 713-483-2871
(977-41-07)

This RTOP covers work in two areas: communication through K-band relay satellites, and spacecraft TV. Existing techniques for communication using high gain antennas (which would be required to operate through a relay satellite at K-band) place transmitters and receivers at considerable distance from the antenna feed. At K-band, this causes intolerable cable losses. Therefore, it is desirable to locate the transmitter and receiver directly on the antenna. In space application, this will expose these units to the rigors of an uncontrolled environment. This task will investigate techniques for packaging, thermal control, and remote tuning that will allow the transmitter and receiver to be integrated directly with the antenna. The components used will be the K-band power amplifier and parametric amplifier receiver developed at GSFC. The resulting subsystem will be incorporated into the CTB (communication terminal breadboard) being supplied by the space station phase B contractor for evaluation in a complete system. Spacecraft TV system requirements continually evolve, generating requirements for new techniques. This RTOP will address (1) high frame rate field sequential color TV techniques which will allow on-board closed circuit color TV without scan conversion, but which will be flicker-free, (2) a new digital TV transmission technique (nonlinear delta modulation) that shows promise of reducing transmission equipment (transmitter power, antenna size, etc.) requirements. Corona has been a significant problem on all space programs. In general, specialized recommendations are scattered among much misinformation in the technical literature. This task will compile a report delineating general solutions using good techniques excerpted from the literature.

W73-70760 909-44-10
Manned Spacecraft Center, Houston, Tex.
ADVANCED GUIDANCE AND NAVIGATION STUDY
T. Murtagh 713-483-4366

This study will investigate the following guidance and navigation areas: (1) Strapdown failure detection and redundancy management; (2) Impact of sensor placement on a space vehicle; (3) Develop software for measurement determination and navigation alinement and calibration, including filter mathematics; (4) Investigate single explicit guidance algorithms; (5) Examine state-of-art in orbit determination, including ephemeris math models and navigation filters, and recommend improvements. (6) Determine all error sources in the navigation of a winged or lifting spacecraft during approach and landing and apply general results to the typical Shuttle flight profile; (7) Deliver an analytical program for conducting navigation error studies, (8) Determine the error sources in defining navigation data during atmospheric flight of a lifting vehicle, such as drag and lift-to-drag ratio, and deliver a program which is applicable to navigation, guidance, and control during ascent and entry flight.

W73-70761 909-44-12
Manned Spacecraft Center, Houston, Tex.
SPACE SYSTEMS DISPLAYS
John C. Peck 713-483-4061

The objective is to further the development of a light emitting diode matrix display that can replace present CRT displays and provide superior display characteristics for a better man/machine communications interface. LED matrix display technology has the potential for providing general-purpose displays for many applications but the technology needs to be further advanced. Presently, special purpose LED display readouts are being used on the Skylab program for the event timers and for other one-line numerical displays Larger LED matrix displays of about 45 square inches have been flight tested as helicopter radar displays. General-purpose LED matrix displays have been developed in the laboratory with up to 1600 elements providing a resolution of 10 lines/inch. This background information illustrates that LED displays have the inherent ruggedness and reliability needed for spacecraft application, but their application as general-purpose matrix displays requires an improvement in their resolution. The approach of this RTOP is to sponsor an investigation into ways of improving the resolution and the development of a prototype model that has sufficient resolution for displaying a 1/4 inch alphanumeric character legibly. In the following years, this development would be extended to obtain even better resolution and a larger general-purpose display with a display surface of about 8 in. by 10 in. Such a device coupled with the LED's advantages of brightness, small volume, low voltages, and extreme ruggedness will provide an exceptional display for future spacecraft.

W73-70762 909-44-13
Manned Spacecraft Center, Houston, Tex.
SPACE SYSTEMS - INSTRUMENTATION
P. E. Sollock 713-483-2688

Space environment simulation plays a significant role in today's space programs. As space vehicle designs become more complex and spacecraft mission durations increase, space simulation facilities are faced with many stringent cleanliness requirements. A major concern of many experimentors is the contamination of ultrasensitive experiment components, viz. optical systems, thermal control coatings, etc. Although an extensive effort has been undertaken at MSC to measure, identify, and control contaminants in the past, it is now necessary to update and advance the technology in this area. An analytical study will be performed to define (1) specific math models of molecular flow in MSC's thermal-vacuum chambers, (2) new molecular contamination measurement techniques, (3) new methods of chamber contamination control and cleanup, and (4) the effects and new measurement techniques for particulate contamination. 'Proof of principle' hardware will be fabricated (where necessary), tested, and evaluated in the MSC laboratories. At the completion of these efforts, new analytical tools, improved contamination measurement equipment, and new knowledge of specific contamination effects will be available to insure that MSC's space environment simulation facilities meeting the minimal cleanliness requirements for future tests

W73-70763 **909-44-33**
Manned Spacecraft Center, Houston, Tex.
SPACE SYSTEMS INFORMATION MANAGEMENT SYSTEM
E. A. Dalke 713-483-4065

A relatively large number of present and future onboard systems and payloads require processing a variety of measurements or handling diverse types of data. The quantity under measurement may require spectral or time/frequency domain analysis and be of such high bandwidth as to preclude the use of onboard information management, and evaluation of data conditioning, compression, and processing hardware which could provide an efficient and practical transition from the high frequency experiment signals into useful digital data for experiment checkout, monitoring, and control by the IMS system. An in-house study will determine, using a representative set of experiments, areas in which the application of special purpose data handling equipment capable of providing an efficient transition from high frequency data to information only data will result in reductions in cost, power, weight, and volume of the overall onboard data systems. The in-house study will provide a functional comparison of the overall data flow from sensor to user with and without special purpose processing equipment to demonstrate the advantages of the former approach. Design requirements for the onboard special purpose processor will be generated and a contract awarded for the design and demonstration of the breadboard model.

W73-70764 **909-44-35**
Manned Spacecraft Center, Houston, Tex.
AVIONICS COST MODEL
Joseph Fuller 713-483-2741

The objective of this plan is to enhance MSC's capability to develop cost and scheduling relationships for advanced avionics subsystems. The approach is to: (1) develop an avionics data base of historical cost, schedule, and technical performance characteristics which are capable of producing statistical inferences for future hardware developments; (2) use the data base developed for each subsystem in determining relationships between cost, schedules, and readilyknown parameters, such as desired technical performance characteristics; (3) perform cost and schedule sensitivity analysis over state-of-the-art and advanced (expected) performance ranges for each subsystem; and (4) verify the validity of cost and schedule estimating techniques developed with an example from each subsystem family, within the relevant performance ranges mentioned in (3).

W73-70765 **909-44-38**
Manned Spacecraft Center, Houston, Tex.
SPACE SYSTEMS - MATERIALS
H. F. Kline 713-483-5539

The objective is to develop an organized method of utilizing information obtained from the examination of materials which have been exposed to space aging environment. This information should assist in predicting the life of nonmetallic materials similar in structure; in continuing the work of NAS 9-11611 (Development of Specification to Evaluate Elastomers Relative to Aging Resistance); and in developing new and novel methods of material degradation testing. A systematic method of testing, classifying and recording aging data will be established. Flight hardware from Apollo program will be dismantled and tested. The program will relate changes of the material to similar changes on new materials of the same formulation obtained by accelerated aging tests. The objective of this RTOP task is to develop a design handbook and guidelines which can be used to minimize contamination problems due to outgassing of materials. One of the primary functions of shuttle will be to deliver experiment packages into earth orbit. In order to accomplish such a task successfully, contamination of the experiments by the shuttle vehicles and the experiments themselves must be minimized. This can best be accomplished by providing to the design engineer ground rules and methods for evaluating and using outgassing data as well as providing access to extensive listings of outgassing data.

W73-70766 **909-44-41**
Manned Spacecraft Center, Houston, Tex.
SIMULATION TECHNIQUES FOR ADVANCED AVIONICS SYSTEMS
A. G. Nolting 713-483-5121
(970-53-10)

The goal of this Research and Technology Operating Plan is to provide a comprehensive set of avionics simulation requirements for an interim functional simulation and the Shuttle Mission Simulator. Efforts will be directed toward evaluating alternatives, e.g., simulation techniques, simulation computer complex configuration, and establishing the requirements for the computer systems and programs for the Shuttle Mission Simulator. The data generated is required early during the Shuttle Phase C effort to influence crew station design and for the early development of simulators and software programs to be used for crew training.

W73-70767 **909-44-42**
Manned Spacecraft Center, Houston, Tex.
CREW PROCEDURES DEVELOPMENT TECHNIQUES
Paul C. Kramer 713-483-3291

The major study objective is to develop a digital computer program to interface flight procedures documentation with man-in-the-loop simulators. This computer program will enable definition, verification, and modification of flight procedures more efficiently than has been possible for the Apollo and Skylab programs. The procedures development program will be used for the following: (1) To produce step-by-step crew timelines directly from simulation runs. (2) To compare actual procedures used during simulator runs with desired procedures stored in computer mass memory. (3) To evaluate, create, and modify crew displays on multi-purpose CRT's. Each crew action to be documented will be defined and identified by NASA approved nomenclature. Other significant procedural factors, such as day-night cycle and tracking station coverage will also be determined and a data format defined which meets procedures documentation requirements. A software program which extracts and records the desired data during simulation runs will be developed. This program will also arrange the data in the desired format and include the capability to produce hard copes. The program will be completely documentated with flow charts and program listings, and a user's manual will be provided.

W73-70768 **909-44-42**
Manned Spacecraft Center, Houston, Tex
SIMULATOR CONFIGURATION, CHECKOUT AND OPERATION
Paul C. Kramer 713-483-3291

The objective of this study is to develop a series of software programs for man-in-the-loop simulators that will provide the techniques for definition, verification and modification of flight procedures and simulator hardware and software. Task 1 - Crew Procedures Development Techniques - This task develops a computer program which will enable definition, verification and modification of flight procedures more efficiently for future manned space flight missions than has been possible in the past. Task 2 - Simulator Software Verification Techniques - This

task develops design methods/techniques that permit rapid verification (self-test) of the simulation hardware and techniques that verify accurate simulator representation of flight vehicle responses, displays, sequencing timing, etc. Task 3 - Development of Simulator Change Control System - This task will develop a documentation system and associated update procedures for using a spacecraft contractor's documentation system as the data source for design and development of a large scale simulator. Task 4 - Automation of Simulator Configuration Control - This task develops the methods for computerizing and controlling the configuration documentation of large-scale simulators to improve configuration control and reduce manpower requirements.

W73-70769 **909-44-42**
Manned Spacecraft Center, Houston, Tex.
DEVELOPMENT OF AUTOMATED SIMULATOR CHANGE CONTROL SYSTEM
Charles C. Olasky 713-483-3421

The goal of this RTOP is to investigate and develop methods for minimizing the manpower requirements inherent with the task of change (configuration) control for large-scale simulators. This study will be divided into two basic tasks: TASK 1 - This task will examine the area of simulator documentation systems and associated update procedures for defining and maintaining a simulated flight vehicle definition. The documentation systems associated with the spacecraft and spacecraft simulators have represented a significant bottleneck in efficient simulator development. It is assumed that little will ever be done to change a spacecraft contractor's system to benefit a simulator design. Therefore, this task would assume a specific spacecraft contractor's documentation system to be the data source for a simulator and subsequently develop a responsive simulator contractor documentation system. A series of test cases based on change control problems encountered during the CMS, LMS, and SLS development would be used to verify the developed system. The end product of this task would be a study report including a procedures document describing the new system. TASK 2 - The goal of this task is to develop methods for centralizing, computerizing and controlling the configuration documentation of large-scale simulators for the purpose of improving configuration control with reduced manpower requirements. This study would define levels of documentation control, computer tasks, human tasks, data base requirements, input-output methods, computer-to-computer data base exchanges, scheduling system, and provide a cost effectiveness analysis.

W73-70770 **909-74-03**
Lewis Research Center, Cleveland, Ohio.
SMALL HIGH SPEED BEARING TECHNOLOGY
W. A. Tomazic 216-433-8358
(502-24-31)

The objective is to develop and demonstrate the technology for small high speed bearings (approximately 20 mm diameter and 120,000 rpm). Such bearings are required for use in hydrogen pumps of small, highly efficient and versatile staged-combustion hydrogen-oxygen rocket engines which must operate reliably in a space environment for long periods of time and over many duty cycles. The contract effort will be carried out in two phases. In Phase 1, the contractor will design, build and test rolling-element type bearings. These bearings will be designed using the best available information, to meet the conditions prescribed for use in a space tug engine, including long-life capability (10 hours and 300 starts). The retainer design is particularly critical in these small bearings. To further improve the life expectancy of these advanced conventional bearings, Phase II will incorporate the best Phase I bearing into a hybrid design, which combines the rolling-element and hydrostatic principles.

W73-70771 **909-74-33**
Langley Research Center, Langley Station, Va.
EVALUATE REALISM OF MANNED ACTIVITY SCHEDULING SYSTEM (MASS) IN SKYLAB MISSIONS
C. H. Nelson 703-827-2893

A cooperative effort between LRC and MSC is currently underway where the LRC Manned Activity Scheduling System (MASS) will be used to support the 56-day SKYLAB Medical Experiments and Altitude Test (SMEAT). LRC will use the MASS to conduct crew activity analyses and to generate crew activity timelines for MSC. In turn, LRC will receive valuable mission experience which is directly related to the in-house support of the Shuttle compatible Advanced Technology Laboratory. In-house and contractural efforts will continue to improve the LRC MASS to make it a more realistic and useful tool for mission planning and operations analyses.

W73-70772 **909-74-35**
Langley Research Center, Langley Station, Va.
SOLAR CELL ENERGY WHEEL SYSTEM FOR SPACE VEHICLE APPLICATIONS
C. H. Nelson 703-827-2893

This work will establish the feasibility of a Solar Cell Energy Wheel System (SCEWS) that can perform the dual function of power generation and attitude control for a broad range of spacecraft and missions. Initial efforts will define SCEW system and component design goals and will investigate the impact of spacecraft integration on SCEW system design. Analyses and simulations will be conducted to determine the system power generation and control capability, to generate component performance specifications compatible with vehicle/mission requirements, and to verify component designs and integration of systems. System hardware which cannot be developed within state-of-the-art technology will be identified, and design and breadboard hardware development efforts will be carried out to assure the SCEWS concept feasibility and practicability. If the SCEWS concept proves viable, laboratory prototype SCEWS hardware will be built and evaluated using existing LRC static and dynamic test setups. Associated development programs will be directly coordinated with LeRC, GSFC, MSC, and MSFC. Primary problem areas include the impact of reliability, safety, maintainability, failure modes, and system integration on SCEWS weight tradeoffs; performance limits of composite materials under cyclic stresses and extended-duration vacuum; development of bearings and seals capable of long life under large cyclic loads; development of high-power, efficient spin motors and generators; development of high-torque, low-rate gimbal actuators; and development of gimbal sensors with high resolution and accuracy. Solutions to these problems will be verified through simulation and hardware tests, which will determine power generation capability, control effectiveness, and spinup-spindown cycling effects on system performance. Successful completion of this program would permit major weight and volume savings for a broad range of spacecraft.

Space Life Sciences

W73-70773 **970-21-11**
Ames Research Center, Moffett Field, Calif.
NEUROPHYSIOLOGY
H. P. Klein 415-965-5094

The objectives are to investigate and evaluate effects of exposure to the space environment on neurophysiological processes in man, with emphasis on visual functions; to provide for the development of practical procedures for in-flight as well as preand post-flight evaluation of these variables, and whenever inevitable temporary disturbances are expected; and to provide adequate compensatory measures. The effects of unusual gravitational forces on dynamic visual accommodation (focusing) will be investigated by: (1) utilizing the SRI-Ames Optometer to measure the accommodative function under bedrest conditions, and (2) developing and utilizing a space-rated modification of the SRI-Ames Optometer for use in flight. The effects of motion sickness on the limits of peripheral vision and on visually-based orientation will be investigated using the rotational facilities of USN-AMI, and test equipment and data-analysis facilities at ARC; real-time analysis techniques will be developed for the on-line measurement and control of the extent of induced motion sickness. The capability for pursuing a program of sophisticated measurements of visual function during space flight will be developed in the Human Vision Space Flight Experiment (T-006) and will provide a comprehensive series of tests of visual functioning with the related equipment consolidated into a single vision tester.

W73-70774 **970-21-12**
Ames Research Center, Moffett Field, Calif.
CARDIOVASCULAR-PHYSIOLOGY
H. P. Klein 415-965-5094

The objectives of this program are to describe and understand the course of adaptation of the cardiovascular system to space flight conditions and its readjustment to normal gravity upon re-entry to the earth's environment. In order to accomplish this the response of the human cardiovascular system will be determined during the various factors and stresses associated with manned space flight. Work will be conducted in both animals and man. Human studies will be conducted using non-invasive methods. Animal studies will be performed in appropriately instrumented chronic animal preparations suitable for use in future space flight experiments. Animal models (dogs and/or chimpanzees) are being created to assess central (heart and lung) and peripheral (arterial and venous) cardiovascular function. Similar studies are being conducted in humans subjected to bed rest simulations of weightlessness. Studies to date have demonstrated that both central and peripheral vascular mechanisms are contributing to the altered orthostatic response after bed rest or associated with the decreased tolerance to acceleration profiles known to occur and anticipated for future space flights.

W73-70775 **970-21-13**
Ames Research Center, Moffett Field, Calif.
RESPIRATORY PHYSIOLOGY
H. P. Klein 415-965-5094

It is predicted that pulmonary function changes significantly in weightlessness. The objective of this program is to determine the magnitude of certain of these changes and determine their effects on the ability of man to adjust successfully to long duration spaceflight and to readjust to normal gravity subsequent to such a mission. In addition, the part played by gravity in determining pulmonary function on earth will be examined to obtain baseline data and improve the predictions which can be made regarding the changes expected in weightlessness. The functions being measured are lung volumes, oxygen and carbon dioxide washout, regional perfusion, regional ventilation, total ventilation, ventilation/perfusion ratio for whole lung and different regions, pulmonary diffusing capacity, mixed venous CO2 tensions, pulmonary blood volume and cardiac output. In the area of aerosol deposition, where significant changes are also expected, experiments will be carried out under high and zero gravity conditions to confirm the predicted changes in deposition in the lung from the larger particle sedimentation factor. Approaches include investigations to determine the effects of gravity on normal human lung, with particular reference to mechanical deformation and its effects on pulmonary function; continued work on baseline data required for the ground controls for a future flight experiment; feasibility demonstrations for hardware systems later to be converted into flight systems; and aircraft parabolic flight experiments to evaluate aerosol deposition changes under varying g loads.

W73-70776 **970-21-14**
Ames Research Center, Moffett Field, Calif.
METABOLISM AND NUTRITION
H. P. Klein 415-965-5094

Major emphasis is placed on the development of an integrated program on general metabolism and nutrition within the framework of the Biomedical Research Division The goals are directed towards obtaining a greater understanding of the regulatory processes required for maintenance of vital functions and from which heat and energy for muscular activity is derived. Approaches are oriented towards ultimate applications to human maintenance diagnosis, prevention, and physiologic factors bearing on mission safety requirements with special emphasis on the effect of acceleration environments. Research is conducted in carbohydrate and fat metabolism; calcium metabolism and factors influencing the physical integrity of bone; work performance, heat production, and temperature regulation; water and electrolyte metabolism; liver function tests; and remedial measures to offset effects of adverse acceleration environments. Researches are performed through simulation studies with experimental animals and human test subjects. Research is conducted in-house and on a contract and grant basis. Animal restraint and bed rest will be used to investigate hypogravic environments; centrifuges will be used to evaluate high g profiles. Flight opportunities will be sought to verify theory with experimental findings.

W73-70777 **970-21-16**
Ames Research Center, Moffett Field, Calif.
ENDOCRINOLOGY
H. P. Klein 415-965-5094

The general objective is to define more precisely the endocrine mechanisms which mediate the physiological responses and adaptations encountered in prolonged space flight. Research will be primarily directed to the analysis of the endocrine mechanisms regulating protein, lipid and mineral metabolism. Emphasis will be placed on the development of biochemical methods for assessing the endocrine status of subjects exposed to prolonged space flight with particular reference to the effects of real or simulated weightlessness and of variable g-forces. The specific approaches to be employed are as follows: (1) the quantitative determination of the levels of circulating pituitary and other peptide hormones in plasma: (2) the analyses of the spectrum of tissue peptidases involved in the conversion of peptide hormone precursors into biologically active hormones as well as their involvement in regulation of the biologically active concentrations of pituitary and other peptide hormones; (3) analysis of the effect of variable g-forces on the plasma concentrations of peptide hormones and their resultant effects on protein, lipid and mineral metabolism; (4) evaluation of radiorespirometry as a tool for assessing the endocrine-dependent metabolic status of the whole animal; (5) analysis of endocrine-dependent enzymes involved in lipid metabolism and transport, and (6) the elucidation of the effect of varying brain serotonin

levels on responsiveness of the pituitary adrenal system to stress.

W73-70778 **970-21-17**
Ames Research Center, Moffett Field, Calif.
COUNTERMEASURES
H. P. Klein 415-965-5094

Research will be continued to determine the effectiveness of candidate techniques to prevent or correct deteriorative physiological changes induced by space flight, primarily in the cardiovascular, musculoskeletal and body fluid disbribution areas. This research will emphasize gradient positive pressure, programmed Valsalva maneuvers, skeletal compression and combinations of these as candidate techniques which may preclude the possible requirement for spacecraft artificial g on future long duration missions. A concept will be developed, hardware manufactured and tested for an oscillating platform to impose intermittent inertial forces to the cardiovascular and musculoskeletal systems, the purpose of which is to maintain normal equilibrium in these systems during bed rest and eventually in orbiting systems.

W73-70779 **970-21-25**
Ames Research Center, Moffett Field, Calif.
CHEMISTRY AND MICROBIOLOGY
H. P. Klein

This program has as its objective the definition and study of potential microbiological and biochemical problems of manned space flight. Studies will be directed to examine and assess alterations between man and his microflora in the spacecraft environment during manned space flight, especially as they may adversely affect astronaut health. Research will be oriented toward a number of parameters concerned with virulence of microorganisms, immunity to infection, rapid diagnosis of the infected state, measures to prevent or limit infectious disease, microbial shock and mutational effects as related to manned space missions. The overall approach will be to study the mechanism of responsibility for undesirable or hazardous changes in the host parasite system in a spacecraft environment, mainly by a continuation and expansion of grants to universities plus specific in-house efforts.

W73-70780 **970-21-35**
Ames Research Center, Moffett Field, Calif.
ENVIRONMENTAL FACTORS EFFECTS
H. P. Klein 415-965-5094

The objective is to determine effects of various environmental factors (atmospheric contaminants, dysbarism, weightlessness and plus G sub z in relation to human performance in space flights Cellular consequences as well as physiological effects will be studied. Human, particulate induced pathology, will be studied as a point of reference with respect to the state of damage which may occur in astronauts. Correlations will be made between morphological alterations and physiological changes caused by agents contaminating the atmosphere. Extent of damage and reversibility will be established using ultrastructural morphology as an endpoint. The greater risk of dysbarism in presently planned atmospheres requires investigations into preventative or remedial techniques. To this end, nitrogen scavenging compounds are being developed which will remove nitrogen from tissues and blood. Design limitations predicate that crew and passengers on space vehicles will be subjected to weightlessness for considerable periods of time during space flights. Tolerance of humans after varying periods of simulated weightlessness will be determined under medically controlled conditions. The effects of weightlessness and reentry profiles from the weightless state will be ascertained in a wider variety of subjects as may be candidates for passengers in the shuttle.

W73-70781 **970-21-45**
Ames Research Center, Moffett Field, Calif.
MEDICAL SUPPORT
H. P. Klein 415-965-5094
(970-21-14)

The objectives of this program are to study environmental influences on the efficiency of specific drugs likely to be used during manned space flight. Emphasis will be placed on determining adverse or beneficial reactions because of altered absorption or metabolism of the drug in the space environment or because of specific synergistic or antagonistic effects of the drug to physiological changes produced by weightlessness and other flight factors. Work will focus on xylocaine, on the interaction of caffeine with amphetamine or amphetamine/scopolamine and on aspirin. The interaction of aspirin with the increased CO2 levels of the space cabin environment will be evaluated by changes in blood acid-base balance, blood and urinary electrolyte balances and bone mineralization. Interference of all drugs tested with routine physiological measurements such as electrolytes and corticosteroids will be assessed.

W73-70782 **970-21-51**
Ames Research Center, Moffett Field, Calif.
HUMAN BEHAVIOR AND PERFORMANCE
H. P. Klein 415-965-5094
(970-21-52)

The objective of this research is to determine the effects of environmental variables characteristics of space man's performance as a systems manager and crew member. Research will be conducted on classes of behavior, likely to be affected by the space environment, specifically, alertness, information acquisition, decision processes, communication and cooperation with other crew members. Laboratory and field studies will be conducted, which explore new methods of maintaining individual and social behavior under conditions approximating space flight. This will involve manipulation of communication patterns, cooperative work, incentive programming and contingency management. Selection versus behavior maintenance approaches to insuring long-term performance will be investigated.

W73-70783 **970-21-52**
Ames Research Center, Moffett Field, Calif.
BEHAVIORAL PHYSIOLOGY
H. P. Klein 415-965-5094
(970-21-53)

The objectives of this program are to establish in animals the brain mechanisms that regulate biologic rhythms and behavior and to apply this information via experiments in man to solving specific spaceflight related problems of behavior, performance and social interaction. These objectives will be achieved by studying in rats and subhuman primates, the central nervous system mechanisms controlling behavioral rhythms by brain electrical stimulation, by alteration in food consumption, feeding time and food composition, and by changing the set-point of the biologic clock by use of noxious stimuli or drugs. Experiments in man will include studies of sleep-wake cycles and sleep deprivation in a time free environment; correlating consumption of specific foods with serotonin systhesis, sleep, alertness and body temperature; determining the thresholds of light intensity necessary to maintain circadian rhythm synchrony in man and whether this threshold is altered by simulated weightlessness (bedrest); and quantitating the changes in gross behavior, performance, social interaction and sleep previously observed in prolonged bedrest.

W73-70784 **970-21-53**
Ames Research Center, Moffett Field, Calif.
SENSORY SYSTEMS AND NEUROBEHAVIORAL STUDIES
H. P. Klein 415-965-5094

The objective of this work is to increase our knowledge of postural and orienting mechanisms--especially their reactions to unusual environmental forces. This information will be applied in the evaluation, prediction and control of the adverse effects of the unusual high and low g forces and unusual linear and angular accelerative forces encountered in extended space missions. Particular attention will be paid to visual vestibular, and proprioceptive (muscle feedback) systems, their interactions, and their relationships with the general mechanisms underlying sleep and wakefulness. Descriptive studies will define the effects of altered gravity on neurophysiological function and behavior, orientation, sensorimotor coordination, postural control and locomotion. Analytical studies will be devoted to the understanding of the neural processes involved in gravity reception and response, thresholds for detecting changes in acceleration and rotation, and the rate and level of adaptation to chronic exposure to altered gravity. Neurophysiological and neurochemical studies will address the mechanisms which underlie levels of sleep and arousal, attention, alertness, and motivation. The behavioral aspects of maturation and development will be investigated with emphasis on the effects of chronic exposure to levels above and below earth gravity. In addition, work on the mechanisms of complex orientational capacities in man and animal will also receive attention. Other sensory systems such as those serving auditory and cutaneous (tactile, thermal, and pressure) sensibilities will be investigated as necessary in support of flight experiments and in developing basic information relevant to remotely operated systems.

W73-70785 **970-21-61**
Ames Research Center, Moffett Field, Calif.
REGULATORY BIOLOGY
H. P. Klein 415-965-5094
(970-21-62)

The objective is to establish the mechanisms of functional adaptation of living systems when influenced by space flight variables. Functional variations, and their inherent mechanisms, will be studied in plant and animal systems at various levels of biologic organization. The research within the scope of this RTOP is related to the quantitation and delineation of the biochemical, anatomic and physiologic changes in organisms exposed to altered gravity. Representative biologic species, both plant and animal, at different levels of biologic organization must be used, comparatively, to determine the influence of altered gravity on major biologic functions. Changes in gravity will be introduced by such means as acceleration (centrifuge), gravity compensation (clinostat), etc. Observations will be made of morphologic changes, of modified biochemical pathways and of changes in specific physiologic function consequent to changes in body functions likely to be manifest. A significant part of this effort is related to an elaboration of the regulatory factors in homeostatic adaptation to and deconditioning from the metabolic stresses associated with a change in the gravity field. The mechanism(s) of graviperception are most important. Thus, a comprehensive, quantitative knowledge of the unique responses of a variety of living systems to space flight factors will afford valuable insights into the biologic aspects of manned space flight.

W73-70786 **970-21-62**
Ames Research Center, Moffett Field, Calif.
DEVELOPMENTAL AND GENETIC BIOLOGY
H. P. Klein 415-965-5094

The objective of this program is to determine the effects of space flight on genetic integrity, differentiation, growth, development, maturation and senescence of living systems. Research will be performed on the role of gravity, from high g to weightlessness, in the maintenance of cellular integrity, of cellular spatial relationships and in biochemical and biophysical reactions that control differentiation, growth, development and maturation of embryonic systems, both plant and animal. Of general importance is the determination of any subtle or gross effect of altered gravity on the organization of living matter during a complete life span in the space environment and its subsequent readaptation to Earth's gravity. The quantitative comparative differentiation between gravity-dependent and gravity-independent systems will be evaluated critically. Also, experiments have been selected which can be developed into flight experiments to investigate the genetic effects of the space environment. Laboratory tests will be required to develop procedures and establish baseline genetic data. Improved techniques to measure specific endpoints such as the fixation of biological material in space for prolonged storage will be developed. A self-powered unit for fixation and preservation will be built. Radiation sources will be developed for in-flight use to detect synergism of radiation and weightlessness in producing genetic damage. The effect of high Z cosmic ray particles will be determined.

W73-70787 **970-21-63**
Ames Research Center, Moffett Field, Calif.
RADIATION BIOLOGY
H. P. Klein 415-965-5094

A comprehensive study addressed to the space radiation problem for manned flights will be accomplished for the purpose of establishing realistic radiation exposure limits and developing protective and preventative procedures and techniques against hazards of space radiation. Emphasis will be placed on studies concerned with biological effects and relevant dosimetry of galactic cosmic ray particles, and combined effects of radiation and dynamic space flight factors. Both ground-based and space flight studies are to be accomplished. Intensive ground-based work will be conducted, utilizing a variety of biological materials and endpoints and existing or modified particle accelerators for irradiation, to establish and understand the mode of action and biologic effectiveness of energetic, heavy-ions (HZE) at the molecular, cellular, and organism levels. The acute and chronic effects of HZE particles on proliferating and non-dividing cells and tissues, and the combined biologic effects of radiation, vibration, and compensated gravity will be assessed. The rate of production and energy spectra of high-LET recoil particles in tissue equivalent nuclear track detectors will be established, and capability to identify track, energy, and charge of particle impacting biologic targets will be developed. Balloon and/or space flight experiments will be conducted to assess the biologic effectiveness of galactic cosmic rays in various biological materials, including brains and eyes of intact organisms, and the combined effects of radiation and dynamic space flight factors.

W73-70788 **970-22-21**
Ames Research Center, Moffett Field, Calif.
AIR REVITALIZATION
H. P. Klein 415-965-5094
(970-22-30)

A program to conduct life support research and advanced technology will be carried out by this Center. The life support areas to be investigated are. advanced academic life support

research; static-feed water electrolysis; nitrogen/hydrogen gas separation; electrochemical oxygen concentration; electrochemical CO2 concentration, solid electrolyte CO2 electrolysis; trace contaminant control; and liquid amine for CO2 removal.

W73-70789 **970-22-23**
Ames Research Center, Moffett Field, Calif.
WATER AND WASTE MANAGEMENT
H. P. Klein 415-965-5094

A program to conduct life support research and advanced technology will be carried out by this Center. The life support areas to be investigated are: (1) urine pretreatment by stabilized urease enzyme; (2) membrane development for reverse osmosis applications; and (3) solid waste incineration.

W73-70790 **970-22-24**
Ames Research Center, Moffett Field, Calif
FOOD TECHNOLOGY
H. P. Klein 415-965-5094

A program to conduct advanced Food Technology research will be carried out by this Center. The areas to be investigated are: (1) chemical synthesis of carbohydrate from CO2; (2) enzymatic synthesis of carbohydrate from CO2; and (3) growth of fresh food by hydroponic techniques.

W73-70791 **970-22-30**
Ames Research Center, Moffett Field, Calif.
CREW EQUIPMENT SYSTEMS
H. P. Klein 415-965-5094
(970-22-21)

Ames Research Center will conduct a program to perform research and advanced technology in crew equipment systems. The areas to be investigated are: advanced space suit and glove development; advanced liquid cooled garment; liquid cooled garment thermal control; advanced extravehicular protective system CO2 control, advanced extravehicular protective system thermal control; and solid oxygen sources.

W73-70792 **970-23-20**
Ames Research Center, Moffett Field, Calif.
TELEOPERATOR MANIPULATOR AND END EFFECTOR TECHNOLOGY
H. P Klein 415-965-5094

Research and development studies are needed to develop subsystem technology for applications to earth-orbital lunar and planetary surface teleoperator missions. Research currently underway includes integrated in-house and grant/contract studies. In-house studies are devoted to the development and evaluation of: a) improved unilateral and bilateral manipulator arms and dexterous end effectors, b) advanced visual environment sensing and display systems which will provide the human operator with a 3-D view of the remote scene, and c) predictor displays based on hybrid computer mapping, storing and manipulating stereo-pair information obtained from the stereo camera subsystem. Grant and contract studies are directed respectively toward a) the development of a collaborative Ames/Stanford program in which a teleoperator research laboratory will be established at Ames to study man-machine integration problems associated with various levels of manual and automatic control, and b) the development and evaluation of advanced sensory aids and the associated displays required to provide relevant information on the remote environment to the human controller during RMS control tasks

W73-70793 **970-23-30**
Ames Research Center, Moffett Field, Calif.
ADVANCED BIOINSTRUMENTATION
H. P. Klein 415-965-5094

The objective for work in this area is the development of bioinstrumentation technology required to enable the measurement of biological, physiological and psychological responses of man and/or selected animal species during space flight. Advanced bioinstrumentation efforts will include the development of various concepts and techniques to monitor physiolgoical function by non-invasive non-injurious methods including swallowable telemetry units, new ECG electrodes and miniature sensors such as accelerometers placed on or about the body surface. Non-invasive techniques will be developed and evaluated for making cardiovascular measurements using primarily Doppler ultrasound. Both continuous and pulsed ultrasonic techniques will be evaluated, particularly multiple range gating of transcutaneous signals. Development of new laboratory techniques and equipment such as holographic microscopy and advanced techniques for processing biological materials will also be pursued. Lastly, new and improved microelectronic methods for measuring physiologic status during space flight will be developed. These methods will be applied to sensors and systems placed in or upon the body surface.

W73-70794 **970-24-01**
Ames Research Center, Moffett Field, Calif.
INTERDISCIPLINARY RESEARCH
H. P. Klein 415-965-5094

Objective is to provide support for preliminary investigation of various alternative advanced research and technology efforts which might ultimately become part of an approved programmed RTOP assigned to the Center. The Center Director of Life Sciences will be the sole authority for selecting those tasks which will become part of this RTOP. Task documentation outlining the efforts undertaken as part of this RTOP will be furnished for information purposes following assignment of the task by the Center Director of Life Sciences.

W73-70795 **970-24-02**
Ames Research Center, Moffett Field, Calif.
BIORESEARCH MODULE
D. L. Winter 415-965-5100

The object of this project is to conduct a study to adapt the Bioresearch module used in the OFO-A flight to a possible longer duration flight of increased complexity The non-recoverable OFO-A bioresearch module design will be used as a technical baseline for this study. Requirements and trade-offs will be explored to increase the life support thermal control and centrifuge capability

W73-70796 **970-42-30**
Flight Research Center, Edwards, Calif.
CREW EQUIPMENT SYSTEMS
L. R. Carpenter 805-258-3311
(970-22-30; 970-52-30)

The objective is to provide applied technology development and flight concept verification of flight crew personal equipment related to the shuttle spacecraft flight test vehicle program. The technical approach will include definition of crew equipments for the flight test vehicle and subsequent development and engineering simulation testing in support of the proposed operations.

W73-70797 **970-51-11**
Manned Spacecraft Center, Houston, Tex.
NEUROPHYSIOLOGY
M. R. DeLucchi 713-483-4731

The objective is to investigate and evaluate effects of the space environment upon the nervous system of man. This body system demands particular attention in that it constitutes the sensory, motor, and most significantly, the coordinating mechanisms for human performance and behavior. It is imperative that neurophysiological function is not impaired by exposure to any of the variables which are experienced during the course of a manned mission. The function of the nervous system is of major significance in any attempt to either evaluate or predict human capabilities and performance. It is to this end that work will be undertaken and directed. It is required that nervous system physiology be assessed both under conditions of ground based research and during space missions so that the information obtained can be utilized to insure appropriate safety and performance potential. Particular emphasis will be placed upon spatial orientation, motion sickness, visual and auditory perception, levels of attention and alterness, since information concerning these has direct application to space flight operations and mission planning. Biochemical and bioelectric correlates of neurophysiological function and behavior will be studied. Weightlessness and its associated alteration of sensory input to the body, duration of sleep and its quality, work-rest cycles, and stress levels---

W73-70798 **970-51-12**
Manned Spacecraft Center, Houston, Tex.
CARDIOVASCULAR PHYSIOLOGY
G. W. Hoffler 713-483-5555

The objective is to determine cardiovascular responses and/or adaptations to the various environmental factors associated with manned space flight. Particular attention will be given to the physiological responses to weightlessness and mission-like workloads. Emphasis will be placed on investigations pertaining to those factors which affect and the mechanisms which control the orthostatic response to gravitational fields following exposure to long duration weightlessness. Ancillary effort will be directed towards other factors and physiologic systems affecting cardiovascular function such as heat loads, water and electrolyte balance renal and endocrine control. Ground based programs will include use of hypodynamic states; study of regulatory mechanisms and related physiologic systems and responses; development of measurement techniques, hardware, and data management and analysis capabilities; and conduct of pre- and postflight evaluations of space crews, and analyze data from inflight medical experiments.

W73-70799 **970-51-14**
Manned Spacecraft Center, Houston, Tex.
METABOLISM AND NUTRITION
John A. Rummel 713-483-5156
(970-52-20; 970-51-13)

Metabolic mechanisms which store and liberate heat and energy are the most basic processes in living systems. In supporting this scientific discipline we can divide it into three overlaping areas: (1) Nutrition - the supply of adequate energy sources, (2) Respiratory/Metabolic - the transformation of energy sources to useful body processes and the resultant external work of the organism, and (3) Thermal - the effect of the environment on the organism's ability to regulate the loss of the heat produced by metabolic processes. The specific objectives and approach in each of these areas is as follows: (1) Nutrition - This program has, as its end point, the development of criteria for optimum foods and packages. It approaches this goal through two major categories of effort: the derivation of nutritional and metabolic requirements and the design of foods and packages to meet those requirements. (2) Respiratory/Metabolic - The objective if this program is to obtain an understanding of the homeostatic mechanisms involved in the adaptation of man's energy transforming processes to the spaceflight environment. This will be accomplished by conducting basic research to evaluate the effect of abnormal and proposed environmental conditions on respiratory/metabolic function in order to determine human effects, tolerances, and protective/preventative requirements. (3) Thermal Physiology - The physical effect of the spacecraft environment on thermoregulation has been included in a model of thermoregulation in man. Although no direct physiologic effect of the spacecraft environment is expected there may be interactions of the pulmonary and cardiovascular systems that will indirectly influence thermoregulation. In addition work will be done to evaluate and optimize cooling systems and to improve the definition of heat storage tolerance

W73-70800 **970-51-15**
Manned Spacecraft Center, Houston, Tex.
HEMATOLOGY (IMMUNOLOGY)
S. L. Kimzey 713-483-4086
(970-51-16)

The overall objective of this program is to assess the physiological costs of manned space flight relative to the hematological and immunological systems. Advanced biochemical analytical techniques are being applied for: 1) detection and characterization of disease states prior to their clinical expression; 2) quantitative and qualitative analysis of cellular chemical constituents of the formed elements of the blood and muscle tissue; and 3) computerized cell identification and functional classification based upon pattern recognition and association routines. Studies are being conducted to perfect procedures for inflight acquisition and preparation of microsamples of blood for postflight physiochemical analysis. Animal models will be utilized to evaluate the influence on the immune response of stresses characteristic of both the terrestrial and space flight environment.

W73-70801 **970-51-16**
Manned Spacecraft Center, Houston, Tex.
ENDOCRINOLOGY
C. S. Leach 713-483-4086

The overall program described herein is designed to further elucidate and define those physiological mechanisms which are operative in adaptation of the man to the space flight environment and in his readaptation to the earth environment following extended duration missions In general, these investigations will be directed toward the identification of hormonal and neurohumeral agents which are active in the readaptive process and will be concerned with describing the relationship between these compounds and those organ systems which are affected by the space flight environment. Research emphasis will be placed on quantitation of endocrine compounds and their effect at the effector within the total system, as pertains principally to the regulation of fluid and electrolyte balance and acid-base equilibrium. The endocrine control of these major system responses will include, but not be limited to, such areas as stress response, physiological cost and reserve, and nutritional effects. The effects of stress induced endocrine/metabolic processes will be examined in reference to the interrelationship of the hormonal system with metabolic process to identify those which are of importance in man's overall adaptation to environmental changes

W73-70802 **970-51-17**
Manned Spacecraft Center, Houston, Tex.

COUNTERMEASURES

G. W. Hoffler 713-483-5554

The objectives of investigations undertaken within the countermeasures area shall be to define, develop and evaluate preventive and/or remedial measures for mitigating the deleterious effects of prolonged weightlessness on crew and/or passenger personnel. These deleterious effects may appear during flight, but are apt to be more evident on return to force fields (l-g). Countermeasures may be physical, pharmacological, or dietary (nutritional) in character and shall relate to the known biomedical problem areas of space flight, viz., cardiovascular deconditioning (postflight orthostatism), bone demineralization, muscle mass loss, decreased exercise tolerance, deconditioning of ligamentous, tendinous or other supportive skeletal structures, and vestibular disfunction. Methods shall be largely empirical but not to the exclusion of defining mechanisms of action in more basic studies. Finally, countermeasures will be validated by appropriate stress testing, which may include centrifugation, zero flights, and other less elaborate verfication techniques. Particular emphasis will be placed on maintaining the integrity of the cardiovascular and musculoskeletal systems, as well as of the general physical fitness of representative candidate crew and passenger populations. Bed rest will be the weightlessness analog utilized to simulate zero g either inhouse or at contractor facilities Such studies are now in progress at the USPHS Hospital, San Francisco in the mineral metabolism, fluid, electrolyte, and cardiovascular areas.

W73-70803 **970-51-25**

Manned Spacecraft Center, Houston, Tex.

CHEMISTRY AND MICROBIOLOGY

B. J. Mieszkuc 713-483-2031

The basic objective is to identify and evaluate potential hazards to crews and passengers on OMSF missions. This includes programs to insure that the spacecraft has a compatible microbial ecology and that potential toxic contaminants are identified and evaluated. The current level of knowledge is not adequate to make satisfactory risk decisions for long-duration space flights, specifically, as related to our ability to provide man with a habitable non-toxic environment and our ability to control or modify the endogenous and exogenous infectious disease potential. The approach to reduction of this knowledge gap requires a three-phased coordinated course of study and action leading to the qualification of man and machine for extended duration missions in space, as follows: (1) determine the nature and extent of problems; (2) derive effective methods of prevention and control; (3) provide microbiological and toxicological support and monitoring systems for use inflight. All in-house and contract research efforts in support of Skylab and Advanced Missions are organized around this approach. This research approach involves: (1) studies utilizing in vitro techniques, (2) comparative sutdies utilizing animal hosts; (3) medical investigations utilizing man as the test subject.

W73-70804 **970-51-35**

Manned Spacecraft Center, Houston, Tex.

ENVIRONMENTAL FACTORS EFFECTS

J A. Rummel 713-483-5156

The objective of this work is to investigate the physiological effects of mechanical forces on man, and to evaluate the physiological adequacy of spacecraft atmospheres. The primary effort is to establish tolerance limits to sustained positive (G sub z) acceleration in order to evaluate crew performance capabilities and passenger protection and comfort for application to future programs. An objective of these studies is to evaluate acceleration tolerance in relation to weightlessness. This will be accomplished by using strict bedrest as a means to simulate weightlessness. The acceleration profile will be such that limits of tolerance can be established that will be applicable to all probable spacecraft reentries involving G sub z acceleration vectors. Protective measures will be investigated. Additional efforts under this RTOP will be to develop automated systems to integrate the results of the data obtained during atmosphere validation studies.

W73-70805 **970-51-45**

Manned Spacecraft Center, Houston, Tex.

MEDICAL SUPPORT

R. L. Sauer 713-483-5056

The objective is to develop techniques, methodologies and procedures for optimal preventive and inflight medical care for future manned space flight missions. This plan encompasses two major areas of activity: (1) Improved diagnostic and predictive capability; and (2) Improved preventive and restorative treatment capabilities. Data collection, documentation and interpretation are essential efforts in enhancement of diagnostic and predictive capabilities. One proposed task, Development of an Automated Neurophysiological Function Test will fill an important gap in our present data acquisition system. Two tasks are involved with the continuing development of our data storage and retrieval system for Dispensary records, hazardous man test records, etc. The task, development and verification of Time Series Analysis Techniques, represents an important attempt at better understanding and utilization of biological data recorded over short time intervals for multiple periods. Two tasks, Automated Cell Identification and Rapid Diagnostic Techniques for the early detection of disease, have important implications for improving our flight crew health stabilization efforts at identification of incubating infectious diseases, and for automation with potential remote utilization in a wide variety of diagnostic problems.

W73-70806 **970-51-51**

Manned Spacecraft Center, Houston, Tex.

HUMAN BEHAVIOR AND PERFORMANCE

W. E. Feddersen 713-483-4734

The objective of research in this area is to optimize man's performance under conditions of long-term space flight. Areas being investigated are: (1) Skill retention for procedural, near-point and far-point control tasks over extended periods of time; and (2) Personality and psychosocial assessment techniques validated and standardized for application to spacecraft crew command structure. To establish the basic principles for optimal structuring of small groups under conditions of isolation, confinement, and other stresses. To advance knowledge of human capabilities and limitations in behavior and performance relevant to roles man must fulfill in space. (1) Identify and select far-point control task requirements, develop candidate skill retention methods, train subjects to conduct tests, and select optimum skill retention methods and specify prototype design requirements. (2) Establish a baseline battery of standardized psychosocial assessment measures for application to crew command structures. Major initial emphasis will be placed on the development of criteria for the selection of individuals for membership in groups which are assigned specific mission tasks Methods for continuous assessment of performance and group interaction over long periods of time will be defined and validated. Such methods should be sufficiently sensitive to detect alteration in the effectiveness of individual and group functioning under adverse conditions such as rhythm desynchronization, sleep deprivation, and situational stress. Research will be devoted to the programming of environmental events and procedures for the prevention and correction of undesirable behavior resulting from social and environmental conditions analogous to those encountered in space flight. (3) Provide in-house laboratory

support in conduct of baseline performance studies in support of Space Shuttle

W73-70807 **970-51-62**
Manned Spacecraft Center, Houston, Tex.
DEVELOPMENTAL BIOLOGY
C. H. Walkinshaw 713-483-2031

Studies are underway at the Manned Spacecraft Center to determine the effects of the space environment on differentiation, growth, development, maturation, and senescence of living systems. These studies have developed from increased technology gained in Apollo 11, 12, 14, and 15 post-flight investigations in the Lunar Receiving Laboratory. The primary objectives of this work are to evaluate the dependence of plant growth upon specific environmental factors, to assess the effects of reduced gravitational and geomagnetic forces on growth and development of plants and animals, and to determine the effects of lunar materials on selected plant species Also included as aims are certain preliminary evaluations on the usefulness of plants and animals in environmental regeneration systems. The overall approach to defining research areas is to utilize plant and animal systems in which the compensation to environmental stress has been exaggerated by an obvious modification in cellular behavior. Specific emphasis is being placed on measuring cellular products of aeromatic amino acids in species exposed to reduced gravity, reduced geomagnetic forces, modified gaseous environments, and modified nutritional conditions. The detailed investigations on the growth promotion of plants treated with lunar materials are also being continued For these latter studies, germfree plants exposed to lunar materials will be analyzed by techniques of gas-chromatography-mass spectrometry, and electron microscopy. The approach to all tasks has been to establish cooperative experiments aimed at utilizing unique resources of the Manned Spacecraft Center and involving NASA, the USDA, universities, and industry. An increased understanding of environmental forces on the morphology and physiology of economically important species will be obtained.

W73-70808 **970-51-63**
Manned Spacecraft Center, Houston, Tex.
RADIOBIOLOGY
R. E. Benson 713-483-4251

This research program is designed to investigate and define the potential biological hazards of the space radiation environment to manned space missions. This includes special attention and emphasis on studies concerning the biomedical effects of high energy high Z (HZE) cosmic ray particles. The program also provides support for development of accetable radiation safety criteria and dose limits, including preventive and corrective procedures and techniques. The physiologic and pathologic changes in man subjected to long duration space radiation are considered. The approach used includes retrospective and prospective studies of human response to radiation therapy and accidental exposures to various radiation sources. In addition, experimental animals are utilized in studies specifically designed to investigate simulated space radiation hazards. Results are evaluated and compared with known human response to radiation. Knowledge of responses to radiation under both continuous and intermittent exposures and at low dose rates is needed. This information is necessary to permit definition of the doses-response thresholds for man. Currently there is insufficient knowledge concerning these factors to permit definition of reliable radiation dose response criteria appropriate for future space programs.

W73-70809 **970-52-10**
Manned Spacecraft Center, Houston, Tex.
LIFE SUPPORT SYSTEMS PROGRAM
Noel C. Willis 713-483-2171
(977-50-06)

The objective of the current ETC/LSS development program is to design, develop and test a flight prototype subsystem to support future long duration earth orbital missions. An equally important objective of this program is to exercise a management approach to advanced hardware development which will reduce the ultimate cost of flight systems. The program philosophy entails development of the ETC/LSS Life Support System Hardware utilizing a flight qualifiable design with sufficient flexibility, such that the program could be applicable to a variety of mission considerations. The basic subsystem performance requirements dictate accommodation of a 6 man crew over a total pressure range of 10 psia to 14.7 psia, with a useful lifetime of 2 years and 180 day resupply interval. Specifically, the space station prototype (SSP) ETC/LSS maintains vehicle cabin pressure, provides a conditioned shirtsleeve atmosphere for the crew, maintains thermal control of electronic equipment and control of the closed-cycle water-supply system and solid wastes. Unlike previous life support systems, the SSP ETC/LSS is an advanced design utilizing the recovery of useful products in order to accommodate long duration missions. The program does not presume to be the specific design for a particular vehicle configuration; however, the realism associated with designing and testing a system with flight type considerations is necessary to attack the systems integration and maintenance concepts associated with advanced ETC/LSS and to develop a low cost approach to managing complex systems for advanced programs. A ground test program for Shuttle integrated ECLSS testing at MSC will be defined. A study will be initiated to define overall ECLSS ground test objectives. From this study a general test plan and test requirements will be development.

W73-70810 **970-52-21**
Manned Spacecraft Center, Houston, Tex.
AIR REVITALIZATION AND CONTAMINANT CONTROL
Frank H. Samonski, Jr. 713-483-2171

The objective is to provide advanced life support technology for components and subsystems for air revitalization, atmosphere storage and generation and carbon dioxide and contaminant control. Subsystem technology will be advanced through to design and verification for reliable hardware for shuttle and near term space missions Performance data on subsystems and components will provide a basis for selection of critical subsystems to make them adaptable to flight type hardware.

W73-70811 **970-52-22**
Manned Spacecraft Center, Houston, Tex.
ATMOSPHERIC PRESSURE, COMPOSITION, AND THERMAL CONTROL
Frank H. Samonski, Jr. 713-483-2171

The objective is to provide advanced life support technology for components and subsystems for atmosphere supply and pressure control, sensor and instrumentation and thermal control. Subsystem technology will be advanced through to design and verification for reliable hardware for shuttle and near term space missions. Performance data on subsystems and components will provide a basis for selection of critical subsystems to make them adaptable to flight type hardware.

W73-70812 **970-52-23**
Manned Spacecraft Center, Houston, Tex.
WATER AND WASTE MANAGEMENT
Frank H. Samonski, Jr. 713-483-2171

The objective is to provide advanced life support technology

for componenets and subsystems for water and waste management. Subsystem technology will be advanced through to design and verification for reliable hardware for shuttle and near term space missions. Performance data on subsystems and components will provide a basis for selection of critical subsystems to make them adaptable to flight type hardware.

W73-70813 **970-52-24**
Manned Spacecraft Center, Houston, Tex.
FOOD TECHNOLOGY
N. D. Heidelbaugh 713-483-5056

The objective is to minimize overall mission costs by maximizing food adaptation to the mission needs rather than adapting mission components to fit commercially available foods. Space food systems engineering design goals are: minimum weight, minimum volume, minimum power requirements, maximum use of familiar types of foods, minimum in-flight food preparation times, and minimum overall program costs. Food technology, food engineering, and food science will be exploited, to support research and development of food systems which provide optimized support for advanced missions of manned space flight. Particular attention will be given to those techniques which are judged to be most likely to aid in achievement of space food systems engineering design goals. Emphasis will be placed on specialized technical areas neglected by the commercial food industry. These efforts will be complemented by tasks to select and adapt commercially developed food technology and food engineering techniques. Priorities will be given to development of overall concepts for advanced food systems by tradeoff analysis. Attention will be placed on optimization of space food preservation techniques, optimization of packaging,and development of efficient in-flight food storage, preparation, and delivery systems, and subsystems hardware.

W73-70814 **970-52-30**
Manned Spacecraft Center, Houston, Tex.
CREW EQUIPMENT SYSTEMS
R. E. Smylie 713-483-4931

The objectives are to define the operational EVA/IVA and emergency IVA requirements for Shuttle, and select the EVA/IVA systems in order to provide systems interface definition to the prime vehicle contractor. Efforts will be made to establish a baseline for the preparation of detailed specifications for EVA/IVA hardware; initiate the design, development, fabrication, and testing of prototype advanced EVA technology suits; and initiate the technology development of selected EVA life support system components. These efforts will be coordinated with the Shuttle requirements definition program in order to provide a definative baseline for the preparation of detailed specifications for EVA equipment.

W73-70815 **970-53-10**
Manned Spacecraft Center, Houston, Tex.
SHUTTLE CREW TRAINING REQUIREMENTS AND MAINTAINABILITY
T. U. McElmurry 713-483-6416
(970-53-50; 908-42-42)

The goal of this Research and Technology Operation Plan is to develop a set of process and product specifications and simulator requirements specifications which can be used to initiate development of operational techniques and resources associated with crew integration, crew training and crew operations for specific near future manned space programs. Task 21 - Shuttle Mission Simulator Definition Study - This task develops and documents the requirements specifications for a Shuttle full mission simulator and provides a basis for initiation of simulator design. Task 22 - Shuttle Simulator Visual System Definition Study - This task develops and documents the requirements specifications for a Shuttle crew training visual simulation system. Task 31 - In-Flight Maintenance and Stowage Operations Study (Phase III) - This task develops process and product specifications for controlling and managing crew interface requirements for in-flight maintenance and stowage functions.

W73-70816 **970-53-20**
Manned Spacecraft Center, Houston, Tex.
VEHICLE ATTACHED MANIPULATORS
Richard B. Davidson 713-483-4966

Analysis, evaluation, fabrication and simulation of a manipulator system for deploying and retrieving shuttle cargo and inspecting and servicing shuttle payloads and satellites. The objectives of this effort will be to fabricate a technology boom manipulator system defined under FY 72 RTOP 970-53-20 and to conduct an in-house simulation program to investigate and evaluate various manipulator techniques and concepts.

W73-70817 **970-53-30**
Manned Spacecraft Center, Houston, Tex.
ADVANCED BIOINSTRUMENTATION
Sam Lee Pool 713-483-4121

The advanced bioinstrumentation programs proposed in this RTOP include many ongoing efforts along with a few new tasks. The scope of the RTOP is broad in the sense that a diverse group of fields is covered from neurology to advanced bioengineering. The overall objective of the advanced bioinstrumentation programs is to develop and test bioinstrumentation techniques which appear most promising from the standpoint of providing a uniquely space-applicable technique adapted from ground-based technology, to a basic advance in the state of the art from bioinstrumentation on earth as well as in space.

W73-70818 **970-53-40**
Manned Spacecraft Center, Houston, Tex.
INTEGRATED MEDICAL AND BEHAVIORAL LABORATORY MEASUREMENT SYSTEM (IMBLMS)
N. Belasco 713-483-4121

Medical research in space has been severely limited by the lack of appropriate instrumentation and techniques which are both functional and accurate under the environmental and operational constraints of space missions. This effort will provide the needed basic tools of biomedical measurement in a form that is flexible enough to allow tailoring of space medical research to individual missions. The IMBLMS concept is one of continuing development and incorporation into a basic system, techniques and instrumentation which are beyond the present state of the art. In past program phases, the feasibility studies have been completed and functional breadboards of the system have been assembled and tested. Presently Phase B, Project Definition, is completed. The preliminary design of the flight type system, plans, and schedules are contained in recent reports from both contractors. However, program results to date have concentrated on developing techniques, protocols, and equipment designs to support the medical and behavioral research experiments for long duration missions. Recognizing that medical care and services are of a higher priority in extended manned space missions, the NASA has elected to increase emphasis upon the development of the IMBLMS onboard clinical capability in Phase C. Because of the similarities of health care in space and providing health care in remote areas, NASA deems it advantageous to assemble and operationally test a remote ground-based health care test bed system to guide future development of a space flight health care facility. Field testing

in typical remote locations will permit compilation of data to guide future efforts.

W73-70819 **970-53-50**
Manned Spacecraft Center, Houston, Tex.
HABITABILITY/FUNCTIONAL MOCKUP EVALUATION
Allen J. Louviere 713-483-4966

The objective is to determine design criteria and requirements for various compartments, furnishings, and crew equipments to be utilized in the Shuttle Orbiter Flight Crew Compartment Efforts will be made to establish design feasibility through one-g simulations and/or neutral buoyancy testing, and provide conceptural design of the personnel compartment and accommodations by considering the limitations and requirements of man. Verification will be established through 3-dimensional engineering models and mockups.

W73-70820 **970-62-21**
Marshall Space Flight Center, Huntsville, Ala.
AIR REVITALIZATION
George Hopson 205-453-3830

This RTOP is composed of two tasks in the area of air revitalization for manned spacecraft. Task 01 is concerned with providing technology for obtaining long life components for air revitalization systems although that technology will be applicable to other systems as well. Those characteristics indicative of impending component wearout and approaching failure will be identified. Methods for repair or replacement of the component prior to system failure will be determined and a feasible concept for a component failure anticipation/detection system established. Task 02 is for development of a Bosch CO2 reduction system. This system can eliminate overboard effluents from the atmosphere revitalization system thus enhancing the local spacecraft environment for experiment performance.

W73-70821 **970-62-23**
Marshall Space Flight Center, Huntsville, Ala.
WATER AND WASTE MANAGEMENT
G. D. Hopsin 205-453-3830
(970-62-20)

The purpose of this RTOP is to provide the technology for recovery of potable water from waste water in life support systems in space. There are two tasks in this RTOP: Task 01 - Vacuum Distillation/Vapor Diffusion (VD/VF) Water Recovery System; Task 02 - RITE Waste Management System. The approach on both tasks is similar; analytical investigations followed by fabrication of prototype units and verification testing. The FY 73 portion of these tasks will primarily complete fabrication of the prototypes and accomplish verification testing. Both tasks cover the recovery of potable water from waste materials. The VD/VF recovers water from urine and condensate water whereas the somewhat more complex RITE system provides for solid waste incineration in addition to water recovery.

W73-70822 **970-62-40**
Langley Research Center, Langley Station, Va.
ZERO GRAVITY FLIGHT EXPERIMENTS
C. H. Nelson 703-827-2893

A set of analytical models has been compiled to describe and predict the behavior of fluids in a reduced gravity field. These models, when verified, can serve as analytical tools for the optimal design of hardware systems that incorporate basic physico-chemical processes which are sensitive to changes in the gravity environment. While the models may be used in the design of any hardware involving fluids, special emphasis is placed on describing those phenomena associated with life support systems. The models have been verified in the laboratory under one g conditions and a program plan has been developed for complete updating and validation of the models through flight testing that includes both aircraft and manned space flight. Recent testing has demonstrated the feasibility of sustaining small animals under simulated space conditions for extended periods of time but pointed out the need for improved reliable feeder lip switches and a means of determining mass in Zero G in order to completely define the hardware design for space missions. A contract is currently being negotiated for the development and testing of a flight configured Zero G Mass/Volume Measurement System and modified lip switches for existing feeders and waterers.

W73-70823 **970-63-10**
Marshall Space Flight Center, Huntsville, Ala.
REQUIREMENTS FOR WORK PERFORMANCE DESIGN
J. R. Thompson 205-453-3739
(970-63-50; 970-63-10)

The objectives of this effort are to optimize utilization of payloads for space flight operations and flight experiments, establish performance measures and assess effect of space flight on man-machine interfaces; and to develop effective configurations for experiment and systems work spaces. Through a combined program of ground and flight evaluations, the necessary technology to assess effectiveness of space flight man-machine interfaces will be developed. Efficacy of assessment techniques by applying interim findings to conceptual work space designs will be tested.

W73-70824 **970-63-20**
Marshall Space Flight Center, Huntsville, Ala.
TELEOPERATOR CONTROL AND MANIPULATION
W G. Thornton 205-453-5530

This RTOP proposes to further develop the technology such that design criteria are available in the time frame of 1975 for application to the free flying teleoperator. Efforts will be made to establish component and integrated systems technology and criteria for free flying teleoperators applicable to shuttle and satellite missions. The main effort will be within the technical areas of manipulative devices; visual systems; remote control of mobility units; the associated control station; and the human factors and man/machine interface. Feasibility studies and investigations will be conducted on advanced manipulators, end effectors, visual systems, displays, and remote control; evalutate man-machine integration methodology for remote, free flying manipulator units.

W73-70825 **970-64-03**
Marshall Space Flight Center, Huntsville, Ala.
LIFE SCIENCES PAYLOAD INTEGRATION INTO MANNED SPACE FLIGHT SYSTEMS
J. D. Hilchey 205-453-3433

The objectives of this activity are. (1) to develop a body of integration data and a variety of engineering and administrative program planning tools which can be used by NASA Life Sciences organization; (2) to establish programs to accomplish integration of Life Sciences payloads into manned space flight systems; and (3) to guide manned flight system planners and developers in development and integration of Life Sciences payloads. With the guidance of a multi-Center/NASA Headquarters Study Management Team, Baseline Life Sciences payloads for manned flight systems were selected, and approved payload layouts were developed under contract NAS8-26468. Funding limitations forced postponement of study tasks to produce

administrative/engineering planning tools as well as conceptual designs of payloads integrated into flight systems. The approach under this RTOP will be to: (1) complete the objectives of the original study, i.e. develop appropriate conceptual designs and program planning tools; and (2) resolve subsystem and other interface problem areas already identified under contract NAS8-26468, planning tools, developed ad hoc for specific Shuttle Sortie laboratory payloads (FY72 study) and specific long duration Life Sciences laboratory payloads (FY73 study) into a Unified Life Sciences Payload Integration Planning System for use throughout NASA. It is expected that timely completion of the proposed studies will permit initiation in FY74 of a Phase B study of small, early Life Sciences Laboratory Payloads for Sortie missions.

W73-70826 **970-71-61**
Wallops Station, Wallops Island, Va.
REGULATORY BIOLOGY
E. M. Holton 703-824-3411

The objective is to understand the biochemical and physiologic mechanisms associated with regulatory changes as a response of living systems to a range of environmental temperatures The principle of transient metabolic states (excitatory and depressed) is being explored as a potential simulator of weightlessness, an antagonist to radiation-induced damage and the understanding of the mechanism of delayed metabolism which allow injury repair processes to avoid untoward effects. Differences in function are being established between rapidly metabolizing systems and those more mature and metabolically stable. Regulatory, intermediary pathways are being established.

W73-70827 **970-83-20**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
ADVANCED TELEOPERATOR SYSTEMS REQUIREMENTS
Ewald Heer 213-354-3060
(112-30-14; 115-04-20; 970-23-20; 970-63-20)

The general objective of this program is to develop needed information about teleoperator/robots that augment and extend man's capabilities so that missions to the Moon, planets, asteroids, etc., requiring the use of such systems can be planned and implemented with the required reliability, performance and economy. Specific objectives of the work of this RTOP are to identify and establish teleoperator/robot system and subsystem requirements, functions, and designs and to determine the machine's and man's complementary roles in the operation of teleoperator/robots which can be used to explore lunar and planetary environments and surfaces. The objectives of this program will be approached through technical studies identifying the scientific and operational mission requirements and by developing the resultant necessary teleoperator/robot functions, by man and machine in the control center, and by the remote system (robot) at the remote site. From the implied capability requirements for man and machine, the necessary technology developments for teleoperator/robot systems and subsystems will be derived. Required studies will be defined and implemented, analytically and/or experimentally using simulation techniques, breadboard set-ups, or prototype equipment. These studies will give insight into the functions to be performed by man or machine or both for remote explorations and operations. Function allocations will be made between man and machine for various communication time delay requirements, so that optimum system performance can be achieved, and critical technology development requirements can be identified. New concepts of teleoperator/robot systems and subsystems will be developed when appropriate and related feasibility studies will be conducted. Man-machine system performance evaluations will be conducted and performance criteria will be established This work will be coordinated with related work at JPL, ARC, MSC, and MSFC.

Payloads

W73-70828 **975-50-01**
Goddard Space Flight Center, Greenbelt, Md.
SHUTTLE-BASED LOW COST SPACECRAFT
J. Purcell 301-982-4345
(976-30-20; 975-84-20)

The principal objective of this task is the demonstration of an example of the type of low cost spacecraft that is made possible by the Space Shuttle The ability to repair satellites in orbit and to retrieve satellites from orbit for repair or overhaul on the ground will permit the application of much less exotic technology and management controls NASA's traditional search for technical perfection, necessary since resupply or retrieval is not possible, is the root cause of the very high cost of present day space hardware. Essential ingredients of a low cost spacecraft development are a design that facilitates orbital resupply without escalated cost and a determined application of a development approach which simplifies those management practices and requirements that have resulted in high cost. A potential resupply concept has been evolved with the GSFC in-house design for the Large Space Telescope. The interfaces with the Shuttle and requirements for remote manipulator design are now being studied under contract with North American Rockwell (RTOP 976-30-20). An interim international agreement with Canada provides for Canada's funding of remote manipulator design by Canadian firms as a part of the study. Both of these tasks are being modified to include an earth observation mission.

W73-70829 **975-61-02**
Langley Research Center, Langley Station, Va.
SHUTTLE ATMOSPHERIC POLLUTION MONITORING EXPERIMENT USING ACTIVE OPTICAL TECHNIQUES
C. H. Nelson 703-827-2893

The large thrust and payload carrying capabilities of the space shuttle in the 1980 period will enable the launching of a dedicated Earth Observations Facility having large and heavy experiments for manned observations of the earth. This new capability and facility for improved earth observations means that new technology must be brought forward for the definition of experiments for shuttle sortie or shuttle laboratory missions to become available in the 1980 period. The objective of this work is to define experiments using active optical sensing techniques and systems for the remote detection and measurement of atmospheric constituents from aircraft and satellite platforms such as Space Shuttle. An optical radar system will be developed which utilizes Raman and resonance Raman scattering, and resonance fluorescence as the measurement technique and which is capable of measuring aerosol distribution and constituent density profiles in the terrestrial atmosphere. The successful application of this technique depends upon correct knowledge of the scattering characteristics of the various atmospheric constituents and upon the development of laser systems with the appropriate range of wavelengths and operational characteristics needed for atmospheric sensing systems. It will, therefore, be necessary to: (1) carry out theoretical and experimental laboratory studies to determine the scattering cross sections of the various naturally occurring aerosols and pollutant gases of interest; (2) conduct laboratory studies to develop tunable lasers to the stage required for application to atmospheric sensing; and (3) to---

W73-70830 **975-70-52**

Langley Research Center, Langley Station, Va.

THE STUDY OF AN ORBITING ADVANCED TECHNOLOGY LABORATORY (SHUTTLE COMPATIBLE)

C. H. Nelson 703-827-2893

The use of space by competent researchers is a National asset that can quicken the pace of technological advancements beneficial to domestic needs. The objective of this study is to define a Shuttle compatible Advanced Technology Laboratory (ATL) particularly suited to Langley Research Center's technical expertise and research requirements. This Laboratory will provide LRC with the capability of implementing a spaceborne research program that is truly accessible to the ground-based researchers. The study effort will include the further definition of those areas of research needing Shuttle Sortie capability. Design concepts for candidate ATL experiments will be developed. An analysis will be made of the experiment integration, checkout, orbital operation, and data recovery required of the ATL. Definition studies will be made which will develop preliminary experiment laboratory equipment designs, schedules, and resource information for phased follow-on design, development and operations activity.

W73-70831 **975-71-53**

Lewis Research Center, Cleveland, Ohio.

ZERO GRAVITY PROPELLANT TRANSFER TECHNOLOGY

D. A. Petrash 216-433-6103

(909-72-31)

This program is to provide the technology base necessary for the design of efficient and predictable in-orbit fluid transfer systems and operations. The objective will be accomplished through an evaluation of the existing technology in the areas of zero-gravity fluid behavior and thermal protection to identify technology gaps with respect to the immediate problem of in-orbit transfer of cryogens and noncryogens. In-orbit fluid transfer systems will be studied to identify critical characteristics and components. Subsequently, research and development studies will be undertaken to fill the gaps in the technology and to establish design criteria for the critical system components and characteristics

W73-70832 **975-72-32**

Langley Research Center, Langley Station, Va

ORBITAL FATIGUE EXPERIMENT

C. H. Nelson 703-827-2893

The development of long-lived space vehicles requires knowledge of the fatigue behavior of engineering materials in the space environment. Data from earth-bound tests in simulated environments must be correlated with data obtained in orbit. The capability for conducting fatigue tests in orbit will be developed in three phases. Specimen geometry and size will be determined in Phase 1. A fatigue testing machine will be designed in Phase 2. One prototype machine will be constructed and tested in a hard vacuum in ground facilities in Phase 3. Operation in orbit will be accomplished when a vehicle is available.

W73-70833 **975-72-39**

Marshall Space Flight Center, Huntsville, Ala.

OPTICAL CONTAMINATION

Hoyt M. Weathers 205-453-3040

(502-21-28)

Flight measurements on both manned and unmanned spacecraft have been seriously degraded by the spacecraft ambient environment. This contamination can originate from several sources, including material outgassing, particulates and debris, various vents, attitude thruster firings, leakage, and even from within experiments. An SRT program for the study, control, monitoring, and abatement of contamination (see related RTOP 502-21-28) has been established within the Space Sciences Laboratory as the key activity in the overall MSFC program in this area. The SRT program is basic to, and necessary for, this effort to define the advanced hardware concepts which will be needed for the Shuttle, Sortie Can, RAM, and the Large Space Telescope. The work described herein continues those on-going activities which were initiated in previous years. The milestone schedule shows the measurements in the "Blue Book" and is addressed by this RTOP.

W73-70834 **975-72-51**

Langley Research Center, Langley Station, Va.

DEFINITION OF METEOROID AND EXPOSURE MODULE FOR SHUTTLE LAUNCH AND RECOVERY

C. H. Nelson 703-827-2893

A simple, inexpensive meteoroid and exposure module and a set of compatible noncritical experiments which will be capable of obtaining valuable scientific and technological data on the near-earth space environment and the effects of this environment on spacecraft materials, systems, simple life forms, etc., will be defined. The definition will be such that shuttle induced environments for payloads can also be investigated with experiments on the module. The module definition will also be such that the module can be placed into orbit and later returned to earth on early shuttle development missions and in no way interfere with the primary purpose of these missions, namely the development of the shuttle. The investigations and definition of experiments for the module will be performed by LRC with the aid of other NASA Centers as well as contracted activities in industry, universities, etc. The investigations and definition of the module configuration and module systems will be performed by MSFC under the overall module direction of LRC

W73-70835 **975-73-48**

Langley Research Center, Langley Station, Va.

DEFINITION OF EXPERIMENTS FOR A PHYSICS AND CHEMISTRY LABORATORY IN SPACE

C. H. Nelson 703-827-2893

NASA programs such as Space Shuttle and Space Station offer unparalleled opportunities for scientific investigations in space covering a wide range of technical disciplines. Two important and related disciplines are physics and chemistry. NASA is planning a space laboratory to support a wide range of original physics and chemistry experiments which makes use of the unique environmental conditions in space. It is envisioned that this laboratory will be available to universities and research laboratories, both in the U.S. and abroad, to conduct experiments with a minimum of expense and lead time, and thus allow new opportunities to experimenters who might otherwise be unable to participate in space experiments. Previous studies have developed a catalogue of experiments considered representative of the types of experiments which will be performed in space in the next decade. Follow-on studies have used the experiment requirements as input to Space Shuttle, Space Station, Research Applications Module (RAM) and other studies to identify interface and support requirements. The study proposed herein will extend work done in the past by (1) defining a small number of specific experiments to be conducted in a physics and chemistry laboratory in space, (2) identifying potential principal investigators for each experiment, and (3) conducting experiment definition studies for the more promising experiments.

W73-70836 **975-73-48**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
PHYSICS AND CHEMISTRY - SUPERFLUID HELIUM
John W. Lucas 213-354-4530

The objective of the work to be carried out under this RTOP is to define a superfluid helium experiment to be performed in an earth orbiting laboratory. The experiment will be used to study the unusual hydrodynamics and thermodynamics of superfluid drops. The hydrodynamics of superfluid drops is not only of interest in its own right, but may also shed light on the dynamics of nuclear fission and the hydrodynamics of pulsars. This experiment -- the first to observe the hydrodynamics of superfluid helium in the absence of constraining walls -- will help answer the question: What role do such walls play in the many and varied phenomena that have been observed in superfluid helium in the last thirty years? Techniques to be developed in the design and performance of this experiment for handling, and even manufacturing, superfluid helium in space will be useful for future space missions. Provision can be made to extend a portion of this experiment into an engineering experiment to design and study a superfluid cooling system that can operate in space

W73-70837 **975-75-49**
Marshall Space Flight Center, Huntsville, Ala.
SPACE SHUTTLE LASER COMMUNICATION EXPERIMENT
J. L. Randall 205-453-3770
(975-22-01; 115-22-05; 115-22-06)

The objective of this program is to develop and implement a flight program to demonstrate a high data rate optical communication (Op/Com) link between a shuttle spacecraft (or other low earth orbit satellite) and a synchronous satellite. This would demonstrate the capability of optical communication for a high data rate relay system from a low earth orbit satellite to ground via synchronous relay satellites. To develop a flight program which will lead to an Op/Com system to be placed on a Space Shuttle (or other Low Earth Orbit (LEO) satellite). This LEO Op/Com system will communicate with an Op/Com package which is being developed now to fly on the ATS-G synchronous satellite. A definition and design study of the LEO Op/Com package is being initiated in FY 72 to start this task. Trade off studies will be performed to optimize the communication capability between this package and the ATS-G Op/Com package. In order to allow for careful planning and coordination the study will be performed by the prime contractor for the ATS-G Op/Com package The FY 73 effort will continue this study and an MSFC in-house effort will begin to develop a preliminary project plan to be submitted by January 1973 to NASA Headquarters for review.

W73-70838 **975-75-50**
Goddard Space Flight Center, Greenbelt, Md.
SPACE SHUTTLE ZERO G MIRROR TEST FACILITY
John Mangus 301-982-4532
(115-24-07; 976-30-20; 975-84-79; 188-78-56; 975-84-20)

The objective is to develop a technology mirror, three meters in diameter, for an optical research test facility for short duration shuttle flights to measure the performance, under operating conditions as a step in the manufacturing process, of large diameter light weight diffraction limited mirrors. The development of Zero G technology for these light weight optical elements is one of the major pacing technology development efforts required for orbiting high resolution earth resources and astronomical telescope systems. The single most important function of this general purpose facility will be the detection and evaluation of dimensional changes which occur on mirror surfaces as a result of the transition from one G to Zero G environment. In addition, the evaluation of thermal gradients on diffraction limited surfaces and the effects of thermal/structural distortions on advanced earth resources and stellar optical packages will be measured. Both are fundamental to the development of operational high resolution telescopes.

W73-70839 **975-84-41**
Goddard Space Flight Center, Greenbelt, Md.
HIGH RESOLUTION SPECTROGRAPH FOR SELECTED SOLAR SPECTRAL LINES
S. D. Jordan 301-982-4872

The Laboratory for Solar Physics, GSFC, proposes to build and test a high resolution spectrometer, which will be built to obtain line profiles for several selected solar spectral lines of chromospheric and transition region origin. The main scientific purpose of the anticipated flight experiment will be to use the spectral data to study wave propagation and mechanical heating in the chromosphere and the transition region. A secondary objective will be to determine the temperature and electron density structure of the line forming regions. It is assumed that a large space telescope of a very high maximum spatial resolution (better than 1.0 arc sec) will be available Preliminary meetings with Dr. Harold Zirin of the California Institute of Technology indicate that his photoheliograph instrument offers one such possibility.

W73-70840 **975-84-78**
Goddard Space Flight Center, Greenbelt, Md.
OPTICAL INSTRUMENTS SYSTEM FOR THE LARGE SPACE TELESCOPE
K. L. Hallam 301-982-6609
(188-78-56; 188-78-57; 188-78-58)

The purpose of this effort is to provide for the development of the system of optical instrumentation for the Large Space Telescope (LST) required for the Research and Application Module (RAM) concept of the OMSF as given in NHB 7150.1 "Reference Earth Orbital Research and Applications Investigations" (Blue Book). The LST must provide the astronomer with the capability of analyzing the spectrum from the ultraviolet to the infrared. In order to provide this capability a full complement of possible instruments must be identified and defined. This Instruments System must then be optimized within the constraints of the entire telescope system which must itself then be influenced by the Instruments System requirements. The Instruments System includes: field imaging cameras, imaging spectrographs, high resolution spectrographs, polarimeters, spectrometers, spatial interferometers and the offset fine error sensor. The instruments must be modular for in-orbit replacement and responsive to the RAM interfaces. Systematic development of the Instruments System will require design analysis, breadboarding, prototype construction and laboratory evaluation.

Space Shuttle Technology

W73-70841 **976-30-09**
Lewis Research Center, Cleveland, Ohio.
NUCLEAR WASTE DISPOSAL IN SPACE
F. E. Rom 216-433-4000

The objective of the study is to determine the technical feasibility, cost and safety of disposing of nuclear radioactive waste in space. More specifically, the use of the shuttle and expendable vehicles as a means for launching safely contained quantities of nuclear radioactive waste material into space will

be investigated. Consideration will be given to (1) various disposal destinations (i.e., earth escape, solar orbits, solar escape and solar impact); (2) trajectories launch and re-entry; (3) payload for various vehicles and combination; (4) packaging techniques for various nuclear waste materials; (5) safety assessment from point of view of hazards to general population; (6) assessment of technical feasibility of constructing containment systems that would prevent the release of fission products from any foreseeable situation; and (7) assessment of the overall cost of the system for disposing of nuclear waste material that is designed for acceptable low potential hazards to the general population.

W73-70842 **976-30-20**
Goddard Space Flight Center, Greenbelt, Md.
INTERFACE DEFINITION STUDY OF SHUTTLE BASED REMOTE MANIPULATOR SYSTEM FOR DOCKING, RESUPPLY AND/OR RETRIEVAL OF SATELLITES
Frank J. Cepollina 310-982-6044
(188-78-56; 975-84-79)

The overall objective of this study is to define the general interface requirements between a shuttle-based remote manipulator system and an orbiting spacecraft relative to shuttle-to-spacecraft docking, resupply and retrieval activities. This study shall deal with establishment and definition of requirements from the standpoint of spacecraft, end effectors and shuttle manipulator, to effect these shuttle activities via a remote manipulator system. During the course of the study, the characteristics requirements and constraints of spacecraft and end effectors to be examined shall include (but not be limited to) the following: (1) Acceptable spacecraft impact loads, (2) Spacecraft provisions for docking, (3) Desirable resupply functions, (4) End effector configurations, (5) Thermal control requirements, (6) Telemetry requirements, (7) Module placement accuracy, (8) Module insertion and breakaway forces, (9) Spacecraft C.G. offsets, (10) Visual sensor needs, (11) Lighting requirements, and (12) Control and display facilities in shuttle.

W73-70843 **976-52-40**
Marshall Space Flight Center, Huntsville, Ala.
DYNAMICS AND AEROELASTICITY
Henry E. Attaya, Jr. 205-453-1121

The objective of this RTOP is to provide the technological basis for improvement and development of analytical and test techniques required to solve critical problems in the following discipline areas: Buffet, Vehicle Dynamics and Response, Noise and Vibration, and Ground Winds applicable specifically to the Space Shuttle (SS). Particular emphasis will be placed on technology improvements needed because of unique shuttle mission requirements and environments, the extreme weight criticality, the unique control requirements, configurations, parallel stacking of multi-stages, water impact and recovery of solid stages, and the sensitivity of the vehicle weight to the dynamic environment. The present configuration has a very strong structural-control-trajectory coupling which requires advancement of state-of-the-art techniques which consider these three disciplines as separate entities. This technology will be acquired through theoretical analysis, dynamics and aeroelastic expermental testing and computer simulation, wind tunnel testing of scale models. This effort is a continuation and up-date of effort covered in FY 72 under 976-30-40.

Research and Application Modules

W73-70844 **977-41-05**
Manned Spacecraft Center, Houston, Tex.
EOS/SPACE STATION - ELECTRICAL POWER
J. L. Cioni 713-483-5361

This program is concerned with power generation and energy storage. In this program, the feasibility of a 10,000 sq ft, flexible solar array for space stations will be demonstrated by manufacturing and testing full scale hardware which is designed to meet the wide range of requirements posed by the space station configurations under study within NASA. For energy storage, a 100 ampere-hour nickel cadmium cell and battery module are being developed. The solar array program (LMSC-Sunnyvale; NAS 9-11039) and the Ni-Cd Battery Program (Grumman-Bethpage; NAS 9-11074) were initiated on FY 70 funds and continued with FY 71 funds. The funds from this RTOP being applied to the Solar Array (NAS 9-11039) and Battery (NAS 9-11074) programs will carry both activities to a point where the programs can be logically concluded and Battery activities will be primarily to obtain long duration testing on the same order as space station missions durations. During the current fiscal year the scope of the Lockheed Solar Array Program is increased to provide the planning necessary to implement a thermal cycling test program for flexible solar arrays. In this planning activity, Lockheed will determine test methods, facility requirements, cost, etc., necessary to implement a standardized, high volume thermal test program. The scope change will also provide for performing studies using the modular hardware developed in the program for alternate station/shuttle applications.

W73-70845 **977-41-06**
Manned Spacecraft Center, Houston, Tex.
EOS SPACE STATION LIFE SUPPORT
Noel C. Willis 713-483-2171
(970-52-10)

The objective of the current ETC/LSS development program is to design, develop and test a flight prototype subsystem to support future long duration earth orbital missions. An equally important objective of this program is to exercise a management approach to advanced hardware development which will reduce the ultimate cost of flight systems. The program philosophy entails development of the ETC/LSS Life Support System Hardware utilizing a flight qualifiable design with sufficient flexibility, such that the program could be applicable to a variety of mission considerations. The basic subsystem performance requirements dictate accommodation of a 6 man crew over a total pressure range of 10 psia to 14.7 psia, with a useful lifetime of 2 years and 180 day resupply interval. Specifically, the space station prototype (SSP) ETC/LSS maintains vehicle cabin pressure, provides a conditioned shirtsleeve atmosphere for the crew, maintains thermal control of electronic equipment and control of the closed-cycle water-supply system and solid wastes. Unlike previous life support systems, the SSP ETC/LSS is an advanced design utilizing the recovery of useful products in order to accommodate long duration missions. The program does not presume to be the specific design for a particular vehicle configuration; however, the realism associated with designing and testing a system with flight type considerations is necessary to attack the systems integration and maintenance concepts associated with advanced ETC/LSS and to develop a low cost approach to managing complex systems for advanced programs.

W73-70846 **977-41-33**
Manned Spacecraft Center, Houston, Tex.
EOS/SPACE STATION IMS COMMUNICATIONS
R. E. Kosinski 713-483-2871
(977-41-07; 908-41-07)

The objectives of this RTOP address three aspects of communication systems of the future that represent departures from present practice. These are: Increased complexity of link interfaces, relay satellite use, and automatic configuration moding and control. In a space station communication complex, potential simultaneous users include station-earth direct, station-relay satellite, station-shuttle, EVA, station-free flying satellite, etc. All of these links could cause a severe frequency spectrum management and EMI (electromagnetic interference) problem. Further, the distribution of links among redundant items of communications equipment must be controlled automatically. In order to insure the success of communications, selected techniques must be investigated and subsystems developed. Specifically, (1) spectrum management and EMI control in multichannel systems will be investigated, (2) subsystem components that allow synthesis and modulation of signals for flexible multichannel communication will be developed, (3) a relay satellite-compatible dish antenna will be developed at K-band which features a reduction in equipment required for tracking, and (4) techniques for automatic RF equipment checkout and control will be investigated. The techniques and hardware developed under this RTOP will be incorporated into the CTB (communication terminal breadboard) being supplied by the space station phase B contractor (NR-ITT) to MSC for evaluation. At MSC, certain equipment gaps in the CTB will be filled, in addition to gaining insight into problems that may be encountered in an orbiting manned vehicle electromagnetic environment. Test and evaluation results will also be applicable to shuttle planning.

W73-70847 **977-41-33**
Manned Spacecraft Center, Houston, Tex.
EOS/SPACE STATION INFORMATION MANAGEMENT SYSTEM
E. A. Dalke 713-483-4065
(502-33-33; 909-44-33)

The objective of this effort is to evaluate various system configurations of the IMS Data Acquisition and Control Subsystem (DACS) so as to determine that configuration best suited for high data rate subsystem support functions such as closed-loop control and checkout, automatic sequencing, and data processing. The approach to be utilized in implementing this effort will be to interface the salient modules of the DACS (Data Bus Control Unit, 10 MBS data bus, and Remote Acquisition and Control Units) to simulated vehicle subsystems and the Computer System I/O. Such an approach will allow for the evaluation of the system's operational integrity and reliability such that comprises in the system's operational integrity and reliability directly associated with the high data rate can be determined and possible design changes proposed and evaluated. The integration of the Computer System I/O with the DACS will aid in evaluating redundant fault-tolerant computer configurations, in addition, this effort will also address itself to evaluating advanced controls and displays for man/machine interfacing.

W73-70848 **982-42-04**
Manned Spacecraft Center, Houston, Tex.
SPACE SHUTTLE ATTITUDE CONTROL PROPULSION
Henry O. Pohl 713-483-4971

The objective of this RTOP is to improve the auxiliary propulsion systems technology base in support of the space shuttle. The programs which comprise this RTOP are intended to provide design and operating data for alternate component and system concepts in direct support of phases C and D of the mainstream vehicle program, and to provide early identification of serious development or technology problems inherent in the primary system approaches. Programs within this RTOP encompass the reaction control system (RCS), the orbital maneuvering system (OMS) and the gas generator combustion devices for auxiliary power unit (APU) turbine. In the RCS area programs will be undertaken to further develop and evaluate nonmetallic (polymeric) seal materials for long term use in the RCS and OMS components. The RCS bipropellant engine technology program will be continued to study reuse and maintainability technology problems. A program will be undertaken to evaluate two light-weight RCS pressurization system concepts. A program will be undertaken to evaluate the basic compatibility problems which will exist between propulsion system materials and fluids In the OMS area a program will be undertaken to evaluate candidate engine cooling techniques. In the APU area a current program evaluating hydrazine gas generator designs will be extended to further evaluate reuse and maintainability capability.

W73-70849 **982-42-05**
Manned Spacecraft Center, Houston, Tex.
SPACE SHUTTLE - ELECTRICAL POWER
G. D. Hydrick 713-483-3286

The objective is to provide technology readiness of fuel cell power generation systems for the space shuttle and to provide supporting systems integration efforts to satisfy shuttle electrical power requirements. The present parallel technology development program will be continued to establish a level of technical readiness in fuel cell power generation. This parallel effort will be maintained to a calendar date which approximates the selection of a fuel cell subcontractor by the shuttle prime contractor. Then, a single contractor effort will be retained to support in-house MSC testing and evaluation efforts which support the mainline shuttle program. The two programs will pursue, (1) an alkaline fuel cell technology at P and W (Pratt and Whitney) and (2) an acid fuel cell technology at GE (The General Electric Company).

W73-70850 **982-42-37**
Manned Spacecraft Center, Houston, Tex.
SPACE SHUTTLE - CRYOGENIC STORAGE SYSTEM
W. A. Chandler 713-483-4771

The space shuttle will require cryogenic storage systems for boost propulsion, fuel cell and environmental control/life support functions and pressurization systems. The storage systems must supply conditioned fluids for up to 7 days and satisfy the shuttle requirements of complete reusability, low cost, minimum maintenance and maximum safety. Present technology is inadequate to meet these requirements. Therefore, selected critical programs were initiated in FY 72 to satisfy these deficient technological areas and will be continued with FY 73 funds The overall program objective is to provide the cryogenic system technology necessary to meet all the objectives for a low cost reusable shuttle vehicle.

W73-70851 **982-42-38**
Manned Spacecraft Center, Houston, Tex.
SPACE SHUTTLE - MATERIALS
R. E. Johnson 713-483-2050

The objective of this task is to select and pursue the development of promising RSI, ablator, and carbon/carbon TPS systems. Emphasis will be placed on material and coating improvements, application of large tile size, attachment design and inspection. Testing and engineering evaluation of gaps, joints, dissimilar material interfaces, closeouts, and material performance will be conducted to understand the implication of, and to verify the feasibility of utilizing advanced or back-up systems for the space shuttle vehicle. These activities will not be in competition to the prime contractor's effort, but will

augment design options available for final hardware selection. There are two major objectives to this RTOP. One is to explore the application of metal composite materials to spacecraft radiators and to simplify the fabrication of panel components from the composite tape material. The composite chosen for the program is boron-aluminum because of its elevated temperature capability, and good thermal properties. The FY 73 funding will be used to scale up the processes developed in FY 71 and FY 72 with the fabrication of a full-size radiator panel. The second objective of the RTOP is to improve the nondestructive testing (NDT) techniques for the detection of flaws in structural materials particularly the aluminum alloys. The approach will be to evaluate and improve existing NDT methods (X-ray, ultrasonic, dye penetrants, and eddy current) for the detection of tightly-closed fatigue cracks resulting from space shuttle operations, and the detection of lack of weld penetration during tank fabrication.

W73-70852 **982-42-39**
Manned Spacecraft Center, Houston, Tex.
SPACE SHUTTLE - AEROTHERMODYNAMICS
R. G. Gonzales 713-483-2237

This effort is designed to provide current state-of-the-art technology studies in support of the engineering design analysis on the space shuttle vehicles. It includes analytical studies and experimental testing as necessary to analyze vehicle aerothermodynamic characteristics and to accurately define performance capabilities. Studies will be performed in developing and improving the analysis and techniques for vehicle aerodynamic configuration trade studies currently being used for the space shuttle vehicle design. Analytical studies and experimental testing will be performed to analyze and evaluate the aerodynamic performance of this vehicle

W73-70853 **982-52-01**
Marshall Space Flight Center, Huntsville, Ala.
STRUCTURES
E. E. Engler 205-453-3958
(114-08-04; 976-30-61)

The objective of this RTOP is to provide the technological base to support the development of the Space Shuttle in the following structures areas: (1) Design Criteria and Analytical Techniques - For critically assessing and optimizing all factors affecting launch vehicle weight to provide maximum payload capability for a given thrust capability, along with emphasis on minimum cost of vehicle development and manufacture. (2) Structural Systems Development - To establish design, analysis, fabrication and inspection techniques and hardware experience necessary to provide low cost, lightweight structural systems with minimum development risks, and to provide realistic weight and cost data along with indications of those areas which show growth potential through the use of advanced filamentary composites and other lightweight materials. (3) Manufacturing Processes - For full scale bulge-formed LH2 bulkheads and LOX tank assembly, and development of the weld-on stiffener concept for tank reinforcement. The approaches to be used in achieving the objectives of this effort will consist of studies, analysis, design, fabrication, materials evaluation, model and full scale tests, computer simulations, and structural testing and evaluation. This effort is a continuation of FY 72 RTOP 114-08-04 and 976-30-61.

W73-70854 **982-52-03**
Marshall Space Flight Center, Huntsville, Ala.
SHUTTLE, MAIN PROPULSION TECHNOLOGY
J. A. Lombardo 205-453-3800
(982-52-04)

The objective of this plan is to provide the required technology for SSME in the areas of POGO suppression, measuring dynamic flow to analyze POGO perturbation devices, incipient failure and malfunction detection systems, reactivity of materials in high pressure oxygen and thermodynamic properties of cryogens at high pressures. Studies will be made to determine the size and location of gas accumulators to inhibit interaction between the SSME propulsion system and vehicle structural modes in order to suppress POGO. The POGO perturbation device for exciting propulsion systems to natural frequencies study will determine methods of dynamic data acquisition in cryogenic systems, and methods of measuring dynamic flow to establish the preferred method, bleed or position displacement pulsers, will be studied. Incipient mechanical failure and malfunction detection will be studied, analyzed, and systems developed to have many components and subsystems monitored by the on-board engine checkout and monitoring system. The reactivity of materials in high pressure, 100 per cent oxygen, will be determined with an impact tester; and the thermodynamic properties of cryogens will be experimentally determined for a wide range of temperatures at pressures up to 15,000 psi. This is a follow-up of FY 72 effort covered under RTOP 113-31-14.

W73-70855 **982-52-38**
Marshall Space Flight Center, Huntsville, Ala.
MATERIALS TECHNOLOGY FOR SPACE SHUTTLE
C. E. Cataldo 205-453-1277
(114-03-35; 114-03-32; 114-03-34)

The objective is to develop and evaluate advanced materials for use in the Space Shuttle. The following tasks will be undertaken during FY '73: Oxygen and Hydrogen Compatibility, Corrosion, Lubricants, Software Materials - Oxygen Compatible Adhesives, High Strength Welds in Aluminum Plate, Drop Tank Insulation, Adhesives for use at Cryogenic Temperatures, and High Temperature Fasteners for Reuseable Thermal Protection System Panels. Pertinent physical, chemical and/or environmental tests such as corrosion, high temperature tensile etc. will be performed in the appropriate task. The results will be used to evaluate and direct the approach to the solution of the problems contained in this RTOP to improve the material usage for Space Shuttle.

W73-70856 **982-52-43**
Marshall Space Flight Center, Huntsville, Ala.
SPACE SHUTTLE THERMAL PROTECTION SYSTEM
J. L. Vaniman 205-453-3821
(976-30-61)

The two tasks included under this RTOP are directed toward verification of the thermal protection system design of two primary regions of the space shuttle booster and orbiter: (1) The solid rocket motor and orbiter drop tank sidewalls and (2) The SRM and drop tank base region. Some effort, too, will be toward TPS design verification of the orbiter base region and LOX/LH2 engine nozzles. The verification will include analytical studies and test programs coordinated with subjunctive tasks aimed at supporting the reuse capability of some regions of the overall vehicle TPS. Disposable TPS trade studies and test programs are also scheduled. Supplemental tasks dealing with TPS degradation, damage surveillance, material requirements, and flight measurement instrumentation are also planned to provide basis of credibility of flight documentation and assessment of multi-mission design impact on TPS cost and weight figures. Projected RTOP completion is one year for all objectives. Contracted efforts are planned to be complemented by inhouse efforts. This is a continuation of FY 72 effort under Code 976-30-61.

RTOP Summary

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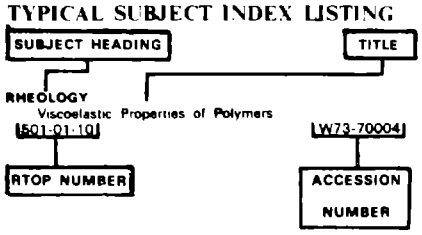

A title is used to provide a more exact description of the subject matter. The RTOP accession number is used to locate the bibliographic citations and technical summaries in the Summary Section

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Programs - YF-12 Research Aircraft
766-72-02 W73-70220
EOS/Space Station/Flexible Spacecraft Simulation Program
502-23-45 W73-70337

DYNAMIC LOADS
Multi-KW DC Distribution System - Evaluation and Demonstration
502-25-73 W73-70309

DYNAMIC STABILITY
Flight Simulation Technology - Piloting Cues
501-29-14 W73-70054
V/STOL Tilt Rotor Research Aircraft Project
767-78-01 W73-70224

DYNAMIC STRUCTURAL ANALYSIS
Loads and Structural Dynamics
501-22-05 W73-70019
Loads and Structural Dynamics
501-22-05 W73-70020
Flight Loads Measurement Techniques
501-22-08 W73-70022
Hypersonic Vehicle Structures Technology
501-22-06 W73-70025
Hypersonic Vehicle Structures Technology
501-22-06 W73-70026
Spacecraft Launch Dynamics
502-22-04 W73-70266
Shuttle Dynamics and Aeroelasticity
502-32-02 W73-70271

DYNAMIC TESTS
Spacecraft Launch Dynamics
502-22-04 W73-70266

E

EARTH (PLANET)
Geophysical Processes Related to Origin and Evolution of the Planets
185-50-50 W73-70586

EARTH ALBEDO
Extended Measurement of Albedo and Terrestrial Radiation
160-44-65 W73-70460

EARTH ATMOSPHERE
Basic Pollution Research
501-04-02 W73-70063
Basic Pollution Research
510-04-02 W73-70066
Lasers for Remote Sensing
502-23-56 W73-70354
Analysis of Energy Interactions Between Levels of the Atmosphere and Solar Terrestrial Relationship
160-44-55 W73-70453
Numerical Model and Simulation of Severe Storms Coupled Earth Energy and Mass Transport Cycles
160-44-63 W73-70458
Development of Neutral Mass Spectrometers for Planetary Atmosphere Experiments
185-47-52 W73-70573
Planetary Atmospheric Processes and Measurements

185-47-91 W73-70584
Magnetospheric Physics - Radio Science
188-36-57 W73-70618
EARTH ENVIRONMENT
Lasers for Remote Sensing
502-23-56 W73-70354
EARTH ORBITAL RENDEZVOUS
Feasibility Study of a Solar Electric Propulsion Stage (SEPS) for Geosynchronous Missions
502-24-13 W73-70294
EARTH ORBITS
Feasibility Study of a Solar Electric Propulsion Stage (SEPS) for Geosynchronous Missions
502-24-13 W73-70294
Earth Orbital Reentry Technology: Thermal Protection Systems
502-27-02 W73-70316
Earth-Orbital Reentry Technology
502-27-02 W73-70317
Advanced Spacecraft and Experiment Control Systems
502-23-44 W73-70336
Use of the Solar Electric Propulsion Stage (SEPS) for Earth Orbital Application
164-76-84 W73-70551
EOS Space Station Life Support
977-41-06 W73-70845
EARTH RESOURCES
Environmental Engineering-Energy Management, Ground Transportation, and Air Pollution Reduction
770-18-01 W73-70392
Microwave Radiometry for Remote Sensing
160-20-54 W73-70444
IPL Methods for Geologic Mapping
160-20-54 W73-70445
Calibration, Evaluation and Simulation of Earth Resource Multichannel Surface Sensors
160-20-58 W73-70448
Remote Sensing of Vegetation and Wildland Resource Stresses
160-75-02 W73-70467
Remote Sensing of Vegetation and Wildland Resources
160-75-02 W73-70469
Remote Sensing for Global Land-Use Mapping and Resource Management in Geography, Demography, and Cartography
160-75-07 W73-70472
Remote Sensing of Physical Oceanography, Coastal Processes and Estuaries
160-75-17 W73-70488
Remote Sensing for Multiple Resource Survey
160-75-30 W73-70504
Remote Sensing for Multiple Resource Surveys in the Chesapeake Bay Area
160-75-30 W73-70505
Remote Sensing - Sensor Technology for Earth Resources Survey
160-75-31 W73-70506
Remote Sensing Sensor Technology for Earth Resources Survey
160-75-31 W73-70507
Remote Sensing Sensor Technology for Earth Resources Survey
160-75-31 W73-70508
Remote Sensing Sensor Technology for Earth Resources Survey
160-75-31 W73-70509
Remote Sensing Data Management and Interpretation Techniques for Earth Resources Survey
160-75-32 W73-70510
Remote Sensing Data Management and Interpretation Techniques for Earth Resources Survey
160-75-32 W73-70511
Remote Sensing Data Management and Interpretation Techniques for Earth Resources Survey
160-75-32 W73-70512
Remote Sensing Data Management and Interpretation Techniques For Earth Resources Survey
160-75-32 W73-70513
Oceanographic Remote Sensing
160-75-66 W73-70517
Microwave Geothermal Exploration
160-75-69 W73-70519
Earth Resources Laboratory at Mississippi Test Facility
160-75-85 W73-70520
Earth Resources Data Base
160-75-88 W73-70521
Applications of Vector Magnetometry to Earth Resources and Geological Studies
160-79-90 W73-70529
Interdisciplinary Support to Earth Observations Programs
160-88-50 W73-70530
EARTH RESOURCES PROGRAM
Climatological-Statistical Atmospheric and Cloud Cover Models
160-44-58 W73-70456
Atmospheric Effects Upon Remote Sensing from Aircraft and Satellites
160-44-60 W73-70457
EARTH RESOURCES SURVEY AIRCRAFT
Visible and IR Sensor Technology
160-20-53 W73-70442
EARTH RESOURCES TECHNOLOGY SATELLITE A
Earth Resources Data Base
160-75-88 W73-70521
EARTH RESOURCES TECHNOLOGY SATELLITES
Electronic Materials and Processes
502-03-51 W73-70330
IPL Methods for Geologic Mapping
160-20-54 W73-70445
Advanced Image Processing Techniques
160-20-59 W73-70449
Atmospheric Effects Upon Remote Sensing from Aircraft and Satellites
160-44-60 W73-70457
Remote Sensing for Global Land-Use Mapping and Resource Management in Geography, Demography, and Cartography
160-75-07 W73-70472
Remote Sensing for Multiple Resource Survey
160-75-30 W73-70504
Remote Sensing Data Management and Interpretation Techniques for Earth Resources Survey
160-75-32 W73-70514
Image Processing Facility Performance Evaluation and Improvement
150-22-39 W73-70722
EARTH ROTATION
Relativity and Celestial Mechanics
188-41-54 W73-70635
Lunar Ranging Experiment Laser System
195-43-51 W73-70698
EARTH SATELLITES
Earth-Oriented Attitude Reference
502-23-41 W73-70333
Automated Data Handling Techniques and Components
502-23-32 W73-70340
Data Management and Storage
160-20-52 W73-70439
Data Management and Storage
160-20-52 W73-70440
EARTHQUAKES
Short and Long Term Geodynamics
160-79-51 W73-70522
ECOLOGY
Remote Sensing/Water and Land Pollution
160-75-22 W73-70492
Chemical, Radiochemical, and Geologic Factors Affecting the Environmental Quality of the Chesapeake Bay Watershed
160-75-22 W73-70493
Remote Sensing: Water and Land Pollution, Biotic and Abiotic Degradation, Energy, Budget and Cultural Pressures
160-75-22 W73-70494
Remote Sensing of Water and Land Pollution
160-75-22 W73-70496
Remote Sensing National Park Areas and Archeological and Historical Sites
160-75-23 W73-70497
Remote Sensing for Multiple Resource Surveys in the Chesapeake Bay Area
160-75-30 W73-70505
Remote Sensing Data Management and Interpretation Techniques for Earth Resources Survey
160-75-32 W73-70514
Biological Adaptations
192-55-64 W73-70683
Environmental Quality
909-62-47 W73-70753
ECONOMIC ANALYSIS
Acceptance of Aircraft Operations - Technology Assessment
501-29-01 W73-70047
Ground-Based Simulation Technology
501-26-08 W73-70123
Systems Analyses of Long Haul High Productivity Transports (TST)
791-91-03 W73-70185
Aeronautical System Analysis (ACSYNT)
791-91-04 W73-70186
Improved Aeronautical System Analysis Capability
791-91-05 W73-70187
Study of the Effects of Government Directed Changes on Basic Costs and Schedule of Selected Flight Vehicles
791-92-04 W73-70192
Subsonic/Sonic CTOL Transport Technology System Analysis and Design Integration (ATT)
791-94-60 W73-70201
CTOL Transport Propulsion Studies
791-94-61 W73-70202
Advanced Propulsion Comparison Studies
792-91-01 W73-70436
Interdisciplinary Support to Earth Observations Programs
160-88-50 W73-70530
ECONOMIC FACTORS
Subsonic/Sonic CTOL Transport Technology Development Propulsion
501-24-60 W73-70082
Data Collection
164-76-60 W73-70545
Solar Power System Development
164-76-83 W73-70550
ECONOMICS
Analysis of Future Civil Air Transportation Systems and Concepts
791-93-03 W73-70195
Analysis of Future Military Aviation Systems and Concepts
791-93-04 W73-70196
Socio-Economic/Technical Assessment of Space Activities
790-92-01 W73-70382
EDUCATIONAL TELEVISION
Educational Communications Satellite System Study
164-06-58 W73-70533
Educational Communications Satellite System Study
164-06-58 W73-70534
EFFICIENCY
Solar Cell Basic Research
502-05-50 W73-70297
ELASTOMERS
Viscoelastic Properties of Polymers
501-01-10 W73-70004
AST Fuel Tank Sealants
501-31-71 W73-70015
Tire Traction, Braking
501-38-12 W73-70171
Crew Equipment Systems
970-52-30 W73-70814
ELECTRIC BATTERIES
Solid Electrolyte Research
502-05-51 W73-70298
Electrochemical Energy Storage Research
502-05-55 W73-70300
Deep Space Batteries
502-25-57 W73-70304
Power Systems and Circuits Development for Planetary Spacecraft
502-25-74 W73-70310
Space Shuttle Instrumentation/Sensors
502-33-85 W73-70359
ELECTRIC FIELDS
Electron Wave Interaction and Electromagnetic Research
503-10-02 W73-70425
Magnetospheric Physics - Particles and Particle/Field Interactions
188-36-55 W73-70608
Magnetospheric Physics - Particles and Partical/Photon Interactions
188-36-56 W73-70612
ELECTRIC GENERATORS
Power Processing For Earth Orbital Space Science and Applications Satellites
502-25-72 W73-70308
Power Conversion of Coherent Light
502-11-11 W73-70372
Brayton Conversion Technology
503-35-01 W73-70407
Plasma Dynamics
503-10-03 W73-70428
Solar Power System Development
164-76-83 W73-70550
EOS/Space Station - Electrical Power
977-41-05 W73-70844
ELECTRIC POWER
Space Shuttle H-O APU (was Flight Control Power Unit)
502-35-60 W73-70311
Terrestrial Applications of Solar Energy
502-35-62 W73-70312
Earth Orbital Systems Electric Power Technology
909-51-05 W73-70742
ELECTRIC POWER TRANSMISSION
Multi-KW DC Distribution System - Evaluation and Demonstration
502-25-73 W73-70309
Nuclear Power Systems Technology
503-25-07 W73-70404
Space Shuttle - Electrical Power
982-42-05 W73-70849
ELECTRIC PROPULSION
Physical Processes in Plasma Propulsion
502-04-14 W73-70277
Pioneer Solar Electric Propulsion Spacecraft
502-24-12 W73-70293
Electric Auxiliary Propulsion Systems for Application Satellites
757-51-09 W73-70386

30-cm Ion Thruster and Power Conditioner Development and Test
758-57-04 W73-70390
Solar Electric Thrust Subsystem Development
758-57-11 W73-70391
Liquid Metal MHD
503-05-02 W73-70399
Thermionic Reactor Power System Technology
503-25-02 W73-70401

ELECTRIC ROCKET ENGINES
30-cm Ion Thruster and Power Conditioner Development and Test
758-57-04 W73-70390

ELECTRO-OPTICS
Astronomical Sensors and Imaging Systems for Large Space Telescopes
502-23-54 W73-70352

ELECTROCHEMICAL CELLS
Electrochemical Energy Storage Research
502-05-55 W73-70300

ELECTRODES
Solid Electrolyte Research
502-05-51 W73-70298

ELECTROHYDRODYNAMICS
Thermal Control
502-21-27 W73-70246

ELECTROLYSIS
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970-22-21 W73-70788

ELECTROLYTIC CELLS
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502-05-51 W73-70298

ELECTROMAGNETIC FIELDS
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188-41-59 W73-70642
Soft X-Ray Spectroscopy for Shuttle
188-41-61 W73-70645

ELECTROMAGNETIC INTERFERENCE
EOS/Space Station IMS Communications
977-41-33 W73-70846

ELECTROMAGNETIC RADIATION
Electron Wave Interactions
503-10-02 W73-70426
Magnetospheric Physics - Radio Science
188-36-57 W73-70618
Experiment Development - Laboratory and Theoretical Solar Physics
188-38-53 W73-70627
Astronomy in the 150 keV to 15 MeV Range
188-46-55 W73-70663

ELECTROMAGNETIC SCATTERING
Experiment Development - Laboratory and Theoretical Solar Physics
188-38-53 W73-70627

ELECTROMAGNETISM
Lunar and Planetary Studies
185-50-61 W73-70588

ELECTRON BOMBARDMENT
Advanced Bombardment Thruster Technology
502-24-03 W73-70291

ELECTRON IRRADIATION
Planetary Solar Power Research
502-05-54 W73-70299

ELECTRON MICROSCOPES
Surface Physics and Chemistry
502-01-01 W73-70232

ELECTRON SCATTERING
Theoretical Studies-Planetary Atmospheres
185-47-72 W73-70583

ELECTRON SOURCES
Electronic Device and Systems Support
502-23-55 W73-70353

ELECTRONIC EQUIPMENT
Electronic Materials and Processes
502-03-51 W73-70330
Electronic Devices and Components
502-03-52 W73-70331
Screening and Reliability Testing of Microcircuits and Electronic Devices
502-23-52 W73-70350
Electronic Device and Systems Support
502-23-55 W73-70353

ELECTRONIC PACKAGING
Electronic Parts and Packaging for Outer Planet Missions
186-70-51 W73-70606
Advanced Technological Development, General On-Board Processing Electronics; Solid State Nuclear Detectors
188-78-51 W73-70670

ELECTROPHOTOMETRY
UV and Optical Astronomy
188-41-51 W73-70631

ELECTROSTATIC ENGINES
Ion Thruster Research
502-04-01 W73-70274
Advanced Bombardment Thruster Technology
502-24-03 W73-70291

ELEMENTARY PARTICLES
High Energy Cosmic Rays
188-46-52 W73-70657

EMBRITTLEMENT
Physics and Chemistry of Solids
501-01-02 W73-70001

EMISSION
Pollution Technology
501-24-02 W73-70069
Clean Combustor Technology
501-24-18 W73-70070

EMISSION SPECTRA
Infrared Astronomy
188-41-55 W73-70639
X-Ray Astronomy
188-41-59 W73-70642
Soft X-Ray Spectroscopy for Shuttle
188-41-61 W73-70645
Ground-based Infrared Astronomy
196-41-50 W73-70700
Adaptation of Mariner Mars IRIS Breadboard for Space Shuttle Missions
196-41-52 W73-70702

ENDOCRINE SYSTEMS
Endocrinology
970-21-16 W73-70777
Endocrinology
970-51-16 W73-70801

ENDOCRINOLOGY
Endocrinology
970-21-16 W73-70777

ENERGY ABSORPTION
Gamma Ray Astronomy
188-46-54 W73-70661

ENERGY CONVERSION
Energy Conversion Generation and Transport Research
503-05-01 W73-70398
Thermionic Reactor Power Technology
503-25-01 W73-70400
Thermoelectric Systems Technology
503-35-04 W73-70410
Electron Wave Interactions
503-10-02 W73-70426

ENERGY DISTRIBUTION
High Energy Cosmic Radiation
188-46-52 W73-70658

ENERGY REQUIREMENTS
Solar Power System Development
164-76-83 W73-70550

ENERGY SOURCES
Terrestrial Applications of Solar Energy
502-35-62 W73-70312

ENERGY SPECTRA
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188-46-58 W73-70666

ENERGY STORAGE
Electrochemical Energy Storage Research
502-05-55 W73-70300
EOS/Space Station - Electrical Power
977-41-05 W73-70844

ENERGY TRANSFER
Environmental Engineering-Energy Management, Ground Transportation, and Air Pollution Reduction
770-18-01 W73-70392
Atmospheric Chemical Physics - Research Studies of Processes in Planetary Atmospheres, Comets and Interstellar Space
185-47-66 W73-70579

ENGINE CONTROL
Inlet Technology
501-24-05 W73-70073

ENGINE DESIGN
Advanced Airbreathing Propulsion Systems Analysis
791-91-10 W73-70189
CTOL Quiet Clean Engine (MK II)
791-94-08 W73-70200
Upper Stage and Planetary Experimental Motors
758-56-47 W73-70389

ENGINE INLETS
Inlet Technology
501-24-05 W73-70073

ENGINE NOISE
Structural Acoustics
501-22-07 W73-70021
Basic Noise Research
501-04-01 W73-70058
Basic Noise Research
501-04-01 W73-70060
Noise Technology
501-24-01 W73-70067
Noise Technology
501-24-01 W73-70068
AST Propulsion Noise
501-24-19 W73-70079
VTOL Technology
501-24-11 W73-70084
VTOL Technology
501-24-11 W73-70085
STOL Technology
501-24-12 W73-70087
Engine Noise and Sonic Boom Effects
501-38-15 W73-70179
CTOL Quiet Clean Engine (MK II)
791-94-08 W73-70200
CTOL (MK I) Quiet Engine
765-68-01 W73-70206

ENGINE PARTS
Composite Materials Application to Aircraft Structures
501-22-03 W73-70028

ENGINE TESTS
VTOL Technology
501-24-11 W73-70085
JT3D/JT8D Retrofit Demonstration
765-70-01 W73-70208

ENVIRONMENT MODELS
Meteors and Meteoroid Studies
502-21-29 W73-70252
Environmental Design Criteria
502-21-30 W73-70253
Operations, Maintenance and Safety
909-52-31 W73-70751

ENVIRONMENT POLLUTION
Short-Haul V/STOL Transportation System Studies
791-93-01 W73-70193
Environmental Engineering-Energy Management, Ground Transportation, and Air Pollution Reduction
770-18-01 W73-70392
Remote Sensing/Water and Land Pollution
160-75-22 W73-70492
Operations, Maintenance and Safety
909-52-31 W73-70751
Shuttle Atmospheric Pollution Monitoring Experiment Using Active Optical Techniques
975-61-02 W73-70829
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976-30-09 W73-70841

ENVIRONMENTAL CONTROL
Hypersonic Vehicle Structures Technology
501-22-06 W73-70026

ENVIRONMENTAL ENGINEERING
Environmental Engineering-Energy Management, Ground Transportation, and Air Pollution Reduction
770-18-01 W73-70392
Technology Applications to Environmental Problems
770-18-04 W73-70394
Space Technology Applications (STA)
770-18-08 W73-70395
Environmental Factors Effects
970-51-35 W73-70804

ENVIRONMENTAL TESTS
Environmental Design Criteria
502-21-30 W73-70253

EOSS
EOS/Space Station - Thermal Control
909-41-02 W73-70737
EOS/Space Station Communications
909-41-07 W73-70738
EOS/Space Station Checkout
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EOS Space Station Life Support
977-41-06 W73-70845
EOS/Space Station IMS Communications
977-41-33 W73-70846
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977-41-33 W73-70847

ERROR DETECTION CODES
Coding for Space Communication
502-23-13 W73-70344
Network Data Stream Performance Monitoring and Control
150-22-70 W73-70734

ERRORS
Earth Statics/Dynamics - VLBI
160-79-64 W73-70525

ESTUARIES
Remote Sensing of Physical Oceanography, Coastal Processes and Estuaries
160-75-17 W73-70487
Remote Sensing of Physical Oceanography, Coastal Processes and Estuaries
160-75-17 W73-70488
Remote Sensing of Biomes, Ecosystems, Ecological Dynamics and Productivity Pressures
160-75-21 W73-70490
Remote Sensing: Water and Land Pollution, Biotic and Abiotic Degradation, Energy, Budget and Cultural Pressures
160-75-22 W73-70494
Oceanography Studies (Radar)
160-75-67 W73-70518

EVACUATING (TRANSPORTATION)
Evaluation Program of Improved Aircraft Cabin Materials
501-38-19 W73-70180

EVALUATION

Calibration, Evaluation and Simulation of Earth Resource Multichannel Surface Sensors
160-20-58 W73-70448
EVOLUTION (DEVELOPMENT)
Comets and Asteroids
188-45-51 W73-70647
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192-55-61 W73-70678
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195-42-51 W73-70690
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Electron Wave Interaction and Electromagnetic Research
503-10-02 W73-70425
EXHAUST GASES
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501-04-02 W73-70062
Basic Pollution Research
501-04-02 W73-70063
Basic Pollution Research
510-04-02 W73-70066
Pollution Technology
501-24-02 W73-70069
Clean Combustor Technology
501-24-18 W73-70070
Environmental Quality
909-82-47 W73-70753
EXHAUST NOZZLES
Nozzle Technology
501-24-06 W73-70074
EXHAUST SYSTEMS
Airport Air Pollution
501-38-17 W73-70168
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192-55-63 W73-70681
Biological Adaptation
192-55-64 W73-70682
Biological Adaptations
192-55-64 W73-70683
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192-55-65 W73-70685
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970-51-16 W73-70801
Radiobiology
970-51-63 W73-70808
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Definition of Experiments and Instruments for a Communication/Navigation Research Laboratory
164-76-80 W73-70548
Definition of Experiments for a Physics and Chemistry Laboratory in Space
975-73-48 W73-70835
EXPLOSIVE WELDING
Explosive Welding for Earth Orbital Fabrication
909-71-21 W73-70745
EXPOSURE
Definition of Meteoroid and Exposure Module for Shuttle Launch and Recovery
975-72-51 W73-70834
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502-21-30 W73-70255
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192-55-61 W73-70678
EXTRATERRESTRIAL LIFE
Life Detection
192-55-63 W73-70680
Life Detection
192-55-63 W73-70681
Biological Adaptation
192-55-64 W73-70682
EXTRATERRESTRIAL MATTER
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188-45-53 W73-70652
EXTRATERRESTRIAL RADIATION
Radiation Shielding and Dosimetry
502-21-32 W73-70256
Isotopic Abundances in Low-Energy Cosmic Radiation
188-46-51 W73-70655
X-Ray and Gamma Ray Astronomy
188-46-53 W73-70659
Radiation Biology
970-21-63 W73-70787
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970-51-63 W73-70808
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Crew Equipment Systems
970-22-30 W73-70791
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970-52-30 W73-70814
EXTREMELY HIGH FREQUENCIES
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164-21-54 W73-70538
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909-44-07 W73-70759

F

F-111 AIRCRAFT
F-111 TACT Research Aircraft
766-76-02 W73-70212
F-8 AIRCRAFT
F-8 Supercritical Flight Experimental Program
766-73-61 W73-70221
FABRICATION
Advanced Materials for Aircraft
501-21-20 W73-70008
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501-21-26 W73-70011
Explosive Welding for Earth Orbital Fabrication
909-71-21 W73-70745
FABRICS
Support of DoD in Balloon Engineering
501-22-10 W73-70023
FAIL-SAFE SYSTEMS
Earth Orbital Reentry Technology Thermal Protection Systems
502-27-02 W73-70316
FAILURE ANALYSIS
Screening and Reliability Testing of Microcircuits and Electronic Devices
502-23-52 W73-70350
A Vehicle Status and Monitoring System
502-33-82 W73-70356
Aerozine 50/N2O4 Autogenous Pressurization System
180-31-02 W73-70565
FAILURE MODES
Engineering Instrumentation
180-24-51 W73-70564
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Remote Sensing of Vegetation and Wildland Resource Stresses
160-75-02 W73-70467
Remote Sensing of Vegetation Stress
160-75-02 W73-70468
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160-75-02 W73-70469
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501-21-21 W73-70013
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501-22-01 W73-70017
Loads and Structural Dynamics
501-22-05 W73-70020
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501-22-02 W73-70024
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975-72-32 W73-70832
FATIGUE TESTS
Orbital Fatigue Experiment
975-72-32 W73-70832
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Advanced Liquid Rocket Component Technology
502-24-24 W73-70285
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502-24-26 W73-70286
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Composites
501-21-23 W73-70006
Composites for Shuttle
502-31-52 W73-70261
FIGHTER AIRCRAXT
Military Aircraft - Vectored Thrust Maneuverability
760-67-03 W73-70160
Military Aircraft - Remote Piloted Vehicle
760-67-05 W73-70161
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760-17-01 W73-70162
YF-12 Flight Tests
766-72-01 W73-70216
YF-12 Disciplinary Research
766-72-02 W73-70217
YF-12 Disciplinary Research
766-72-02 W73-70218
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766-72-02 W73-70219
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502-32-03 W73-70272
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Identification of Fingerprints by Optical Processing
164-06-70 W73-70535
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501-21-22 W73-70010
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501-38-19 W73-70181
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770-18-02 W73-70393
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Remote Sensing of Oceanic Bio-Productivity
160-75-16 W73-70485
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Energy Conversion Generation and Transport Research
503-05-01 W73-70398
Plasma Dynamics
503-10-03 W73-70430
FISSIONABLE MATERIALS
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501-24-17 W73-70092
Plasma Dynamics
503-10-03 W73-70431
FLAPS (CONTROL SURFACES)
QUESTOL Project
741-87-01 W73-70205
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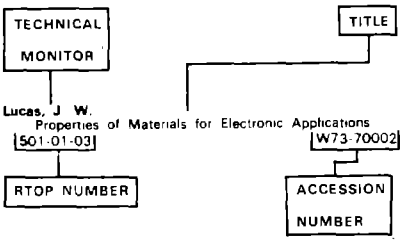

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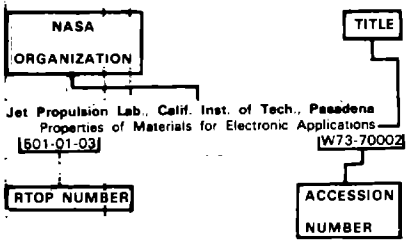

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