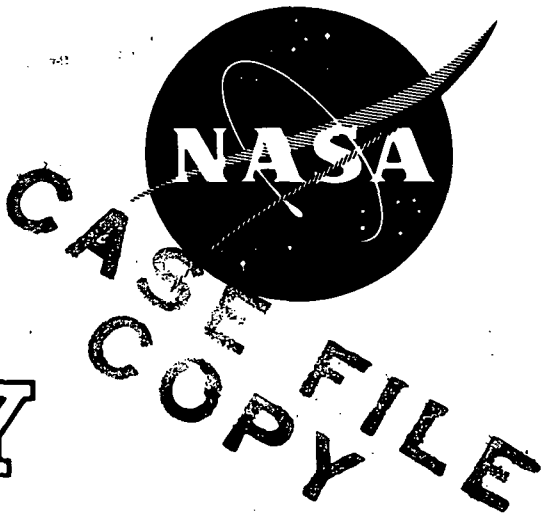
Research and Technology Operating Plan SUMMARY



FISCAL YEAR 1975
RESEARCH AND
TECHNOLOGY PROGRAM

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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INTRODUCTION

This publication represents the NASA Research and Technology program for FY 1975. 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 Management Systems Division (RM)
Washington, D.C. 20546

Dr. Alan M. Lovelace
Associate Administrator for
Aeronautics and Space Technology

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TYPICAL CITATION AND TECHNICAL SUMMARY

RTOP ACCESSION NUMBER → **W75-70003** — **504-09-21** ← RTOP CURRENT NUMBER

RESPONSIBLE NASA ORGANIZATION → Langley Research Center, Langley Station, Va.

TITLE → **RIDE QUALITY**

G. B. Graves 804-827-3745 ← TELEPHONE NUMBER

RELATED RTOPS → (504-29-21) ← TECHNICAL MONITOR

TECHNICAL SUMMARY →

The objectives of this research are to define and quantify those ride-environment properties, particularly motion and vibration, that determine ride quality and associated passenger acceptance pertaining to air transportation systems. Research studies are being conducted to develop data appropriate for establishing criteria for ride-environment requirements and for aircraft operational limits relevant to aircraft attitude, accelerations, and angular motions. Included are: field studies to obtain data aboard scheduled airline systems as well as other vehicles; studies under controlled conditions aboard research aircraft including in-flight simulators; laboratory studies using ride-motion simulators under very closely controlled conditions; and analytical studies of experimental data to model the phenomena and to develop criteria. Supporting efforts will be carried out as required to develop appropriate study methodology, subjective response opinion questionnaires, portable ride-measuring instruments, laboratory simulators, and analytical procedures.

RESEARCH AND TECHNOLOGY OPERATING PLAN

a summary **FISCAL YEAR 1975**

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

Aeronautics Research and Technology Base

W75-70001 **504-09-11**
Langley Research Center, Langley Station, Va.
HUMAN RESPONSE TO NOISE
G. W. Brooks 804-827-2042

The objective of this work is to define and quantify properties of aircraft noise that cause community annoyance. Included is the development of research evaluation techniques and measuring scales along with accomplishment of research to assess effects of aircraft noise on sleep, speech interference, and performance. Emphasis for FY-75 will be the check out, man-rating, calibration, and initial research implementations at the new Aircraft Noise Reduction Laboratory. This effort along with limited contract/grant studies will be directed toward studies concerned with noise annoyances, background noise, low frequency noise, speech/communication effects, sleep/performance effects, anxiety/fear, and multievent noise exposures. A downstream goal of this program is to develop a model for reliable prediction of responses of people to aircraft-generated noise.

W75-70002 **504-09-12**
Ames Research Center, Moffett Field, Calif.
ACCEPTANCE OF AIRCRAFT OPERATIONS - TECHNOLOGY ASSESSMENT
H. P. Klein 415-965-5094

The objective of this program is to develop an understanding of the social and psychological effects of large scale technological innovations, as exemplified by air transportation systems, particularly for short-haul operations, and to attempt to model such effects so as to impact the design of these systems. Studies of both the short and long term social impacts (including psychological, political, environmental, and economic) of short-haul air transport as an element of the total transportation system will be continued. Field studies of existing systems will be conducted as needed to meet the objectives. Laboratory studies of the behavioral and attitudinal effects and after-effects of aircraft sound stimuli will be conducted. Standard psychological judgment techniques will be used to assess degrees of annoyance associated particularly with the stimulus context and instructional context in which judged aircraft sounds are experienced. Behavioral effects will be assessed through a variety of recently developed cognitive and psychophysical task measures.

W75-70003 **504-09-21**
Langley Research Center, Langley Station, Va.
RIDE QUALITY
G. B. Graves 804-827-3745
(504-29-21)

The objectives of this research are to define and quantify those ride-environment properties, particularly motion and vibration, that determine ride quality and associated passenger acceptance pertaining to air transportation systems. Research studies are being conducted to develop data appropriate for establishing criteria for ride-environment requirements and for aircraft operational limits relevant to aircraft attitude, accelerations, and angular motions. Included are: field studies to obtain data aboard scheduled airline systems as well as other vehicles; studies under controlled conditions aboard research aircraft including in-flight simulators; laboratory studies using ride-motion simulators under very closely controlled conditions; and analytical studies of experimental data to model the phenomena and to develop criteria. Supporting efforts will be carried out as required to develop appropriate study methodology, subjective response opinion questionnaires, portable ride-measuring instruments, laboratory simulators, and analytical procedures.

W75-70004 **504-09-22**
Ames Research Center, Moffett Field, Calif.
RIDE QUALITIES CRITERIA VALIDATION/PILOT PERFORMANCE DURING LOW ALTITUDE HIGH SPEED FLIGHT
H. P. Klein 415-965-5094
(505-06-92)

Ride qualities, handling qualities and display qualities of large, flexible aircraft are important factors affecting pilot vehicle performance during severe turbulence penetrations. Existing ride qualities criteria, used as a guide in the design of the B-1 aircraft, need to be evaluated and refined. The B-1 development program offers an excellent opportunity for NASA to evaluate the results from planned simulation and flight tests to validate and refine current criteria for use in the design of future civil and military aircraft. Specific objectives are to: (1) validate/ refine current ride qualities criteria, and (2) develop pilot/vehicle systems models which account for the effects of ride qualities, handling qualities and display configuration on pilot terrain - following performance. Results from ongoing and planned NAR simulation and flight tests will be analyzed with the above objectives in mind. If practicable, NASA recommendations regarding simulator and/or flight experiment protocol and instrumentation will be implemented to maximize utility of results for NASA objectives. Ongoing simulator studies at Ames on the VARD (RTOP 505-06-92) will be continued to provide information and inputs as appropriate to the NAR B-1 development program.

W75-70005 **504-09-23**
Flight Research Center, Edwards, Calif.
ACCEPTANCE OF AIRCRAFT OPERATIONS - RIDE QUALITY
W. R. Winter, M.D. 805-258-3311

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 groundbase simulator capabilities. The effort 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. Passenger responses to turbulence encounters aboard commercial aircraft will be correlated with aircraft motions and turbulence levels to permit mathematical modeling.

W75-70006 **504-09-31**
Langley Research Center, Langley Station, Va.
FLIGHT MANAGEMENT SYSTEMS
G. B. Graves 804-827-3745
(768-81-01)

The objective of this research is to specify the crew responsibilities, flight procedures, control, and display requirements for advanced transport systems. The concerted effort underway to improve the safety and efficiency of advanced transport systems will require research in both hardware and human elements to systematically carry out the above objective. Therefore, the present work will take the following approaches: (1) develop tools and techniques that will define the crew responsibilities and measure their workload, (2) apply these tools and techniques to assess current and contemplated flight systems, and (3) develop analytical techniques that will assess advanced system requirements, human operation, and predict cockpit displays and controls needed for a satisfactory flight management system.

W75-70007 **504-09-32**
Ames Research Center, Moffett Field, Calif.
AIRCREW PERFORMANCE AND AVIATION SAFETY
H. P. Klein 415-965-5094

This program will investigate pilot training, and performance measurement/evaluation problems, and will explore the relationship between aircrew performance and the causation of aviation accidents and incidents. General aviation and civil air transport operations will be considered. Specific objectives are to: (1) determine human factors involvement in air transport critical incidents; (2) evaluate and compare shared and monitored approach philosphies of air transport flight deck crew management; (3) develop training technology for general aviation communications skills; and (4) develop technology for the measurement and evaluation of pilot cognitive skills. A behavioral model for use in analyzing and classifying pilot errors is currently being developed at Ames. This model will be used to structure interview techniques for collecting data from pilots and training personnel about critical events in otherwise routine transport operations. Objective performance data will be collected during standard and monitored low visibility approaches in a transport simulator flown by experienced airline crews. A part-task simulator for training radio communications skills will be designed and evaluated using general aviation student pilots. A GAT-1 simulator will be modified to permit real time preformance measurement. Standard mission scenarios will be used to study pilot cognitive behavior in simulated and actual flight.

W75-70008 **504-09-33**
Ames Research Center, Moffett Field, Calif.
FLIGHT MANAGEMENT SYSTEMS - PILOT/SYSTEM INTERFACE AND PROCEDURES
H. P. Klein 415-965-5094

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 to be fabricated and flight tested by the end of the decade. Special attention will be given to safety, human factors, and full system simulation. The objectives are to (1) determine system/pilot communication requirements (especially CRT displays) for aircraft flight management in the 1980's, and define the content, format, location, function, and pilot procedures for such displays; (2) determine pilot-system communication requirements and device specifications for entering alphanumeric data and system commands; (3) integrate the results of objectives 1 and 2 in the design of a flight deck system for commercial transport application; and (4) fabricate and flight test an integrated flight deck to demonstrate operational utility. Full-flight integrated cockpit 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: (1) the pilot's ability to be constantly apprised of past, present and (predicted) future system status; (2) the pilot's ability to monitor the system for exceeding performance tolerances or system failures; and (3) the pilot's ability to make decisions and execute them in an accurate and timely manner.

W75-70009 **504-09-34**
Flight Research Center, Edwards, Calif.
FLIGHT MANAGEMENT RESEARCH
W. R. Winter, M.D. 805-258-3311

This flight test program is primarily piggy back on other flight research programs. Pilot taskload is analyzed and the psychophysiological response of the aircrew is correlated with total flight performance. The objectives of this program are: (1) to evaluate aircrew performance by correlation of workload and psychophysiological response with performance so that predictive models can be formulated; (2) evaluate a high g seat configuration in flight in a low g mode utilizing existing aircraft and evaluate pilot performance; and (3) evaluate and compare performance of the pilot utilizing a closed circuit TV display in the cockpit, to his performance utilizing the same displays in a remotely piloted vehicle.

W75-70010 **504-09-41**
Langley Research Center, Langley Station, Va.
FLIGHT SIMULATION TECHNOLOGY - SIMULATION TECHNIQUES
G. B. Graves 804-827-3745

The objective of this RTOP is to contribute to the technical advancement of flight simulators as applied to aeronautical research, development, and flight training. The approach of new operational requirements for simulators to support Langley Research Center programs provide the motivation and laboratory environment for significant contributions to the advancement of simulation technology. Interagency involvement with the application of the differential maneuvering simulator also provides valuable insights into the needs for improved simulator capability for flight training and pilot proficiency, as well as for the support of research programs. This RTOP will cover both in-house and contractual studies which address current constraints in simulator equipment, the formulation of simulation math models, and the linkage of the two to provide effective simulations. Results of the effort will be documented in NASA Technical Notes and contractor reports and will be applied to simulations of interest to Langley Research Center.

W75-70011 **504-09-42**
Ames Research Center, Moffett Field, Calif.
SIMULATION TECHNOLOGY FOR AERONAUTICS
H. P. Klein 415-965-5094

The objectives of this RTOP are to provide a scientific and technical base of information that will allow the valid, reliable and economic substitution of simulators for actual flight operations in aeronautical research, development and crew training. Specific objectives are: (1) provide an understanding of pilots' perception and processing of complex visual, motion and auditory stimuli, (2) provide evaluations and engineering development of computer driven graphic displays, including full color systems, high contrast CRT's amd multiplanar displays, and (3) provide a simulated ground station and develop and evaluate critical display concepts for RPRV systems. During FY-75, (1) in-house pilot perception studies will be continued, (2) a computer graphic color display system will be improved and evaluated and high contrast CRT's and multiplanar displays developed, and (3) RPRV ground station and display concept development research will be continued with NASA Flight Research Center. To supplement various phases of these in-house activities, grant activities will continue at California State University at San Jose and at the Scripps Institute of Oceanography.

W75-70012 **505-01-11**
Lewis Research Center, Cleveland, Ohio.
RELATIONSHIP OF ATOMIC STRUCTURES TO MATERIAL PROPERTIES
H. B. Probst 216-433-4000
(505-01-12)

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 in three broad classes of high temperature materials; these are alloys, coatings, and ceramics.

W75-70013 **505-01-12**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
ADVANCED MATERIALS FOR HIGH TEMPERATURE TURBINES
R. R. McDonald 213-354-6186

Processing techniques and improved materials are to be developed for preparing ceramic and cermet components for use in high temperature turbines. The materials would be based on silicon nitride and silicon carbide which have shown promise for this application. The long range goal is the development of turbine components with optimum structures suitable for testing in an operating turbine. The short range (FY-75) objective would be appropriate physical testing of initial specimens to determine feasibility of several approaches but with no attempt at optimization. The approach would be through hot isostatic pressing of powders and repressing of reaction sintered material with and without additives. During the initial period of investigation, available commercial materials would be used, and processing conditions taken from the best available information. During the later stages, improved processing techniques and materials would emphasize microstructure control for improved properties, and reduced cost for the production of final parts. The materials processed would be evaluated first by conventional mechanical, physical, and thermal test, next by testing under simulated turbine conditions, and finally, by actual turbine performance. In the case of cermets, improved attachment of blades would be attempted through compositional transitions to metal root structures.

W75-70014 **505-01-12**
Lewis Research Center, Cleveland, Ohio.
ADVANCED PROPULSION MATERIALS
H. B. Probst 216-433-4000
(505-01-11)

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 improvement not only in technical performance but also in economy in terms of costs and life. The classes of materials to be investigated include directionally solidified eutectics, dispersion strengthened alloys, protective coatings, and ceramics. 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 simulated gas turbine engine environments. The ultimate materials evaluation for gas turbine engines is accomplished by engine testing of components fabricated from newly developed materials. In addition, efforts will be directed toward improving analytical techniques that are used to analyze and characterize these materials.

W75-70015 **505-01-21**
Ames Research Center, Moffett Field, Calif.
FATIGUE, FRACTURE AND LIFE PREDICTION
D. R. Chapman 415-965-5065

The objectives are to develop the basic understanding required to capably select materials and to reliably predict the life of engineering structures exposed to potentially degrading chemical environments through the study of the following programs: the prediction of time-dependent fracture of structural metals caused by subcritical crack growth, the study of the mechanisms of failure of fibrous composite materials, and the definition of stress-corrosion cracking of low and high alloy, high strength steels in anticipated service environments. Experiments will be conducted on metals under conditions of static and cyclic loading in a variety of environments to determine the mechanisms and kinetics involved in the process of environmental embrittlement. Both experimental and analytical investigations will be conducted on fibrous composite materials to determine the relation of the properties of matrix, fiber, and interface to the failure behavior. Also, tests will be performed on alloy steels being considered for high strength aeronautical applications to determine the incubation period for crack growth as a function of parameters of the service environment.

W75-70016 **505-01-21**
Lewis Research Center, Cleveland, Ohio.
FATIGUE, FRACTURE, AND LIFE PREDICTION
J. C. Freche 216-433-4000

The 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 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 test methods are being developed to properly characterize the fatigue and fracture behavior of materials and to provide background information for rational design procedures.

W75-70017 **505-01-31**
Ames Research Center, Moffett Field, Calif.
FIRE RESISTANT, NON-TOXIC POLYMERS
Dean R. Chapman 415-965-5065

The objectives are to synthesize new and improved polymers, and to develop polymeric composites and other lightweight fire-resistant materials for greater safety, longer lifetime, greater reliability and improved efficiency for use in airframes and aircraft interiors. To develop and evaluate nonflammable reinforced foamed plastics and other composites for use in unattended void spaces in aircraft and as secondary airframe structures. To evaluate the toxicity of the gaseous thermal degradation products of polymers currently used and potentially useful in aircraft interiors. To synthesize other nonflammable nontoxic polymers for use in aircraft interiors. To develop and evaluate clear polymers and laminates for use as fire and impact resistant windows and canopies and coatings. To demonstrate through laboratory and full scale tests that the use of these materials in unattended void spaces can provide increased passenger survivability in aircraft interior fires. The thermophysical properties of low density polymeric composites will be evaluated for application in aircraft interiors areas such as lavatories. The toxicity of the gaseous species present in combustion products of these and other materials will be defined. Other nonflammable polymers will be synthesized for potential use in the passenger area of the aircraft. Polycarbonate copolymers and other fire-resistant resins will be evaluated as windows and coatings.

W75-70018 **505-01-32**
Ames Research Center, Moffett Field, Calif.
FIRE-RETARDANT AND LASER COUNTERMEASURE MATERIALS FOR MILITARY PROGRAMS
Dean R. Chapman 415-965-5065

The objectives of this research are: to apply state-of-the-art and advanced aerospace derived fire-retardant and laser resistant

materials and technology developed at NASA Ames to support current and future DOD survivability programs and other related military efforts where materials and material technology is required; to provide data and technology for survivability improvements in aircraft, aircraft ordnance, missiles, and surface vehicles; and to assist the military, when requested, in the actual survivability design of a specific system and to assist with the implementation of the design. Assistance will be provided the military to reduce the vulnerability of flight and missile systems when subjected to an induced fire environment and to provide laser hardened materials for selected applications. This will be accomplished by active participation on survivability/vulnerability committees in the DOD Joint Technical Coordinating Group/ Aircraft Survivability (JTCG/AS), by direct contract with specific survivability groups of each of the services, by developing advanced fire retardant materials, laser countermeasure materials, and fire related technology which will enhance the survivability of military systems. The development of advanced fire and laser ablation technology and its application will be coordinated with the responding military (DOD) agencies.

W75-70019 **505-01-34**
Lewis Research Center, Cleveland, Ohio.
COMPOSITES
R. H. Kemp 216-433-4000
(743-32-24)

The overall objective of this research is to develop fiber and laminate composite materials, structures, and components for various aeronautical propulsion applications. The higher mechanical properties and reduced weight of the composites in comparison to monolithic engineering materials make them particularly attractive for advanced turbine engine components such as fan and compressor blades, fan frames, guide vanes, and sound suppressors. Recent payoff studies show that the application of composites to these components is highly cost-effective. Composites being considered include resin matrices reinforced with graphite, boron, Kevlar 49, and glass fibers. In addition, aluminum and titanium matrices reinforced with boron and SiC fiber are being studied for temperatures beyond the capability of the resin matrices. In the resin matrix work, emphasis is placed on the development of processable polyimides and polyphenylquinoxalines to provide increased temperature capability over the conventional epoxy materials. In the metal matrix work, emphasis is placed on the development of fabrication processes and the improvements of impact resistance. A further objective of the research is to develop fire retardant polymers for use as matrix materials having low or no toxic combustion products.

W75-70020 **505-01-34**
Langley Research Center, Langley Station, Va.
COMPOSITES AND ADHESIVES
G. W. Brooks 804-827-2042

The objective is to develop new or improved lightweight polymeric, composite and metallic materials that have longer lifetimes, greater reliability and improved structural efficiency in aeronautical structures. The work will consist of research aimed at improvement of structural resins and adhesives through systematic variation in the polymer molecular structure, determination of behavior of new or advanced filamentary composite materials containing either resin or metal matrices, and development of new or improved fabrication methods for metal-matrix and resin-matrix composite materials. Research will also be directed at repair technology of composites including detection of flaws, determination of critical flaw sizes, development of appropriate repair procedures, and evaluation of the effectiveness of the repairs on composite repair procedures, and evaluation of the effectiveness of the repairs on composite behavior. Studies of interfacial reactions and diffusion processes in advanced metal-matrix composites with emphasis on degradation as a function of temperature, stress and environmental corrosion will also be made. These studies will help to identify new or advanced materials for aeronautical structural applications and will provide important data on the behavior, capabilities and limitation of such materials.

W75-70021 **502-02-11**
Langley Research Center, Langley Station, Va.
ADVANCED CONCEPTS FOR COMPOSITE STRUCTURES
G. W. Brooks 804-827-2042
(505-02-42)

The objectives are to find innovative ways to apply composite material to obtain higher performance in aerospace structures, and perform advanced studies and demonstrate performance by test. The approach taken was to continue studies to develop lighty-loaded aircraft wing structures. Under a grant, MIT students are developing an integrated preliminary design system to optimize the performance of a light sailplane. The design of compression-resistant wing skins will be investigated. A horizontal stabilizer will be fabricated using a mold developed from an airfoil section already tested in a wind tunnel to verify its aerodynamic performance. Continue studies to develop composite ribbon material which will significantly enhance transverse stiffness and strength of composite laminates. An improved substrate for rectangular-shaped filaments will be studied and attempts to improve processing of silicon carbide filaments will be explored. Multiple ply unidirectional laminates will be fabricated with both resin and metal matrices. Elastic constants and failure strengths will be determined by test. Initiate studies of composite energy storage wheels useful for both aerospace and civil sector applications. Other configuration studies have indicated composites have high performance potential as energy storage devices. Effort will be to perform tradeoff studies on advanced composite concepts such as spoked wheel, tension shell or isotensoid structures to determine most practical, reliable configuration. If funding permits, detail design effects such as dynamic sobble and fail safe design techniques will be investigated and a demonstration wheel will be constructed and tested.

W75-70022 **505-02-12**
Langley Research Center, Langley Station, Va.
HYPERSONIC VEHICLE STRUCTURES
G. W. Brooks 804-827-2042

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, establish design guidelines, and provide guidance for future research efforts.

W75-70023 **505-02-12**
Flight Research Center, Edwards, Calif.
HYPERSONIC VEHICLE STRUCTURES TECHNOLOGY
Roger A. Fields 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 HRA.

W75-70024 **505-02-13**
Langley Research Center, Langley Station, Va.
CIVIL AVIATION - CRASHWORTHINESS
G. W. Brooks 804-827-2042

This RTOP is the NASA portion of a joint FAA/NASA General Aviation Crashworthiness Program to provide the analyst or designer with a proven analytical methodology for prediction of collapse of a structure under crash conditions. To achieve this objective, analytical and experimental studies will be performed to define the basic mechanisms involved in crash behavior. This technology, coupled with research on improved energy dissipation concepts will be applied to current general aviation aircraft to evaluate potential improvements in survivability for specific crash envelopes. There are three basic of research in this program: full-scale crash simulation testing, nonlinear structural analyses necessary to predict total collapse of the vehicle, and evaluation of energy absorption concepts for specific component design. Both analytical and experimental methods will be used to develop expertise in these three areas. Analyses will include both simplified procedures for estimating energy absorption capabilities and more

complex computer programs for analysis of general airframe response. Under the crash program these analyses will be developed to provide the designer with methods for predicting accelerations, load, and displacement histories of collapsing structures. Full-scale tests of typical structures as well as tests on structural components will be used to verify the analyses and to demonstrate improved design concepts.

W75-70025 **505-02-21**
Langley Research Center, Langley Station, Va.
LOADS, AEROELASTICITY AND STRUCTURAL DYNAMICS
G. W. Brooks 804-827-2042

In order predict flutter and other aeroelastic phenomena more accurately, research will be conducted to improve aeroelastic analysis methods, to provide accurate unsteady transonic aerodynamics, and to validate rotor dynamic analysis. The feasibility of increasing the Mach number range of the transonic dynamics tunnel will be explored. In order to improve and validate aeroelastic loads analysis programs, various load prediction techniques (including FLEXSTAB) will be evaluated and improved for integration into computer systems such as ATLAS and IPAD. In order to develop methods for predicting acoustic loads, structural response, and noise transmission through aircraft structures, methods for analyzing panel response with a thick boundary layer will be developed and compared with experiment. Noise transmission through aircraft structures will be studied.

W75-70026 **505-02-21**
Ames Research Center, Moffett Field, Calif.
LOADS, AEROELASTICITY, AND STRUCTURAL DYNAMICS
H. M. Drake 415-965-5880
(743-36-01; 766-72-02)

The objective of this research is to provide improved prediction methods and data that apply to several dynamic load and aeroelasticity problems involving aircraft. In the area of dynamic loads, investigations will be conducted to study the flow fields and pressure fluctuations within and in the vicinity of cavities (such as open ports and bomb bays), protuberances, and turrets on aircraft. Means of eliminating cavity resonances and alleviating high-intensity local dynamic loads will be sought. With respect to aeroelasticity, both analytical and experimental investigations will be conducted to develop and validate computational methods for prediction of panel flutter including the effects of the boundary layer. Improved methods for predicting aeroelastic loads will be incorporated in FLEXSTAB including gust loads and active control loads capability. Experimental investigations of unsteady pressures on oscillating semispan wings will be investigated at transonic speeds and studies will be conducted of the flutter and divergence of oblique wings.

W75-70027 **505-02-22**
Langley Research Center, Langley Station, Va.
DRONE FLIGHT PROGRAM
G. W. Brooks 804-827-2042

The objectives are to provide flight data for comparison with results from various prediction methods and for cases where analyses are known to be inadequate. Emphasis will be on measurements of transonic aerodynamic loads and flight demonstrations of active control systems for load alleviation and flutter suppression. Flight testing techniques will be developed using drone-type vehicles to gather the desired data. An aeroelastic research wing will be provided with its flutter boundary within the flight envelope when flown on a Firebee 2 vehicle. First flights will be aimed at measuring aerodynamic loads in the transonic range, then active control systems will be incorporated for flight assessments of their performance in alleviating loads and suppressing flutter. Flights will be made cooperatively with the Flight Research Center.

W75-70028 **505-02-22**
Flight Research Center, Edwards, Calif.
PROJECT DAST
Berwin M. Kock 805-258-3311
(505-06-44)

Project DAST (Drones for Aerodynamics and Structural Testing) is a technology development program that will provide data that will lead to a better understanding of unsteady aerodynamic loads and flutter at transonic speeds. The program is a combined theoretical, wind-tunnel and flight-test activity and is a joint LaRC/FRC program. The flight-test activity is the subject of this RTOP. A supercritical wing will be installed on a Firebee 2. This wing will be at a planform representative of transport aircraft. The wing will be designed to be flutter critical within the normal flight envelope of the modified Firebee 2. A system will be installed to provide the necessary flutter damping. The vehicle will be instrumented to measure wing pressures, accelerations, and strains. The vehicle to be modified will be the Firebee 2 used in the capability development program currently underway at FRC.

W75-70029 **505-02-23**
Flight Research Center, Edwards, Calif.
FLIGHT LOADS MEASUREMENT TECHNIQUES
J. M. Jenkins 805-258-3311

The problem currently approached in this RTOP is to work toward a solution as to how to avoid the fatigue sensitive attachment problems resulting from spotwelding strain gages to titanium structures. Weldable strain gages possess the most advantageous high temperature attachment characteristics. The resources of this RTOP will be directed toward developing, under R and D contract, a method to accomplish a metal to metal attachment for weldable strain gage configurations to titanium structures.

W75-70030 **505-02-24**
Flight Research Center, Edwards, Calif.
FLIGHT RESEARCH OF A STRUCTURAL MODE CONTROL SYSTEM (SMCS, I.E. MODAL SUPPRESSION SYSTEM)
Jim M. McKay 805-258-3311

This RTOP is to: (1) investigate the improvements in total dynamic response of a flexible aircraft and the potential benefits to ride qualities, handling qualities, crew efficiency, and reduced dynamic laods on the primary structure; and (2) evaluate the effectiveness and performance of the SMCS which uses small aerodynamic surfaces at the vehicle nose to provide damping to the structural modes.

W75-70031 **505-02-31**
Langley Research Center, Langley Station, Va.
FATIGUE AND FRACTURE
G. W. Brooks 804-827-2042
(743-32-02)

The research is conducted through a combination of analytical development, experimentation, and supplementation of in-house work by contracts and grants. Some specific goals are to improve life prediction techniques, to devise ways to predict the residual strength of reinforced sheet structures, to develop nonlinear fracture mechanics methods for ductile structural materials, to verify techniques to compress test times for fatigue tests of heated structures, to improve ways to predict rates of crack growth in flawed structures, to establish the long-time fatigue behavior of composite materials, and to devise ways to apply reliability methods to aircraft structures where the number of structures tested is limited by cost. To the degree possible, the work anticipates the design problems and materials that will be encountered by advanced subsonic and supersonic aircraft, rotary-wing aircraft, and vertical- and short-take-off-and-landing aircraft.

W75-70032 **505-02-41**
Langley Research Center, Langley Station, Va.
COMPOSITE MATERIALS APPLICATION TO AIRCRAFT STRUCTURES
G. W. Brooks 804-827-2041
(505-01-31; 743-32-22; 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: (1) develop analytical methods to improve understanding of composite materials, evaluate behavior under various environmental conditions, develop concepts, fabrication, and nondestructive evaluation technology; (2) fabricate and test critical components to demonstrate performance; (3) conduct engineering studies to determine applicability of composites in primary or secondary structures of commercial or military aircraft; (4) establish repair techniques for flawed or damaged structure; (5) develop applications to operational aircraft such as the CH-54B helicopter, B-737,L-1011, and DC-10 commercial transports; and (6) determine maintenance experience with flight service applications. 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.

W75-70033 **505-02-42**
Langley Research Center, Langley Station, Va.
DESIGN TECHNOLOGY FOR COMPOSITE STRUCTURES
G. W. Brooks 804-827-2042
(505-02-11)

The objective is to develop base technology necessary to confidently design composite structural components. Develops methods of predicting the strength of composite components. The approach taken was to advance methods of predicting the strength and stability of laminates, panels and stiffened components will be applied to new test data. Analysis will be applied to define the limitations of conventional test methods, and to develop more satisfactory test methods. Development of a strong in-house program for design and test of aircraft components will be continued. Designs for wing compression covers will be developed using advanced methods. A large series of graphite panels with either open or closed sections will be designed, fabricated and tested in the LaRC Structures Laboratory. Effort will include industry-developed as well as NASA-developed designs. Data will be generated over a large range of loading to provide a substantial NACA-type data bank upon which to base designs. A paralled program for wing shear webs will be continued. Optimum design curves will be developed over a wide loading range for both sandwich and stiffened shear web designs. Maximum strength of large graphite webs will be determined in a series of tests at Langley. A design for a 4' by 8' composite aileron will be developed for the L-1011 aircraft. Aileron will be of sandwich construction with design goal of being lighter than the metal flight structure, yet cost competitive with it. Subject to NASA approval, a successful design could be a candidate for flight service on five commercial aircraft. To support this effort, in-house evaluations of the resistance of composite sandwiches to low-velocity impact will be continued. Effort this year will be focused in determining the residual strength of impact-damaged sandwiches.

W75-70034 **505-02-51**
Langley Research Center, Langley Station, Va.
STRUCTURAL ANALYSIS AND DESIGN METHODS
G. W. Brooks 804-827-2042

The objective was to advance state-of-the-art for the analysis and design of aerospace structures by developing new or refined analysis techniques. Perform theoretical and experimental studies to demonstrate the effectiveness of new methods. Apply advanced analysis to generate meaningful design curves. Develop rapid methods of sizing structural components to meet multiple load conditions and aeroelastic constraints. The approach taken was to continue support of development of advanced computerized analysis of shell-of-revolution structures using methods which are foolproof in requirements for user skills because of the use of integration (the 'field' method) for solutions rather than more numerically uncontrolled algebraic solutions. Continue support and improvement of analysis tools which determine linear/nonlinear stress behavior and vibration characteristics of two-dimensional shell structures. Apply analysis to critical agency problems as required. Conduct theoretical and experimental studies of stability of shells with cutouts to validate analysis and provide data to guide studies of complex configurations. Study effects of imperfections in shell structures to generate more rational design procedures. Continue development of methodology to permit more effective use of computer-aided techniques for structural design. Perform basic studies of structural synthesis methods to develop more efficient search techniques to identify optimum designs. Investigate applications and modifications of analysis/design codes such as SPAR and ATLAS to help define best techniques for functional design codes.

W75-70035 **505-03-11**
Langley Research Center, Langley Station, Va.
BASIC NOISE RESEARCH
G. W. Brooks 804-827-2042
(505-10-26; 505-06-23)

The objective of this research is to provide a data and technology base for reducing aircraft propulsion generated noise with minimum weight performance and economic penalties. Included in this objective is the location of sound sources in flow fields tracing the emission paths, through refraction, propagation, and scattering, the improved efficiency of acoustic suppression materials and treatment technology, the design of low noise propellers for general aviation aircraft, and the development of a unified data acquisition system. Both theoretical and experimental studies are involved and work will be accomplished in-house and under contract. Emphasis is placed on substantially improving analytical and experimental methods as well as equipment and facilities for subsonic and supersonic jet noise research; work will continue on optimum jet exhaust noise suppressor designs. The effects of the atmosphere on noise propagation will be studied using a high instrumented tower. This work will also include precision measurements and calculations of the sound fields inside finite ducts with airflow, with varying cross sectional areas, and with and without acoustic treatment materials. Results of in-house analytical duct propagation and radiation studies, acoustic measurements in the ANRL test duct, and of contract and grant study programs will be inputs to the development of a program for predicting the acoustic performance of engine flow ducts. Noise and performance measurements of a shrouded propeller design will be conducted in the Full-Scale Tunnel. Studies will also be undertaken to evaluate the influence of forward flight on propeller noise with a turboprop short-haul airplane.

W75-70036 **505-03-11**
Lewis Research Center, Cleveland, Ohio.
BASIC NOISE RESEARCH
E. W. Conrad 216-433-6886
(505-15-18; 505-03-12)

This RTOP covers work directed toward understanding the basic principles and phenomena involved in the generation, propagation and suppression of turbomachinery, jet, jet-surface interaction, and core noise. The work combines in-house analytical and experimental studies with a number of university type grants and contracts to form a coordinated basic noise research program that is structured to permit aeroacoustic specialists to carry out investigations of several years duration, if appropriate. The work is directed toward providing a broad base of understanding and knowledge of the various noise areas through fundamental, analytical and experimental studies. This foundation will provide a fundamental base for reducing aircraft propulsion generated noise with minimum weight, performance, and economic penalties.

W75-70037 **505-03-11**
Ames Research Center, Moffett Field, Calif.
BASIC NOISE RESEARCH
H. M. Drake 415-965-5851
(505-06-23)

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 of predicting noise generated in jet exhausts and noise propagation in ducts and through a turbulent medium. The research will involve both analytical and experimental studies of aerodynamic noise generation in propulsion systems. The research on noise generating mechanisms in jet flows will include

detailed studies of hot and cold jets, combustion and core noise, and noise suppression effects of swirling flows and advanced mixer suppressor nozzles. The acoustics of aircraft engine duct systems are being investigated to establish practical high Mach number throat inlet design concepts. Computer algorithms, which were developed for predicting the propagation of plane waves in variable area ducts with general area and velocity distributions are being extended to include the effects of spinning modes, duct liners, and finite duct lengths. To assess the effect of the atmosphere on the propagation of aircraft noise, a theoretical effort is being conducted on wave propagation in a turbulent medium. The relative importance of the coherent and incoherent wave due to the presence of a simulated aircraft noise field propagating through the real atmosphere will be investigated. The results of the analytical study will be compared with selected small scale experiments.

W75-70038 **505-03-11**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
BASIC NOISE RESEARCH
R. R. McDonald 213-354-6186

The general objectives of this RTOP are (1) to characterize the fluctuating quantities and obtain a relationship between the fluctuations and the intensity and frequency spectrum of the noise radiated from jets, (2) to find methods of reducing jet noise by controlling the shear noise sources, and (3) to determine how core flow disturbances increase the radiated noise from jets with the ultimate goal of developing efficient means of reducing jet noise emission by reducing core flow disturbances. Experimental measurements of the perceptive noise level are made with pairs of microphones at selected locations in the surroundings of high temperature jets emerging from a nozzle. Crossed laser beams, set up as a schlieren system, are projected through the jet and probes are used to acquire information that characterizes the fluctuating density and pressure. The relationship between the fluctuating density and the noise is established from the respective autocorrelation functions. The tests are conducted in an anechoic chamber. The following major effects of core flow disturbances on the generation of noise radiated from a supersonic jet will be examined: (1) the oscillation of the inviscid jet boundary and Mach wave structure, (2) the effect on the mixing layer structure (particularly large scale eddies), (3) shock wave oscillation, and (4) entropy fluctuation interactions. Available theories will be examined with particular attention focused on scaling properties of the different disturbance-noise interaction processes. The distribution influences to be studied include oscillating pressure, composition and temperature.

W75-70039 **505-03-12**
Lewis Research Center, Cleveland, Ohio.
NOISE TECHNOLOGY
E. W. Conrad 216-433-6369
(505-03-11)

The objective of this research is to provide data and a technology base directed toward improved understanding of noise generation mechanisms and improved correlation and prediction techniques for reducing aircraft propulsion noise with minimum weight, performance and economic penalties. Research is performed on fan, core and combustion noise generation and its suppression and shielding. Fan noise research will be conducted in the six-foot fan acoustic test rig and the 20-inch model rig in W-2 as well as by contract. Several acoustic parameters (such as reduced fluctuating stator lift, reduction of mpt's in transonic and supersonic fans by means of shock swallowing and shockless rotor blades reduced rotor stator interaction, and boundary layer bleed) will be evaluated. Combustion noise research will be conducted to determine internal and far field noise spectra. Jet noise generation and methods of shielding jet noise will be examined. Forward velocity effects on STOL engine-over-the-wing configurations will be evaluated. Fly-over acoustic tests will be conducted for three sound suppression nozzle configurations. New ideas for noise generation mechanisms, reduction, suppression, and measurement will be investigated and improved correlation and prediction techniques will be established. Sonic and hybrid inlets will be studied and evaluated experimentally to optimize noise reductions with regard to performance losses, operational limitations imposed, and system economics as effected by weight, complexity, reliability and maintenance.

W75-70040 **505-03-12**
Ames Research Center, Moffett Field, Calif.
BASIC NOISE TECHNOLOGY
B. H. Wick 415-965-5036
(505-10-31)

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 program proposed for FY 1975 continues the studies to understand lift fan noise sources. This includes a continuation of analytical studies, the fabrication of experimental gear to isolate the noise caused by the hub supports and the tip turbine, a theoretical and experimental study of inlet turbulence and the effect of inlet shape, and an experimental investigation of the noise of a VTOL jet directed perpendicular to the free stream flow.

W75-70041 **505-03-12**
Flight Research Center, Edwards, Calif.
PROPULSION NOISE REDUCTION
T. W. Putnam 805-258-3311

The technical objective is to investigate by means of full-scale flight and ground tests the noise generated by various aircraft, and propulsion systems. The various noise sources are to be identified, and in addition, the effects of shielding ground proximity and atmospheric conditions on the noise spectra received at a given position relative to the noise source will be determined. The noise of various aircraft for static conditions, during takeoffs, landings, and flybys will be measured at ground stations.

W75-70042 **505-03-21**
Lewis Research Center, Cleveland, Ohio.
NOISE FOOTPRINT PREDICTION
M. F. Valerino 216-433-6280

Based on theoretial and experimental knowledge of aircraft component source noise and noise propagation, first-generation noise prediction models are formulated for incorporation into the forthcoming NASA Aircraft Noise Prediction Program being developed at Langley Research Center for noise footprint prediction. The specific aircraft noise areas of major technical effort are: Fan/Compressor, Turbine, Jet, Flap, Combustion, Duct Acoustics, and Shielding/Reflection. The noise prediction models are formally documented as NASA publications. Those research areas critical to the improvement of noise prediction are identified and specific research programs to obtain the improvements are suggested. The work is structured to permit convenient validation, improvement and updating of the prediction models as additional information is developed.

W75-70043 **505-03-21**
Langley Research Center, Langley Station, Va.
NOISE FOOTPRINT PREDICTION
G. W. Brooks 804-827-2042

The objective of this work is to develop and verify an integrated, state-of-the-art Aircraft Noise Prediction Program (ANOPP). A wide range of activities will be undertaken to assure that the most advanced, yet widely accepted, prediction methods are implemented. The areas of flyover noise measurement noise data reduction techniques, airport and aircraft operating procedures, data base maintenance, component noise sources and source noise modeling, shielding, reflection, progagation, and computer sciences will be continuously reviewed and updated.

W75-70044 **505-03-31**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
BASIC POLLUTION RESEARCH
R. R. McDonald 213-354-6186

In part I, photochemical processes related to pollution of the upper atmosphere by high-flying aircraft are being studied,

with emphasis on the effects of such pollutants on the stability of the ozone layer. The work is experimental in nature and involves laboratory measurement of steady state ozone concentrations under simulated stratospheric conditions. Relationships between stratospheric pollution and urban air pollution are being studied, with the objective of formulating a unified model of photochemical pollution applicable to all regions of the atmosphere. In part II, the specific objective is to study, model and analyze the particle size spectrum and spatial distribution in a jet contrail. The effort consists of several sub-tasks which encompass a review of current related work, theoretical analysis and modeling, computer programming and simulation, and comparison with available experimental data. On completion, a final report and a computer program and its documentation will be made available.

W75-70045 **505-03-31**
Langley Research Center, Langley Station, Va.
BASIC POLLUTION RESEARCH
E. S. Love 804-827-2893

The objective of this work is to investigate the effect of combustion kinetics, temperature, pressure, mixing, and nature of the fuel on the production of gaseous and particulate pollutants in hydrocarbon-air combustion systems. The results of these studies will be used to assemble more reliable chemical kinetic schemes for describing hydrocarbon combustion and predicting pollutant formation (NOx and soot) in gas turbine combustors. These studies will be made using laboratory flame burners, a chemical shock tube, and a jet-stirred combustor.

W75-70046 **505-03-32**
Lewis Research Center, Cleveland, Ohio.
EXHAUST EMISSION POLLUTION REDUCTION
R. A. Rudey 216-433-4000
(743-34-21)

The objective is to develop, evaluate, and demonstrate the technology required to reduce modern gas turbine aircraft engine exhaust emission pollutants to levels complying with current and future environmental air quality standards with minimum adverse effects on performance, weight and complexity. Various techniques for reducing pollutant emissions are being investigated both in-house and under contract in full scale combustor rigs, combustor segment rigs, and basic flame-tube type rigs. Four major multi-phased contract efforts are being used to develop and demonstrate, in modern aircraft engines, advanced combustor concepts that are aimed at reducing the pollutant emissions to levels equal to or less than those established by the EPA for engines manufactured after 1979. These programs do or will include candidate engines from all designated classes covered by the EPA standards for civil aviation aircraft. In-house and contract efforts to explore high pressure-high temperature advanced combustor designs, fundamental modeling and combustion pollutant formation studies, identification of odorants, and non-invasive measurement techniques are also being conducted.

W75-70047 **505-03-32**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
GAS TURBINE ENGINE POLLUTION REDUCTION TECHNOLOGY
R. R. McDonald 213-354-6186

New (unconventional) combustor design concepts for application to aircraft gas turbines are being evaluated for their potential for providing significantly reduced pollutant emissions. Reducing oxides of nitrogen while maintaining efficient, clean combustion is emphasized. The central conceptual approach is to minimize NO formation rates by reducing flame temperature and by promoting off-stoichiometric burning. The primary objective for FY-75 is to complete an experimental evaluation of the potential of H2-enriched, JP fuel-air mixtures to provide for very lean combustion; hence, significantly reduced NOx emissions. A secondary objective is to commence exploratory experiments on the feasibility of incorporating a H2 generator as an integral part of the combustor.

W75-70048 **505-03-33**
Langley Research Center, Langley Station, Va.
EXHAUST EMISSION REDUCTION-INTERMITTENT COMBUSTION AIRCRAFT ENGINES
E. E. Kempke 216-433-4000
(770-54-02)

The overall objective of this program is to establish and demonstrate the technology necessary to safely reduce general aviation intermittent combustion engine exhaust emissions and noise to meet EPA/FAA 1979-1980 standards with minimum adverse on cost, weight, and fuel economy. With the advent of more restrictive standards on the pollutant emission and noise of aircraft piston engines and the drive to conserve our natural resources, there is a need to determine and develop better ways of handling the diverse but related areas. A comprehensive program comprising contract work by the primary engine manufacturers as well as a Lewis Research Center in-house technology effort has been established. Work performed under contract to the engine manufactures will be directed to establish near term solutions while in-house work will concentrate on longer term solutions such as alternative engines and concepts requiring additional technology.

W75-70049 **505-03-41**
Lewis Research Center, Cleveland, Ohio.
INTERACTIONS OF EXHAUST EMISSIONS WITH ATMOSPHERE
R. A. Rudey 216-433-4000
(505-03-32)

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 747 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 carbon dioxide, carbon monoxide, oxides of nitrogen, oxides of sulphur, ozone, water vapor, and total particulates.

W75-70050 **505-03-41**
Ames Research Center, Moffett Field, Calif.
ATMOSPHERIC EMISSION INTERACTION
D. R. Chapman 415-965-5065

The objective of this research is to provide basic models of jet aircraft engine pollution and wakes for use in the assessment of the impact on the atmosphere engine pollution and wakes for use in the assessment of the impact on the atmosphere of jet-powered aircraft operations. The models will be used to support the Stratospheric Jet Wake Experiment and will, in turn, be modified by the experimental data obtained in that flight experiment. Production of pollutants from jet aircraft engines is being studied by computer modeling the chemically reacting flow through the engine, and the subsequent dispersion and chemistry in the wake. Hydrodynamic dispersion models of the wake will be combined with the chemical models to describe the concentrations and distributions of exhaust products within the wake for long distances behind the aircraft. Sets of chemical reactions with appropriate reaction rates are being provided to the chemical models. Because basic equation sets have already been developed and integrated into the model, special emphasis is now being applied to organic reactions and their rates which may influence exhaust chemistry. The models will be used to describe the chemistry and wake dynamics of the YF-12 aircraft in support of the Stratospheric Jet Wake Experiment.

W75-70051 **505-03-41**
Langley Research Center, Langley Station, Va.
ATMOSPHERIC EMISSION INTERACTION
E. S. Love 804-827-2893

The objectives of this work are as follows: (1) to resolve questions pertinent to the formation of HNO3 in the stratosphere due to wake chemistry and dynamics; (2) to investigate the role of water vapor emitted by aircraft on temperatures and chemistry within the aircraft wake region or flight corridor and

to determine the role of water vapor in the formation of HNO3, and (3) to systematically investigate the scattering properties of aerosol layers associated with the lower stratosphere. An investigation of the formation of HNO3, and the role of water vapor in this information, and on the temperature structure of the flight corridor, will be carried out. Use will be made of existing submodels developed at LaRC for the thermal code, at the Aeronautical Research Associates of Princeton, Inc. (ARAP) for the wake submodel, and at Aerospace Corporation for a 2-D Transport code. With these codes, the required parametric studies will be carried out. The properties of the stratospheric aerosol layers will be determined by systematic experiments conducted with the LaRC 48-inch LIDAR, by comparison of experimentally measured volume backscatter functions with accepted aerosol models, and with the aid of experimental measurements of depolarization.

W75-70052 **505-04-11**
Langley Research Center, Langley Station, Va.
INLETS AND NOZZLES
R. E. Bower 804-827-3285

Studies of locations of the engine power plant in various positions on the airframe will be conducted in order to achieve better integration with the airframe and to exploit any favorable jet interference effects which may enhance the wing lift performance efficiency, reduce or permit vectoring of the jet exhaust to improve performance and control of the aircraft. For the exhaust nozzle, investigations will be made to determine a means of improving the internal and external performance of both uninstalled and installed nozzles and to explore the integration procedures for incorporating the exhaust system into the fuselage or pods. General experimental and theoretical research studies will be conducted to improve the understanding of the flow phenomena associated with boattail/jet/empennage interference. Experimental research on axisymmetric nacelles and rectangular inlets will be conducted for correlation with analytical results and design procedures will be developed from this information.

W75-70053 **505-04-11**
Ames Research Center, Moffett Field, Calif.
INLET TECHNOLOGY
Hubert M. Drake 415-965-6116
(505-06-14; 505-06-11)

The objective of this research is to provide information needed in the design and operation of efficient air induction systems for subsonic and 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 to define those characteristics of the inlet flow distortion that affect engine operation and correlate them with engine stall margin. The research studies are both analytical and experimental, and involve in-house, grant, and contract efforts.

W75-70054 **505-04-11**
Lewis Research Center, Cleveland, Ohio.
INLET AND NOZZLE TECHNOLOGY
D. N. Bowditch 216-433-4000

Improved analytical and experimental design methodology for inlets and nozzles will be generated to achieve higher performance with increased propulsion system stability. These results will minimize future development effort and cost of advanced civil and military aircraft. Computer analysis programs for predicting both internal and external flows will be synthesized *inhouse and by contracts and grants. These programs will make* it possible to analyze combined viscous and inviscid flows and, in some cases, three-dimensional flows. A matrix of inlets and nozzles will be tested for comparison with theory and to provide design trade information for optimization of aircraft configurations. The compatibility of the inlet and nozzle with the turbine engine and airframe will be investigated to develop inlet-engine-nozzle compatibility methodology. Experimental testing will take place in 10x10, 8x6, on the F106 aircraft and in a static thrust stand, CE22.

W75-70055 **505-04-21**
Lewis Research Center, Cleveland, Ohio.
FAN AND COMPRESSOR TECHNOLOGY
M. J. Hartmann 216-433-4000
(724-12-01)

Approaches to improve efficiency, operating range, distortion tolerance, durability, and reliability, and to reduce weight, volume, and cost of the wide variety of fans and compressors required for advanced propulsion systems will be investigated. Analytical methods to improve accuracy of performance prediction to reduce the time, cost and risk of incorporating advanced fans and compressors into future engine development programs will be developed and compared to experimental data obtained in advanced single and multistage compressors. Both in-house and contract efforts are required. The major program thrusts are to: (1) extend fan stage pressure ratio; (2) improve fan performance with low noise design and devices; (3) improve distortion performance; (4) evolve design/analytical/evaluation method; (5) determine matching requirement of high pressure stages; (6) extend core stage pressure ratio; and (7) improve performance of small centrifugal compressors.

W75-70056 **505-04-22**
Lewis Research Center, Cleveland, Ohio.
TURBINE TECHNOLOGY
D. Poferl 216-433-4000

The turbine program includes research on turbine aerodynamics, turbine cooling and turbine life. Each of these areas are inter-related, 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 cooling. The effects of this and other types of cooling air discharge are being investigated from the standpoints of heat transfer, aerodynamics, and blade life. Heat transfer, fluid flow, aerodynamics, and life investigations are underway for a variety of convection and film configurations for turbine sizes ranging from those for helicopter engines to high spool turbines for turbofan engines. Fundamental heat transfer investigations on film 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 heat transfer and structural problems encountered with these high temperature, high pressure turbines is being accomplished using Coff funds. In addition, investigations are being made on multi-stage turbines with work factors from 3 to 5 for application to high bypass ratio lift or cruise engines.

W75-70057 **505-04-31**
Lewis Research Center, Cleveland, Ohio.
COMBUSTION AND AUGMENTATION SYSTEMS TECHNOLOGY
R. A. Rudey 216-433-4000
(505-03-32)

The objective is to establish the technology necessary for combustors and augmentors to achieve high performance and good durability at operating conditions typical of advanced commercial and military gas turbine engines. A swirl-can combustor is being developed for use in the High Pressure Facility (HPF) both as a heat source combustor for the turbine rig and also as a research combustor. A variety of new combustor concepts will be investigated; first in a sector rig at low pressure, then further refined in design and tested as full annular designs *in ECRL-1 at pressures up to 120 psi, and finally tested in HPF* at pressures up to 580 psia. This effort will be supported by research on liner film-cooling, jet penetration and mixing, fuel injection, vaporization and premixing and various diffuser and cold flow model tests. Several designs of small combustors of the reverse flow and axial flow types will be designed and tested for performance and emission characteristics. An augmentor program will study ways of improving augmentor performance

of turbofan engines by investigating a variety of new design approaches.

W75-70058 **505-04-41**
Lewis Research Center, Cleveland, Ohio.
DRIVE SYSTEM MECHANICAL COMPONENTS TECHNOLOGY
W. J. Anderson 216-433-4000
(506-16-22)

The objectives of this work are to advance the technology for bearings, seals, gears, shafts, lubricants, and lubrication systems to achieve increased effectiveness, life, reliability, efficiency, and low weight in the high temperature, high pressure, and high speed environments of gas turbine engines, and mechanical power transmission systems. 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, designs 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. New transmission concepts will be developed.

W75-70059 **505-05-11**
Flight Research Center, Edwards, Calif.
DYNAMIC BEHAVIOR AND CONTROL TECHNOLOGY
Weneth D. Painter 805-258-3311

The objective of this effort is to flight test an integrated propulsion control system (IPCS) on an F-111E airplane. The IPCS program objectives are to: (1) demonstrate the control of a state-of-the-art propulsion system using a digital computer and associated interface equipment; (2) evaluate the improvement in steady-state and transient propulsion system performance due to IPCS; and (3) evaluate the changes in compatibility between the engine and inlet, (stall margin change); This is a joint USAF/NASA program in accordance with the Memorandum of Understanding dated 6 September 1972. The IPCS will be designed and fabricated by the Boeing Company under a contract from the USAF. Engine tests will be conducted by NASA Lewis Research Center with flight tests at FRC in October, 1975. A baseline flight test program to define the performance of the standard F-111 propulsion system is planned for July 1974.

W75-70060 **505-05-11**
Lewis Research Center, Cleveland, Ohio.
DYNAMIC BEHAVIOR AND CONTROL TECHNOLOGY
D. I. Drain 216-433-4000

The objective is to improve the understanding and prediction of propulsion system dynamics behavior so that it can be controlled at its maximum performance and yet be able to accommodate sudden and unexpected distrubances safely and reliably. The approach is to apply the methods of dynamic analysis and simulation to establish the characteristics of airbreathing propulsion systems. Control theories and concepts will be developed and applied to achieve improved performance and operation of the system. Special control hardware, such as servos, instruments, and actuators, will be developed as required. Experiments with components and complete systems will be performed to validate the methods and concepts developed for propulsion system control.

W75-70061 **505-05-21**
Lewis Research Center, Cleveland, Ohio.
ENGINE TECHNOLOGY
J. Povolny 216-433-6624
(505-04-31; 505-04-11)

The objective is to conduct research subprograms on the latest advanced subsonic and supersonic military and civil engines with the emphasis on increasing the understanding and technology base of the various technical disciplines involved so that designers can better predict the performance of advanced or modified engines and components. Particular emphasis will be placed on seeking an understanding and solution of the dynamic interaction problems associated with propulsion systems. The subprograms will include considerations of investigations in the areas of aeromechanical instability, fan-compressor system performance, inlet distortion and component (including inlet) interactions, engine control dynamics, and the performance and characteristics of the various other components. This program is primarily concerned with those technical areas which are causing the most problems, or where there is the most discrepancy between theory or prediction and actual performance. Engines currently included in this program are the NASA Quiet Engine, J-58, J-85, F-100, and JT8D Refan.

W75-70062 **505-05-22**
Lewis Research Center, Cleveland, Ohio.
V/STOL ENGINE TECHNOLOGY
Raymond J. Rulis 216-433-4000
(738-13-01)

The objective of this RTOP is to advance the technology of turbine engine systems required for future STOL and VTOL aircraft. In particular to develop improved understanding of and solutions to the problems associated with the integration of the engine into the aircraft system. In addition, to provide the technology base for engine components, inlets and exhaust systems, that is unique to and required by STOL and VTOL aircraft systems. Particular emphasis will be placed on developing the technology which will satisfy the stringent acoustic goals proposed for these aircraft systems. The desired technology base will be brought forth through component development and test programs of components; engines; and engine, nacelle, and wing systems as required.

W75-70063 **505-05-23**
Lewis Research Center, Cleveland, Ohio.
QUIET, CLEAN GENERAL AVIATION TURBOFAN
E. William Conrad 216-433-4000

This RTOP is to cover Lewis activities in preparation for the initiation of the Quiet, Clean General Aviation Turbofan (QCGAT) program currently being proposed as a new start for 1976, to meet future environmental requirements with economic viability and low fuel consumption. Principle activities will include two study contracts to manufacturers of small turbofan engines to provide information to NASA required for program initiation. Such information includes (1) suitable engine quieting through application of technology derived for large engine programs, (2) application of clean combustor technology to reduce emissions of these small engines, (3) consideration of other factors involved in improving the applicability of small turbofans to the general aviation field (reduced cost, airplane safety, etc.) and (4) formulation of projected programs directed at achieving the objectives of the QCGAT program including scheduling, risk assessment, cost, etc. These contract efforts will be supported by appropriate in-house activities related to the program definition.

W75-70064 **505-05-24**
Lewis Research Center, Cleveland, Ohio.
MMVRA PROPULSION SUPPORT
Warner L. Stewart 216-433-4000

This RTOP is to cover LeRC activities in support of the Multi-Mission VTOL Research Aircraft (MMVRA) program being initiated under joint NASA/Navy sponsorship and currently, within NASA, under the responsibility of Ames Research Center. The support includes: (1) further study of lift fan engines suitable for this aircraft; (2) propulsion support to the contractors involved in the aircraft studies; (3) generation of appropriate engine information to provide a base for formulating the fan package development and the procurement of engines for the research aircraft; and, (4) assistance to Ames, as required, in its technology programs where propulsion is involved.

W75-70065 **505-05-31**
Lewis Research Center, Cleveland, Ohio.
LOW COST SMALL ENGINE TECHNOLOGY
Lawrence Macioce 216-433-4000
(505-04-21; 505-04-31; 505-05-11)

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 to a wide range of general aviation aircraft and expendable military engine applications, where in both cases broader use of gas turbine engines is currently inhibited by their cost. Contribution to small gas turbine engine cost reduction technology is being made by simplification of the engine configurations, reduction in 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 has been and will continue to be demonstrated by the fabrication and testing of low cost components in component rigs and existing test bed engines, where applicable basic low cost technology will be transferred to the private sector by adapting concepts to production engines allowing large production considerations to impact sub-component design.

W75-70066 **505-05-41**
Langley Research Center, Langley Station, Va.
HYPERSONIC PROPULSION TECHNOLOGY
R. E. Bower 804-827-3285

Research program is directed at the development of concepts for airframe-integrated scramjet engines and the associated basic technology. Component development investigations are conducted inhouse at LRC on inlet, combustor, and nozzle designs applying to flight Mach numbers from 3 to 10. These results are incorporated in complete subscale hot engines models on which experiments are conducted at Mach 7 in the LRC Scramjet Facility and at Mach 4 in the AEDC APTU Facility. More basic research is conducted on H2 fuel injection, mixing, and combustion in both 2-D and axisymmetric flow fields for both wall and stream injection in order to advance prediction and design techniques. Inhouse program is augmented in some areas by R and D grants and contracts. Design studies on flight weight, fuel-cooled engine structures and systems are conducted in parallel with the aerothermal program. Program generally is focused on definition of experimental scramjet engine for flight tests on research airplane. Studies of low speed thrust devices are conducted primarily inhouse for the purpose of synthesizing complete propulsion system concepts for hypersonic vehicles.

W75-70067 **505-05-41**
Ames Research Center, Moffett Field, Calif.
HYPERSONIC PROPULSION RESEARCH
Hurbert M. Drake 415-965-5876
(501-24-05; 505-03-11)

This is a continuation of the investigation of advanced hypersonic inlet flow fields to develop the methodology for predicting the internal flow (i.e., shockwave boundary layer interactions, etc.) in hypersonic inlet systems needed for efficient and stable scramjet engine system design. Experimental and analytical studies of hypersonic inlet flows will be conducted 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 on an in-house and contract basis in phases thru early FY-76.

W75-70068 **505-05-42**
Langley Research Center, Langley Station, Va.
HYPERSONIC RESEARCH ENGINE
Ernest A. Mackley 804-827-3675

This program is responsive to the NASA Level IV Specific Objective titled Hypersonic Propulsion, which can be found in the NASA PASO Documents. To define a practical high performance, Mach 3-8 liquid hydrogen ramjet engine of laboratory size by building a full-scale, hydrogen-cooled, Structures Assembly Model (SAM), and a full-scale, water-cooled Aerothermodynamic Integration Model (AIM) of the HRE and by measuring in wind tunnel tests the aerothermodynamic and thrust performance at Mach 5, 6, and 7 of the AIM. The engine structures thermal performance and low cycle fatigue characteristics were evaluated during Mach 7 testing conducted in the 8-foot High Temperature Structures Tunnel. The AIM tests were conducted at Mach 5, 6, and 7 in Lewis Research Center/Plum Brook Station's Hypersonic Tunnel. The data analysis is to be completed and the results reported. The objective is to advance the technology of hypersonic airbreathing propulsion systems and to evaluate the requirements for future research. The superior fuel economy of airbreathing propulsion requires that such systems be re-examined in light of current technology for application to any new hypersonic atmospheric flight mission.

W75-70069 **505-05-51**
Lewis Research Center, Cleveland, Ohio.
ADVANCED PROPULSION SYSTEM CONCEPTS
R. J. Weber 216-433-4000

In-house and contracted studies will be performed of engine cycles, complete propulsion systems, and integrated engine/airframe combinations applied to representative airplane missions. The object of the studies is to determine desirable engine component and system design characteristics for future aircraft and to identify technology deficiencies and profitable areas for research. The studies will explore the opportunities for satisfying environmental and nature resource constraints and their related impact on propulsion system selection and aircraft performance. *Representative topics include concepts for reducing fuel consumption* of subsonic transports and variable-cycle engines for supersonic military aircraft.

W75-70070 **505-06-11**
Ames Research Center, Moffett Field, Calif.
COMPUTATIONAL AERODYNAMICS
Leonard Roberts 415-965-5861
(501-06-05; 501-06-08; 505-06-31; 505-06-15)

This RTOP is to develop and apply analytical and numerical procedures which can be used for study of complex aerodynamic flow fields at subsonic, transonic and supersonic flight speeds. The procedures will apply to two and three-dimensional configurations and will include consideration of inviscid flows, viscous effects and propagation of sound through non-homogeneous and/or stratified media. Flow field studies in the subsonic, transonic, and supersonic speed regime will continue covering inviscid and viscous laminar and turbulent flows with and without separation using finite difference, relaxation technique, and integral method solutions. The Ames Finite-Element Wing-Body Aerodynamics Computer Program will be modified to incorporate multiple bodies and vertical surfaces. Several of the computational methods that are under development or nearing completion will be tested and/or modified for use in the aircraft synthesis program (ACSYNT) being used to study various vehicle concepts. The computer codes will be compared against a more simplified existing code and implemented in ACSYNT, if accuracy or computation time is enhanced. Additional emphasis will be given to the subsonic speed regim, particularly in applying numerical analysis techniques to three-dimensional flows occuring on blown flaps, augmentor wings, multi-element wings and other high-lift configurations.

W75-70071 **505-06-11**
Langley Research Center, Langley Station, Va.
COMPUTATIONAL AERODYNAMICS
P. J. Bobbitt 804-827-2627
(505-06-14; 505-06-15)

The objective of this RTOP is to develop the capability to analytically predict complete aerodynamic characteristics of complex three-dimensional aircraft configurations, now obtainable only by extensive wind tunnel tests (constrained by Mach number and Reynolds number limitations, sting and wall interference effects) to a degree that preliminary design concepts can be evaluated and screened with reduced tunnel test time and cost. The approach of analytical and numerical procedures will be developed for the prediction of pressure distributions, aerodynamic characteristics, flow fields, skin friction and heat transfer for inviscid, viscous and coupled inviscid-viscous flows with attached and separated boundary layers, detached lee side flows with vortex formation and other interactions. Both linear and nonlinear, exact and approximate flow equations will be applied as

appropriate. Mathematical techniques required typically depend on the problem; however, finite-element, finite-difference relaxation, time-asymptotic, 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. Several problems requiring large computer storage will be programmed for the interim STAR with particular emphasis on efficient solution algorithms.

W75-70072 **505-06-11**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
COMPUTATIONAL AERODYNAMICS
R. R. McDonald 213-354-6186

The objective of this RTOP is to develop a new theory of differential systems, and to apply it to achieving a systematic understanding of selected important equations of continuum mechanics. The methods being developed are especially applicable to coupled sets of nonlinear ordinary and partial differential equations, where results previously have been found by ad hoc methods. Examples are (1) invariance transformations, (2) general similarity solutions, (3) characteristics, (4) integral conservation theorems, (5) functional variable transformations and discovery of superposition principles, and (6) variational principles. Of these, (3), (4), and (6) are of direct applicability in writing programs for numerical computation. (5) and (6) are the most active current areas of research in applied mathematics. The method is based on the modern calculus of exterior differential forms, and is especially appropriate for nonlinear equations such as occur in describing aerodynamic flows. The systematic structure of the theory also allows the use of computer symbolic analysis. In past joint work at JPL and IIT, a unique set of programs was developed for non-commutative algebraic manipulation of differential forms. The most recent work under this task has been (1) in the application to coupled sets of ordinary differential equations, in showing how Hamiltonian structures may always be found for these, and (2) in discovery of transformations generating multiple 'soliton' solutions to nonlinear dispersive wave equations. Such equations occur not only in classical fluids, but in plasmas, solid-state devices, laser optics, and new superconducting computer elements. Work is in progress in applying the theory to the systematic discovery of variational principles for nonlinear flows. These are used in relaxation type computer calculations, and have previously been discovered only by ad hoc methods.

W75-70073 **505-06-12**
Ames Research Center, Moffett Field, Calif.
DEVELOPMENT OF COMPUTATIONAL AERONAUTICAL CODES FOR ILLIAC
Dean R. Chapman 415-965-5065

The overall objective is to develop efficient computer programs for solving fluid dynamics problems on the Illiac and large serial computers. A wide variety of fluid flows is to be simulated, from low subsonic to hypersonic speeds, for steady and unsteady, inviscid and viscous flow over two- and three-dimensional configurations. Specific objectives include the solution of transonic flow around wings, wing-body combinations, and lifting airfoils, the latter for unsteady flow; viscous flows including vortices, separation, and shock-wave boundary-layer interactions; and the nature and effects of turbulence. New numerical methods will be developed and analyzed with emphasis on those especially suited for parallel processing. The programs will be written in CFD Code for processing on the Illiac; however, by use of translators, it will be possible to debug and execute these programs on serial computers. The most efficient and reliable programs will be selected for final documentation and dissemination.

W75-70074 **505-06-13**
Ames Research Center, Moffett Field, Calif.
PHYSICAL MODELING AND VERIFICATION OF ILLIAC COMPUTER CODES
Dean R. Chapman 415-965-5065

This RTOP is to perform fundamental experiments specifically designed to verify two- and three-dimensional Illiac codes and to provide the necessary modeling of the physics of turbulent flows to be included in these codes. The Reynolds number domain will extend from the relatively low values of conventional wind tunnels up to the practical range of existing and future aircraft for the transonic and supersonic speed regimes. The flows to be studied will emphasize pressure gradients, separation, and shock interaction regions. Initial objectives are to perform experiments relevant to the development and verification of two advanced transonic computer codes currently being developed. A two-dimensional viscous code will be evaluated by comparing surface pressures, skin friction, and velocity fields obtained from numerically simulated flows with experimental values for unswept wings in supercritical flow regimes including shock-induced boundary-layer separation. A three-dimensional inviscid code, capable of adequately treating highly sweptback local shock waves will be evaluated by comparing surface pressures with measurements on highly swept airfoils at sufficiently high Reynolds number to suppress dominant viscous effects. A study will be conducted at moderately supersonic speeds of the turbulent boundary layer with pressure gradient and/or separation induced by (1) an impinging normal shock wave and (2) a wedge ramp. The measurements will length Reynolds numbers to 300 million to provide turbulent shear stress and kinetic-energy turbulence models needed for computer code development and verification.

W75-70075 **505-06-14**
Langley Research Center, Langley Station, Va.
VORTEX LIFT
R. E. Bower 804-827-3285

Technical objectives of this RTOP are to perform basic research related to various flows which generate vortex lift as required to carry out the following OAST program objective major thrusts: (1) develop the capability to analytically predict complete aerodynamic characteristics of complex 3-D aircraft configurations to a degree that preliminary design concepts can be evaluated and screened with reduced wind-tunnel test time and cost; (2) provide prediction techniques that will allow accurate assessment of a vehicle's high angle-of-attack flight characteristics; also criteria that will yield an expanded high angle-of-attack maneuvering capability for military fighters. The approach, both in-house, contract and grant research will be utilized to accomplish the objectives. The in-house effort will include experimental studies using various windtunnel facilities and analytical studies based on application of finite element techniques and on the application of the edge suction analogy. A flow-through strain-gage balance will be constructed to allow in-house capability to study overall forces related to the jet-augmented vortex-lift concept.

W75-70076 **505-06-15**
Ames Research Center, Moffett Field, Calif.
TURBULENT BOUNDARY LAYERS
Hubert M. Drake 415-965-5861
(505-06-11; 505-06-31)

This RTOP is to conduct analytical and experimental investigations of turbulent boundary layer flows under conditions where our present understanding of such flows is inadequate. These conditions 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 interactions, and (3) flows subject to variation of edge entropy. The flow may be attached or separated in any of the foregoing cases. The results will be utilized to obtain by mid FY-77 empirical turbulence models for use in advanced computer programs for calculating complete flow fields including regions in which viscous effects play a predominant role.

W75-70077 **505-06-15**
Langley Research Center, Langley Station, Va.
TURBULENT BOUNDARY LAYERS
R. E. Bower 804-827-3285
(505-06-11; 505-06-13)

The RTOP presents research to significantly improve our ability to predict the behavior of general turbulent shear flows including turbulent boundary layers and free mixing flows for aeronautical design purposes. Includes theoretical and experimental research on turbulent boundary layers, free mixing layers, and recirculating

flows including effects of compressibility, pressure gradients, mass and heat transfer and three-dimensional flows on turbulence modeling. Studies to include interaction of turbulent boundary layers and shock waves, the development of physical models of turbulent shear, structure of separated turbulent flows and examination of methods for reducing turbulent skin friction drag in subsonic and supersonic flows. A coordinated theoretical and experimental program in which theoretical turbulence models are postulated based on the physics of the situation, with inputs from carefully conducted experiments which measure (1) surface shear and heat transfer and (2) detailed structure of turbulent flows obtained by standard techniques and by means of hot wires, lasers and other advanced measurement techniques. Detailed data and turbulence models are used to develop and verify several large numerical codes including computational methods for three-dimensional boundary layers, three-dimensional mixing, and vortex and separated flows.

W75-70078 **505-06-16**
Ames Research Center, Moffett Field, Calif.
DEVELOPMENT OF ADVANCED FLEXSTAB PROGRAM
H. M. Drake 415-965-5880
(766-72-02; 743-36-01)

The aeroelastic deflections experienced by large supersonic aircraft both in steady state and maneuvering (perturbed) flight have a major impact upon performance, stability, control, 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 nonlinear 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.

W75-70079 **505-06-21**
Ames Research Center, Moffett Field, Calif.
NONSTEADY AERODYNAMICS
H. M. Drake 415-965-5880

The principal objectives of this research are 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, to obtain an improved understanding of the reaction or coupling of the aircraft structure to the unsteady aerodynamics, to develop methods of predicting buffet intensity and wing rock, and to develop means of extending the buffet boundary. 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 through maximum buffet and wing rock onset. Additional wind tunnel parametric studies will be made to assess various approaches toward alleviation of buffet and wing rock.

W75-70080 **505-06-22**
Ames Research Center, Moffett Field, Calif.
WAKE VORTEX MINIMIZATION
B. H. Wick 415-965-5033
(766-70-01; 505-08-21)

To obtain both short range and long range aerodynamic solutions to the aircraft operational hazard caused by aircraft trailing vortices, investigations will be made to determine: (1) the fundamental mechanisms involved in vortex generation and decay, (2) the components of vortex velocity and turbulence up to large distances behind a wing for various conditions of angle of attack, wing sweep, flap deflection, etc. and (3) vortex dissipation resulting from variations in span loading, trailing devices and mass injection, etc. The approaches to be used are: (1) theoretical studies, and experimental investigations utilizing wind tunnels and water tunnels, (2) development of improved equipment and techniques for wind tunnel and water tunnel investigations, and (3) application of promising vortex alleviation devices, and spanwise load variations to models of specific transport aircraft and their experimental evaluation.

W75-70081 **505-06-22**
Langley Research Center, Langley Station, Va.
WAKE VORTEX MINIMIZATION
R. E. Bower 804-827-3285
(766-70-01)

The objective of this RTOP is to develop wake vortex minimization devices that are acceptable for routine aircraft operations. The approach of laboratory and flight tests conducted over the past 18 months have established the feasibility of modifying the trailing vortex system of an aircraft by aerodynamic means. Laboratory testing will continue to investigate new concepts and to develop an alleviation system that will allow safe and economic operation of aircraft with separation distances of 2 nautical miles.

W75-70082 **505-06-23**
Ames Research Center, Moffett Field, Calif.
AIRFRAME AERODYNAMIC NOISE
B. H. Wick 415-965-5036
(505-03-11)

The objective of this RTOP is to provide the necessary data and to determine the design principles necessary to reduce airframe noise by 10 db in the next decade. As a first step in this process, the major sources of airframe noise will be identified by performing extensive measurements in such large scale wind tunnels as the 40- by 80-foot wind tunnel and the 7- by 10-foot wind tunnel. Additional small scale testing on specific noise sources will be conducted in the 25- by 35 cm acoustic test apparatus. Noise sources to be investigated will include turbulent boundary layers, vortex systems and wakes, separated flows, landing gears, and high lift devices. Special diagnostic techniques are under development for discriminating the desired noise signal from the extraneous noise generated in the wind tunnel environment. As a parallel effort, a feasibility study of a low-noise tow facility for measuring airframe noise will be conducted. A theoretical effort for predicting the noise generated by solid bodies in an airstream is also underway. A better understanding of the fundamental mechanisms will be used to design incisive experiments which will reduce aircraft noise to acceptable levels. Noise reduction techniques will be verified in a series of wind tunnel tests on models of existing aircraft and representations of future aircraft.

W75-70083 **505-06-23**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
AIRFRAME NOISE
R. R. McDonald 213-354-6186

The objective of this task is to identify and to seek to reduce the sources of noise produced by the external, i.e. non-propulsive, components of aircraft. The experimental portion of the work is to be accomplished through wind tunnel testing. The flow fields to be studied for noise generation are chosen to represent separated flows over wheel wells and cavities, behind steeply-deflected control surfaces, behind bluff objects, and in the trailing vortex of a lifting wing. Scale models will be tested in the second phase of the work. The theoretical effort will utilize existing computer programs to describe the noise production.

W75-70084 **505-06-23**
Flight Research Center, Edwards, Calif.
AIRFRAME AERODYNAMIC NOISE
P. L. Lasagna 805-258-3311

The technical objectives are to obtain an understanding of the fundamental mechanisms involved in the generation of noise from other than propulsive sources by the airflow over the airframe of an aircraft in flight, and to investigate methods whereby such noise could be effectively reduced without undue design penalties. In addition to theoretical studies, flight tests will be made using a series of airplanes to measure the ground noise of each airplane while descending along a landing approach path with the engines off. In so far as practical, the flight speed and configuration geometry of each airplane will be varied to ascertain the effects of flaps, slats, cavities, etc., on the noise spectrum and level. Initial tests were done with an Aero-Commander. Testing is now being continued with the Jet Star and CV-990.

W75-70085 **505-06-23**
Langley Research Center, Langley Station, Va.
AIRFRAME AERODYNAMIC NOISE
R. E. Bower 804-827-3285

The objectives of this research are to determine the design principles and provide the necessary data on airframe (i.e. nonpropulsive) noise to insure that the CARD policy study goal of reducing aircraft noise by 10 db per decade can be achieved. The aerodynamic factors that control the generation, magnitude, and radiation of aerodynamic noise will be studied to determine the means by which the noise can be reduced. The effort will concentrate on identifying airframe noise sources in both the clean and approach and takeoff configurations, such as from the fuselage, empennage, wings, high lift devices, landing gear, and other protuberances, and wheel well cavities. Studies will be conducted on scale models and components by mathematical modeling and by testing in quiet wind tunnels. Airframe noise prediction techniques will be developed for comparison with flight test data from jet transports and with the model and component wind tunnel results. Aerodynamics design concepts for minimizing airframe noise will then be defined from analytical predictions and demonstrated in flight tests.

W75-70086 **505-08-22**
Lewis Research Center, Cleveland, Ohio.
AIRCRAFT OPERATIONS AND SAFETY R AND T
S. Weiss 216-433-6898

The objective is to provide a broad base of safety-oriented technology for identifying and defining the hazards associated with aeronautical systems and establish criteria for aircraft design and operating techniques leading to reduction in accidents, loss of life and injuries, and loss of equipment. The approach will be to define, recommend, and support research activites that provide solutions to problems impacting on the safety of aviation; cooperate with other NASA Centers and Lewis Divisions to exploit unique facilities and engineering talents necessary for addressing these safety problems; and coordinate research results with the FAA, NTSB, DOD, other interested government agencies, and the aviation industry. Specific areas of current research activities include lightning hazards, rotor burst protection, hi-energy brakes, and aircraft fire prevention and protection.

W75-70087 **505-06-31**
Flight Research Center, Edwards, Calif.
AIRFOIL AND CONFIGURATION AERODYNAMICS
E. J. Saltzman 805-258-3311

The technical objectives are: (1) to improve our ability to predict the aerodynamic efficiency (or performance) of vehicles which move through the atmosphere and (2) to define how the efficiency of airfoils or complete vehicles is influenced by geometry, Reynolds number, surface roughness and texture, and free stream and local flow conditions. In addition, experimental research on turbulent boundary layer phenomena will be conducted including the effects of compressibility, pressure gradient, heat transfer and surface roughness, and the interaction of turbulent boundary layers and shock waves and separated flow phenomena. Overall and incremental drag of powered and coasting vehicles will be defined by the accelerometer and/or dynamic analysis methods augmented by the stabilized glide and rate of sink methods. Airfoil performance will be defined by conventional pressure distribution techniques, boundary layer rakes and trailing wake probes augmented by flow visualization where required. Pressure distribution techniques will also be used in assessing boattail and base drag and in studying means of reducing these components of drag.

W75-70088 **505-06-31**
Ames Research Center, Moffett Field, Calif.
AIRFOIL AND CONFIGURATION AERODYNAMICS
Hubert M. Drake 415-965-5861
(505-06-11)

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 flows, such as flow separation on multi-element high-lift wing configurations, and to determine the potential configuration advantages of the antisymmetric wing concept for use on various configurations. This work will be primarily experimental and will be conducted in-house. Complementary theoretical investigations are covered in RTOP 505-06-11.

W75-70089 **505-06-31**
Langley Research Center, Langley Station, Va.
AIRFOIL AERODYNAMICS
P. K. Pierpont 804-827-2210

The objectives are to provide improved airfoils and multi-element high lift airfoils for advanced subsonic aircraft and transonic executive and commercial transports, and improved blade element airfoils for new performance capability for advanced military and commercial transport rotary-wing aircraft. Improvements are sought in the areas of basic aerodynamic performance, high lift and controls performance, and stall behavior. The work will be an intermix of both experiment and applied theory and will provide: (1) measurements of aerodynamic characteristics for selected configurations, (2) upgraded predictive aerodynamic analysis, (3) generation of airfoil design methodology for both subcritical and supercritical aerodynamic regimes, and (4) stimulation of new and unique design concepts, theoretical methods, and experiment techniques. Examples include new supercritical airfoils, general aviation airfoils, leading and trailing edge high lift devices, and new rotorcraft blade sections. In addition, the work includes improvements in existing research facilities and techniques together with development of new and unique capabilities. These new capabilities are specifically directed toward achievement of high quality data at intermediate and very high Reynolds numbers, such as are obtainable through cryotechnology.

W75-70090 **505-06-41**
Langley Research Center, Langley Station, Va.
BOUNDARY LAYER STABILITY AND TRANSITION
R. E. Bower 804-827-3285

Research was made to improve the understanding and prediction of boundary layer stability and transition. The importance of transition behavior to aerodynamic heating and its influence on thermal protection systems, aircraft lift-drag ratios, missile observables, and vehicle dynamics was also noted. 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, a quiet supersonic tunnel which would suppress adverse environmental disturbances is to be developed. The program is primarily experimental but with close theoretical support and is directed toward understanding of fundamental processes. Such a quiet facility is also needed for supersonic application of drag reduction techniques such as compliant walls and laminar flow control.

W75-70091 **505-06-42**
Ames Research Center, Moffett Field, Calif.
TUNNEL AND SCALE EFFECTS ON TRANSONIC FLOW
H. M. Drake 415-965-6463

The general objective of this research is to develop by FY-77, 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 heavy gas mixtures will be investigated analytically and experimentally.

W75-70092 **505-06-42**
Langley Research Center, Langley Station, Va.
TUNNEL AND SCALE EFFECTS IN TRANSONIC FLOW
R. E. Bower 804-827-3285

The technical objective is to provide the technology for improved transonic test capability for experimental prediction of performance and flight characteristics of conceptual or new aircraft designs. In-house, contract, and grant supported research utilizing both analytical and experimental approaches will be used to accomplish the objective with the efforts being concentrated in the following specific areas: (1) cryogenic wind-tunnel technology and studies in direct support of the Transonic Research Tunnel project, (2) research on magnetic suspension and balance systems for the elimination of model support problems and studies of the combined application of the superconducting coil balance and cryogenic tunnel technologies, and (3) research on transonic tunnel walls designed to minimize interference and the development of improved wall interference correction methods.

W75-70093 **505-06-43**
Ames Research Center, Moffett Field, Calif.
FLOW MEASUREMENT TECHNIQUES
Hubert M. Drake 415-965-6116
(505-06-14; 505-06-31; 505-06-81)

A laser velocimeter system is being developed for obtaining mean velocities, turbulence intensities, and Reynolds stress components in both low and high speed flows. Further, a large scale (8 watt) portable laser velocimeter system is to be developed for measuring local velocities in the Ames 2- by 2-foot and 6- by 6-foot facilities. Measurements will continue to be made with the 4-watt laser velocimeter in the Ames 8 x 8 inch supersonic wind tunnel in the natural boundary layer on the tunnel wall and downstream of a shock-wave boundary-layer interaction, and compared with hot wire anemometer measurements. This effort to be completed by FY-76, will be coordinated with the analytical and experimental studies in the turbulent boundary layer task of RTOP 505-06-14.

W75-70094 **505-06-43**
Langley Research Center, Langley Station, Va.
FLOW MEASUREMENT TECHNIQUES
R. E. Bower 703-827-3483

This effort will develop instrumentation technology to improve measurement techniques to satisfy present and future aeronautical testing requirements. The work is predominately an in-house effort with emphasis placed on research where successful results will provide measurement technology broadly applicable to aeronautical programs. Technology developed under this RTOP will be coordinated with more focused instrument development in other programs. Research to be pursued includes development of gas velocity measurement techniques, improvements in heat flux and thermal mapping measurements, aerodynamic load measurements, model attitude, and digital data acquisition techniques. These research tasks will be continually alined with present and projected aeronautical program measurement requirements.

W75-70095 **505-06-44**
Flight Research Center, Edwards, Calif.
RPRV CAPABILITY DEVELOPMENT
B. M. Kock 805-258-3311

This RTOP covers a remotely piloted research vehicle (RPRV) capability development program. The program will develop a baseline capability for performing flight research with supersonic, maneuverable, vehicles. Particular emphasis will be placed on developing the existing FRC RPRV operating systems to be compatible with this class of vehicle. A Firebee 2, target drone (BQM-34 E/F) converted to an RPRV, will be used. The vehicles will be on loan from the USAF. The technique development program will consist of a series of flights using MARS recovery technique. During these flights the performance and maneuvering envelope of the airplane will be explored so as to meet the program objectives. To accomplish the program the vehicles will be modified with a complete research instrumentation capability. This instrumentation along with the RPRV command and control capability will develop the Firebee 2 into a versatile high performance research test bed.

W75-70096 **505-06-81**
Langley Research Center, Langley Station, Va.
VEHICLE DYNAMICS - STALL/SPIN/HIGH ALPHA CHARACTERISTICS
R. E. Bower 804-827-3285

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 wing-tunnel force tests, theoretical analysis, piloted simulator tests, and dynamic model tests.

W75-70097 **505-06-81**
Ames Research Center, Moffett Field, Calif.
VEHICLE DYNAMICS - STALL/SPIN/HIGH ALPHA CHARACTERISTICS
Hubert M. Drake 415-965-6396

The primary emphasis in this program is to provide a basic understanding of the aerodynamic characteristics of aircraft at high angles of attack through the development of improved theoretical methods supported by static and dynamic wind tunnel tests. Also through the application of the test results to develop new criteria for designing vehicles capable of performing controlled manuevers over an expanded angle-of-attack envelope. Investigations to evaluate various experimental concepts for determining dynamic characteristics of aircraft at high angles of attack are in progress. The design and construction of a large scale rotary apparatus is underway along with a feasibility study for an oscillatory apparatus for use in the Ames Unitary and 12-foot wind tunnels. Large scale low speed tests will be conducted to examine the cause and effect of asymmetrical forces occuring at high alpha's and the limitations of controls that restrict the allowable alpha beta maneuvering envelope. Alternate control methods and the use of unique devices for coping with the upsetting forces will be evaluated.

W75-70098 **505-06-91**
Flight Research Center, Edwards, Calif.
HANDLING QUALITIES - CRITERIA FOR HIGHLY AUGMENTED VEHICLES
Dr. 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 tests 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 will be investigated. 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. Certain aspects of wake vortex encountering dynamics will be studied through theoretical analysis, simulation and flight tests to assess the hazard involved and the ability of alleviating the upset by use of an automatic control system.

W75-70099 **505-06-92**
Ames Research Center, Moffett Field, Calif.
HANDLING QUALITIES - TURBULENCE/FLEXIBILITY EFFECTS
H. P. Klein 415-965-5094

Aircraft and pilot responses during atmospheric turbulence encounters are prime factors in the design and operation of all

aircraft. To develop the basis for improved methods for specifying acceptable aircraft behavior under these circumstances, work is underway or planned to: (1) develop and validate more accurate models of atmospheric turbulence; (2) develop an optimum gust alleviation system for aircraft with serious ride qualities problems, e.g., light wing loading STOL airplanes, (3) refine existing ride qualities criteria for application to future large military or civil aircraft where structural mode excitation may have a first-order effect on both ride and handling qualities, and on pilot/aircraft performance, and (4) develop improved displays, autopilot modes and pilot procedures for severe turbulence encounters with advanced short-haul transport aircraft. This work will be accomplished by means of analytical and piloted simulator studies, both in-house and under grant or contract. Completion of objective (1) under grant to the University of Washington (FY-73 funds) is planned. Objective (2) will be accomplished in-house by a NAS-NRC postdoctoral associate. Research related to objective (3) will be continued by both in-house and contract personnel on the VARD simulator. Objective (4) will be accomplished by means of a contract study on either the VARD or another suitable ARC simulator.

W75-70100 **505-06-93**
Langley Research Center, Langley Station, Va.
ADVANCED CONTROL APPLICATIONS
G. B. Graves 804-827-3745
(766-75-02; 742-73-01)

The objectives are: (1) 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 of 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 (2) 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 were made to investigate the applications of several aspects of modern control theory to airplane dynamics and control systems synthesis. 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 were utilized to investigate the effect of promising systems on pilot opinion and handling qualities.

W75-70101 **505-07-11**
Ames Research Center, Moffett Field, Calif.
APPLICATION OF CONTROL AND GUIDANCE THEORY TO THE AUTOMATIC AND MANUAL CONTROL OF FUTURE STOL AND VTOL AIRCRAFT
H. W. Bradford 415-965-5567
(768-83-01; 501-23-33)

The purpose of this research is to extend and apply advanced linear and nonlinear modern control theory techniques to the guidance and control of STOL and VTOL aircraft. Major efforts are made to: (1) develop methodology and algorithms for generating fuel, time and noise optimal trajectories of STOL and VTOL aircraft operating in an advanced air traffic control environment, (2) create a flexible real time terminal area simulation to evaluate the impact on the future air traffic system of the optimal 4D guidance system, (3) verify the guidance system design through an experimental flight program using the STOLAND system on the augmentor wing jet STOL aircraft, (4) design a full flight envelope autopilot (FFEAP) which recognizes all the fundamental aircraft nonlinearities and uses a digital computer to process basic aerodynamic force and moment data and compute essentially open loop control sequences for following ATC trajectory commands, (5) verify system performance by an experimental flight program using the STOLAND system (substantially modified) on the augmentor wing jet STOL aircraft, (6) apply FFEAP design technique to tilt rotor aircraft, and (7) investigate concepts for fault-tolerant aircraft control systems.

W75-70102 **505-07-12**
Langley Research Center, Langley Station, Va.
JOINT UNIVERSITY PROGRAM ON AIR TRANSPORTATION SYSTEMS
G. B. Graves 703-827-3745
(768-81-01; 791-93-51)

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 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 transporation. Efforts to further improve communications and interactions between the schools, and to foster initiation of complementary research projects will include joint quarterly meetings of the principal investigators, the production and exchange of video recordings of technical lectures, and the extension of the contract between Litchford Systems, Inc., and the Universities. Some NASA, FAA, industrial, and aircraft user-operating organizations will participate in briefings for program coordination.

W75-70103 **505-07-21**
Flight Research Center, Edwards, Calif.
GENERAL AVIATION FLIGHT CONTROL SYSTEM AND DISPLAYS
Shu 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 pilots workload and enhance his performance by applying human factors engineering to system design. Emphasis will be on low cost designs for general aviation.

W75-70104 **505-07-22**
Langley Research Center, Langley Station, Va.
ANTENNA AND RECEIVER TECHNOLOGY
G. B. Graves 804-827-3745

The increase in air traffic that is occurring in the U.S. today is rapidly outmoding some of the current avionics systems in use. Work in being conducted on a national basis to define new system configurations and to upgrade existing systems to provide improved performance in the areas of traffic surveillance and control, landing guidance, and aircraft navigation. The problems associated with the introduction of new or improved avionics systems consists of: (1) meeting the more stringent performance characteristics usually required, (2) providing equipment at a cost suitable for general acceptance by the civil aviation fleet, and (3) providing for the retrofit of new equipment on existing aircraft. Work will be conducted to apply the latest technology to solve these problems, such as; the development of low profile antennas which can be mounted on the skin of an aircraft with a minimum of structural penetration, and the development of a class of digital communications receivers which are optimized with respect to both the thermal receiver noise and multipath interference.

W75-70105 **505-07-31**
Langley Research Center, Langley Station, Va.
HIGHLY RELIABLE CIVIL AIRCRAFT COMPUTER TECHNOLOGY
G. B. Graves 804-827-3745
(766-75-02)

This program will provide the research needed to begin the development of a highly reliable fault-tolerant flight control computer system. Ultra-reliable fault-tolerant computer system architectural concepts will be defined; formal mathematics will be developed to describe the error detectability and system diagnosability of fault-tolerant systems; new measures for reliability assessments will be precisely defined; and in-house investigations of off-the-shelf computer systems will be performed

to validate reliability improvements obtained from special hardware organizational concepts and software redundancy managements techniques.

W75-70106 **505-07-41**
Langley Research Center, Langley Station, Va.
AUTOMATED VTOL AVIONICS
G. B. Graves 804-827-3745
(768-82-02; 766-75-02; 505-10-23)

This effort will derive and validate 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 (505-10-23) and operating systems (768-82-02) are the major elements of an integrated LRC 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 for 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 radio-inertial navigation systems, displays, sensors, and to evaluate hemispheric coverage landing guidance systems. Designs of functionally integrated systems will be implemented in prototype hardware and flight tests will be conducted to evaluate and demonstrate systems performance. The VTOL guidance, navigation, and control requirements, and concepts will be investigated by extending previous analytical studies, simulation, and flight experiments to include automatic flight and landing operations.

W75-70107 **505-08-10**
Langley Research Center, Langley Station, Va.
KNOWLEDGE OF ATMOSPHERIC PROCESSES
E. S. Love 804-827-2893

The purpose of the program is to generate a quantitative understanding of the atmospheric particulate radiation environment as a function of altitude, latitude, and solar activity. To develop such an understanding requires a knowledge of the basic nuclear process as related to its transport within the earth's atmosphere. To this end, experiments to measure reaction cross sections will be performed and reaction models developed to interpolate between experimental data points. Basic studies will also be made to ascertain solution techniques of the transport equations which are appropriate for this study. As our understanding of the atmospheric radiation progresses, analysis of radiation enviromental considerations for high altitude aircraft, of historic carbon dioxide content in the atmosphere for the assessment of climatic impact, and of the radiation belts, will be made. Basic data for a satellite radiation monitoring system for the protection of occupants of high altitude aircraft will also be generated during the progress of this study. The main objective is to determine biological doses in different depths in the atmosphere for all latitudes and solar activity, and to further the concept of radiation monitoring via satellite for commercial SST operations. Also to explore the relationship of atmospheric radiation to other geophysical phenomena (such as atmospheric CO2 content). Another objective was to investigate the relevant nuclear processes via experiments to be performed at Berkeley (LBL) and further develop the nuclear reaction and transport theory in-house. Further studies to determine historic concentrations of atmospheric CO2 by the relation to radiative phenomena will also be conducted.

W75-70108 **505-08-10**
Flight Research Center, Edwards, Calif.
KNOWLEDGE OF ATMOSPHERIC PROCESSES
L. J. Ehernberger 805-258-3311

The objective of this work is the definition of the atmospheric conditions in which turbulence, temperature transients, potential pressure altimetry problems and excessive wind shears occur. The major emphasis is the atmospheric environment of supersonic aircraft. Development and acquisition of sensors needed to measure these phenomena are also included. Results of this work will be applicable to aircraft systems design as well as flight operations routing and scheduling. Observations of these phenomena are obtained from instrumented aircraft test flights. The associated meteorological conditions are analyzed and studied both in-house and on contract.

W75-70109 **505-08-10**
Marshall Space Flight Center, Huntsville, Ala.
KNOWLEDGE OF ATMOSPHERIC PROCESSES
G. H. Fichtl 205-453-3168
(501-08-10)

The objectives of this RTOP are: (1) the definition of the steady-state wind and turbulence environments applicable to the design of aeronautical systems, (2) the feasible modification of fog at airports, and (3) the development of techniques and procedures whereby the knowledge of the natural environment can be better utilized for the safe operation of aeronautical systems. The first objective shall be accomplished through the development of models of atmospheric boundary layer blow properties, namely (1) steady-state wind profile, (2) steadystate and instantaneous wind shear, (3) statistical properties of turbulence, (4) modification of flows as air passes over and around buildings or natural obstructions and from rough to smooth and from smooth to rough terrain, (5) the structure of wakes behind buildings and natural obstructions, and (6) structure of the turbulence in the cold air outflow of thunderstorms. For the free atmosphere probabilistic models of turbulence and the conditions which lead to turbulence will be developed. The second objective, through analytical and laboratory tests relative to the life cycle of fog. Techniques shall be developed whereby potential candidates for the dispersal of fog can be evaluated rapidly and in a cost effective manner. The third objective will be accomplished by developing potential requirements, criteria and procedures for the reporting of atmospheric parameters to pilots prior to take-off and prior to the final approach.

W75-70110 **505-08-11**
Ames Research Center, Moffett Field, Calif.
NEUTRON ENERGY SPECTRA AND DOSE RATES AT AIRCRAFT ALTITUDES
C. A. Syvertson 415-965-5222
(501-08-10; 970-21-63)

Measurements will be made of neutron energy spectra at aircraft altitudes using improved instrumentation and analysis techniques. The data will aid in resolving controversies reported in the literature concerning the shape of the spectra and the relative contribution of fast neutrons to the total neutron dose. The validity of existing computer codes for calculating neutron fluxes will be tested. Variations in the spectra with time at a given reference point in the atmosphere during a significant portion of the solar cycle will be determined. Changes in the spectra as a function of altitude and latitude will be reassessed. The total radiation dose and the percentage of the dose contributed by neutrons will be measured. A capability for determining the effect of a solar flare on the neutron flux and radiation dose at aircraft altitudes will be developed. The approach to these objectives will involve the collaborative effort of several laboratories in developing improved dosimetric instrumentation and methods of analysis. Ames aircraft will be used in a series of 3 or 4 flights per year to establish baseline spectra at approximately 45,000 feet over the Center. Changes in the flux with altitude and latitude will be determined on other flights. Theoretical calculations of the expected fluxes will be obtained from consultants for comparison with the experimental data. A solar flare dosimetry package will be developed which will be flown quickly to a reference altitude if a solar flare occurs.

W75-70111 **505-08-20**
Langley Research Center, Langley Station, Va.
AIRCRAFT OPERATING EXPERIENCES
R. E. Bower 804-827-3285

Statistical data on the operational experiences of general aviation airplanes are being collected and analyzed. Data are obtained by NASA VG and VGH flight recorders from airplanes involved in representative operations of general aviation aircraft usage. The information obtained provides: (1) a continuous basis for comparing actual airplane loadings with design loadings, and thereby a check on the adequacy of design criteria; (2) a means of detecting unanticipated operational practices; and (3)

provides a bank of data useful in the design and development of airworthiness requirements for new types of airplanes.

W75-70112 **505-08-21**
Lyndon B. Johnson Space Center, Houston, Tex.
DEVELOPMENT PROGRAM OF IMPROVED AIRCRAFT CABIN MATERIALS
R. W. Bricker 713-483-3166
(501-38-19)

The effort defined in this RTOP is a continuation of work originally started in FY-73. During FY-73 and FY-74 numerous small scale materials flammability tests and three full-scale tests on a 737 aircraft fuselage were conducted. Additionally, a contract to develop high temperature aircraft insulation was awarded. However, some of the work that was planned for FY-74 was deferred for lack of funds. The work planned for FY-75 and covered by this RTOP will finalize the insulation development, procure fire resistant windows, refurbish the aircraft fuselage with the improved materials and conduct a full-scale external fuel fire test.

W75-70113 **505-08-21**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
AVIATION SAFETY R AND T-FIRE TECHNOLOGY
R. R. McDonald 213-354-6186

The objectives of this RTOP are to reduce the flammability of materials in and around an aircraft. Both the fuel and the polymeric materials of the cabin interior and secondary structure will be modified to accomplish this purpose. Fuel additives will be developed which will markedly reduce the mist formed when a tank or line is ruptured, with a consequent reduction in the fireball which can form on ignition. A secondary objective will be to perform thermodynamic calculations to determine flame temperatures and theoretical combustion products for the proposed modified aircraft materials and to determine flammability regimes as functions of oxygen partial pressure and ignition energy.

W75-70114 **505-08-21**
Ames Research Center, Moffett Field, Calif.
AVIATION SAFETY RESEARCH AND TECHNOLOGY
Dean R. Chapman 415-965-5065

The objectives are: to develop and evaluate prototype fire-safe aircraft interior and fuselage structures for current and future aircraft utilizing fire-resistant materials and other fire control systems such as detectors and fire extinguishants in order to provide an increased probability of human survivability in fires where there is minor fuselage damage; and to evaluate fire extinguishing technology for engine nacelles and fuel lines. The program consists of three elements: crash fire survivability, aircraft interior fire safety, and aircraft component evaluation such as windows. In the first area, studies and appropriate tests will be conducted to evaluate the use of fire-retardant composites as secondary fuselage structures and to define other benefits obtained by the use of these materials. In the second area, prototype studies of sensitive cabin areas such as lavatories and cargo compartment will be conducted to assess the fire threat level that current structures can withstand, and to develop and evaluate fire-resistant composites, detector and quenching systems that can control and contain the fire. The third area involves the development and evaluation of fire-resistant and antistatic aircraft windows.

W75-70115 **505-08-22**
Langley Research Center, Langley Station, Va.
HAZARD AVOIDANCE AND ELIMINATION
R. E. Bower 804-827-3285

The objective is to provide basic technology for the improvement of the level of safety in aircraft operations with regard to natural atmospheric phenomena and aircraft-induced hazards. Experimental flight research and analytic studies are to be conducted in areas of aircraft trailing vortices and slant-range visibility measurements.

W75-70116 **505-08-22**
Ames Research Center, Moffett Field, Calif.
AVIATION SAFETY RESEARCH AND TECHNOLOGY - WAKE HAZARD
L. Roberts 415-965-5066
(766-70-01)

The trailing vortex systems generated by aircraft can be hazardous to other aircraft following along or near the same flight path. A three phase program involving piloted moving-base simulation will be conducted to provide a data base to assist the FAA in establishing safe separation distances. A hot-wire anemometer system will be employed to gather basic data in flight on vortex behavior for various aircraft types. Certain of these results, in which the velocity data and response are measured simultaneously, will be employed in validating the modelling of aircraft response to vortex encounter for use in the simulations.

W75-70117 **505-08-22**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
HAZARD AVOIDANCE
R. R. McDonald 213-354-6186

The objective of this effort is directed toward improving aircraft safety. A practical approach to marking trailing vortices generated by large aircraft will be investigated, with emphasis placed on injection of non-polluting particulates. Several candidate marking materials and techniques will be identified based on consideration of their requirements and characteristics. These will then be subjected to an in-depth analytical evaluation, so that one or more promising candidate concepts can be embodied in a working model for demonstrations in FY-1975.

W75-70118 **505-08-22**
Marshall Space Flight Center, Huntsville, Ala.
AVIATION SAFETY RESEARCH AND TECHNOLOGY/ HAZARD AVOIDANCE AND ELIMINATION
E. A. Weaver 205-453-4629

Using the laser Doppler technique, systems and instrumentation will be developed for measuring natural and induced atmospheric flow phenomena concentrating on aircraft wing tip vortices and clear air turbulence (CAT). This will be accomplished as follows: (1) perform system feasibility studies, design studies, analyses and tests with laboratory ground based laser Doppler instrumentation to determine operational requirements, specifications, constraints and capability; (2) develop and test two- and three-dimensional systems for measuring atmospheric flow, concentrating on aircraft wing tip vortices; and (3) develop and test a laser Doppler clear air turbulence detection system as appropriate on the ground and aboard an aircraft, evaluating test data and the findings as the basis for system modification to assure overall system performance goals.

W75-70119 **505-08-30**
Langley Research Center, Langley Station, Va.
CROSSWIND LANDING FOR STOL OPERATIONS
R. E. Bower 804-827-3285

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 techniques, flight safety margins, and crosswind limits during STOL-type landing operations. A crosswind landing gear will be designed, built, and flight tested. Studies also will be made of control concepts such as the use of an all-moving vertical tail for crosswind landing control.

W75-70120 **505-08-31**
Ames Research Center, Moffett Field, Calif.
AIRCRAFT SYSTEMS OPERATIONAL SAFETY AND EFFICIENCY IMPROVEMENT
Dean R. Chapman 415-965-5065

The objectives are: to improve aircraft performance and safety on the runway through the utilization of improved materials in aircraft tires and brake linings; to develop and evaluate new elastomer formulations for use in tires on high performance aircraft having superior wear and safety properties compared to state of the art tires; and to develop and evaluate composite materials based on aromatic carbonaceous compounds which could serve as long wearing and improved frictional materials for aircraft brake linings. Tread vulcanizates consisting of new and improved

elastomers either alone or in polyblends with natural rubber and/or cis polybutadiene will be evaluated for thermal-oxidative stability and physical properties. Optimization of polymer structure and rubber compounding will be sought in order to yield elastomeric materials having improved tread wear and safety characteristics over state of the art tread formulations. Aircraft tires will be retreaded with improved elastomer stocks and then evaluated in commercial airline service as well as in special runway traction tests. Failure modes of tire carcasses and treads will be studied. Brake lining composites will be molded of para-polyphenylene, polybismaleimide and branched polyphenylene. The processing and formulation parameters will be investigated, and the key properties, namely, friction, wear, thermal - oxidative stability, determined. Selected composites will be tested on a full scale dynamometer.

W75-70121 **505-08-31**
Langley Research Center, Langley Station, Va.
AIRCRAFT GROUND PERFORMANCE
G. W. Brooks 804-827-2042

Aircraft operations on prepared runways under adverse weather conditions and on certain unprepared surfaces present requirements on braking and steering systems, tires and runway that are vital to aircraft safety and passenger comfort as well as being necessary to procedures for alleviating airport congestion. The objectives of programs covered by 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 operations on unprepared fields, including water, and permit continuous use of prime runways for all-weather operations, (4) to evaluate tire cornering behavior with and without braking such that high-speed turnoffs can be designed to increase the flow of traffic at congested airports, and (5) to relate the character of the runway surface to aircraft braking and steering performance. Research to meet these objectives will employ full-scale aircraft, landing gear systems and subsystems, and scaled pneumatic tires. The test facilities will consist of Aircraft Landing Loads and Traction Facility, airport runways, including the landing research runway at Wallops Station, ground test vehicles, flight-type aircraft simulators, and various laboratory equipment.

W75-70122 **505-10-11**
Langley Research Center, Langley Station, Va.
GENERAL AVIATION AERODYNAMICS
R. E. Bower 804-827-3285

The objective is to develop and demonstrate advanced technology that will permit the design of general aviation aircraft that are safer, more productive, and clearly superior to foreign competition. This work will be accomplished by analytical studies, model tests, and flight tests to develop and demonstrate improved airfoil sections, wing designs, control characteristics, handling qualities, stall/spin characteristics, ride comfort, and pilot information.

W75-70123 **505-10-12**
Ames Research Center, Moffett Field, Calif.
GENERAL AVIATION - TECHNOLOGY
Leonard Roberts 415-965-5066
(505-06-31)

The objective of the research was to provide advanced technology for general aviation that will permit the design of future aircraft that are safer and more productive. Advanced wing designs will be developed having improved low-speed control and stall characteristics combined with improved cruise drag and stability. Stall envelopes of existing light aircraft will be expanded and improved through wind tunnel testing of various aerodynamic and control system modifications. In addition, promising future aircraft configurations will be studied which have potential for inherent or imposed stall immunity.

W75-70124 **505-10-13**
Flight Research Center, Edwards, Calif.
FLIGHT DYNAMICS - CONTROL AND DISPLAY
S. W. Gee 805-258-3311

The technical 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 realization of 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 axes in order to define minimum system characteristics will be explored. Studies will be made of benefits, including direct lift/drag control devices in a flight path command mode of control.

W75-70125 **505-10-21**
Ames Research Center, Moffett Field, Calif.
HELICOPTER AERODYNAMIC PERFORMANCE, DYNAMICS AND NOISE
B. H. Wick 415-965-5044
(505-10-22; 791-93-22)

This RTOP covers research on performance, dynamic loads, stability, control system, and noise characteristics of advanced edgewise rotor concepts and configurations. Analyses will be followed by large scale wind tunnel tests to evaluate these configurations and provide a data base to improve analytical techniques. A dynamic properties evaluation of the new rotor test apparatus will be completed to insure applicability to a wide variety of rotor systems. The baseline rotor will be tested. Procurement of a pressure/boundary layer instrumented rotor will be initiated. A follow on test of the effects of rotor geometry on noise will be initiated. The controllable twist rotor will be tested to determine performance/stress trade offs. Analysis and preliminary design of multicyclic flap systems for vibration/stress suppression will continue. The blade/vortex interaction study will be continued, and a rotorcraft drag reduction study will commence. Design and fabrication of optical elements for a laser velocimeter for application to rotor inflow studies in the 40- by 80-foot wind tunnel will be completed. The small scale feasibility experiments on the reverse velocity rotor are in progress. Analysis and reporting of the results will be accomplished during the first quarter of FY-75.

W75-70126 **505-10-21**
Langley Research Center, Langley Station, Va.
HELICOPTER AERODYNAMICS
R. E. Bower 804-827-3285
(505-10-23; 505-10-26; 766-79-01)

Analytical and experimental studies will be made to identify factors contributing to the aerodynamic and structural 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 response and aerodynamic performance. In-house experimental studies will be continued to better define unsteady local-flow parameters significant in the prediction of rotor blade section lift and drag. Analytical, wind tunnel, and whirl tower investigations will be made to determine performance, dynamic loads, vibrations, and wake flow characteristics of advanced rotor concepts, rotorcraft configurations, and tail rotor arrangements. These studies will be coordinated with the airfoil development research under RTOP 505-06-31, and with the rotor aeroelastic and acoustic studies under RTOP 505-10-26. Note: This program will, in general, be carried out jointly with the Langley Directorate of the Army Air Mobility Research and Development Laboratory.

W75-70127 **505-10-22**
Ames Research Center, Moffett Field, Calif.
TILT ROTOR AIRCRAFT AERODYNAMIC PERFORMANCE, DYNAMICS AND NOISE
B. H. Wick 415-965-5044
(505-10-21; 791-93-22)

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 systems and noise characteristics of advanced tilt rotor concepts and configurations. The basic in-house dynamic stability theory completed last year will be updated with an improved representation of blade elasticity and extended to include the capability

for feedback control system synthesis using optimal control theory. Contracted analyses and tests will be conducted to determine tilt rotor gust response and means for gust alleviation and blade load suppression. Generalized feedback controller studies will be contracted based on cantilever wing methodology in FY-75 followed by complete vehicle and conversion studies in FY 76-77. In-house analyses of airfoil sections and variable geometry appropriate to the tilt rotor will continue. Contracted analyses and tests will be initiated to study rotor/wing/tail interference problems. Contracted analyses to evaluate the cost of noise reduction for tilt rotor aircraft will be extended.

W75-70128 **505-10-23**
Ames Research Center, Moffett Field, Calif.
ROTORCRAFT FLIGHT DYNAMICS
B. H. Wick 415-965-5066
(767-78-01)

An hierarchy of control systems will be investigated to establish the minimum augmentation requirements and to develop methods of implementation. Emphasis will be given to minimizing the system complexity, minimizing the effects of upsets and disturbances, and on developing techniques for decoupling controls. A coordinated flight and simulation study will be completed to determine the effect of gross weight on the handling qualities and flight control requirements for crane helicopters up to the heavy lift class. Simulations of commercial versions of tilt rotor aircraft will be conducted in a program to develop control systems suitable for the short-haul transport mission. Flight verification will be accomplished using the Tilt Rotor Research Aircraft.

W75-70129 **505-10-23**
Langley Research Center, Langley Station, Va.
ROTORCRAFT FLIGHT DYNAMICS
R. E. Bower 804-827-3285
(768-82-02; 505-07-41; 768-83-04)

Using broad capability helicopter in-flight simulators as primary tools, required research will be conducted to develop improved certification criteria (primarily in the areas of handling qualities and overall flight characteristics) for the various classes of VTOL vehicles as well as for helicopters and other rotorcraft. The scope of the research includes consideration of manual IFR flight conditions, as well as consideration of advanced vehicles having automatic 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 area. Representative types of problems to be investigated include defining the requirements and flight/operational characteristics of advanced flight control systems including active controls, inherent and augmented stability, cockpit displays, pilot controls, vehicle/pilot interfaces with ground based and onboard navigation systems for manual flight in IFR conditions, and vehicle/pilot interfaces with automatic flight systems. The VALT CH-47 will be instrumented to provide a highly flexible and efficient replacement for the CH-46 in-flight simulator during FY-1975. The SH-3A will be used for cockpit display - pilot workload studies.

W75-70130 **505-10-24**
Langley Research Center, Langley Station, Va.
ROTORCRAFT CIVIL HELICOPTER TECHNOLOGY
R. E. Bower 804-827-3285
(505-10-21; 505-10-23; 505-10-26)

The objectives are: (1) to identify in critical disciplinary areas the projected requirements and associated criteria for achieving successful and acceptable civil operations, and to evaluate existing vehicles in meeting these requirements, (2) to assess the extent to which existing advanced technology can be applied to meet projected requirements, and to identify areas requiring additional research, (3) to conduct vehicle and systems design application studies utilizing existing advanced technology, and (4) to carry out key experimental evaluations which are deemed critical to industry acceptance and use of promising advanced technology features. Studies will be carried out both through analytical, design, and systems studies and through experimental evaluation of selected systems in simulated operational environments. The program will utilize principally contractual effort, plus some in-house effort in flight research experiments.

W75-70131 **505-10-26**
Langley Research Center, Langley Station, Va.
ROTOR ACOUSTICS AND AEROELASTICITY
R. E. Bower 804-827-3285
(505-10-21; 505-10-25)

The objective of this plan is to develop technology related to the aeroelastic and noise characteristics of rotors, and to use this technology in developing and validating adequate design prediction methods. Technical areas of interest include methods of predicting aeroelastic stability characteristics of rotors in hover and forward flight, vibration characteristics of helicopters and means for reducing or alleviating excessive vibrations, unsteady rotor aerodynamics, tip air mass injection for controlling rotor noise, and design prediction methods for noise from main and tail rotors. Work will continue on the establishment of a generalized rotor aeroelastic model (GRAM) to be used for experimental correlation of advanced aeroelastic stability analyses being developed in-house and under contract. The GRAM will also be used for testing advanced rotor configurations, such as the variable geometry rotor, being proposed for RSRA. An analytical effort will begin to develop a mathematical model for predicting the vibration characteristics of a complete helicopter configuration. An in-house research project will address the problem of active vibration isolation systems which will have application to RSRA. Structural system identification techniques will be used in an attempt to predict blade rotating properties from non-rotating vibration tests. A program to compute compressible, unsteady, rotor aerodynamic loads will be formulated for use in aeroelastic stability calculations. Rotor noise tests using the rotor test tower will be conducted to validate available noise prediction theories. In-house research on impulsive rotor noise will be conducted along with contractural tests for evaluation of tip air mass injection as a means for controlling rotor noise.

W75-70132 **505-10-31**
Ames Research Center, Moffett Field, Calif.
VTOL AERODYNAMIC PERFORMANCE
B. H. Wick 415-965-5036
(505-03-12)

This RTOP covers research on the aerodynamics, performance, stability and control of promising jet-lift VTOL commercial and military transport configurations, including a better understanding of propulsion-aerodynamic interactions. Analytical methods for predicting these characteristics will be improved. Wind tunnel investigations of a large scale model of a lift-fan research aircraft both in and out of ground effect will begin. Large scale wind tunnel investigations of aircraft components will continue, as will wind tunnel research on the noise generated by lift-fan jet-lift VTOL aircraft at forward speed. Analytical studies to improve prediction methods will begin. Studies of advanced augmentors at both large and small scale will continue. Theoretical and experimental studies of cruise performance of lift/cruise fan powered VTOL aircraft will continue.

W75-70133 **505-10-31**
Langley Research Center, Langley Station, Va.
VTOL AERODYNAMIC PERFORMANCE
R. E. Bower 804-827-3285
(505-11-41)

This research is a continuing three-part effort in VTOL aerodynamics involving applied fluid mechanics phenomena, combat aircraft, and transport aircraft. The basic research objective is to provide the technology required for improved performance, stability, and control of promising VTOL configurations applicable to civil and military transports as well as military fighter and attack aircraft. 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 VTOL aircraft. University grants will augment the in-house analytical work. Major emphasis will be placed on investigations of promising lift-fan transport configurations in the V/STOL tunnel and investigations of combat aircraft configurations in both the V/STOL and full-scale tunnels. This will include

exploratory wind-tunnel research of VTOL fighter-type configurations suitable for application by the Navy on ships without catapults or arresting gear. These concepts include the ejector-augmented-lift principle, deflected thrust, lift-engines plus lift/cruise engines, and a 'tail sitter' configuration.

W75-70134 **505-10-32**
Ames Research Center, Moffett Field, Calif.
VTOL FLIGHT DYNAMICS
B. H. Wick 415-965-5567
(505-10-33; 505-10-34)

Design and handling qualities criteria will be developed 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 transport aircraft will be conducted to evaluate various techniques of automating control of the magnitude and direction of the thrust, and to develop improved concepts. 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.

W75-70135 **505-10-33**
Ames Research Center, Moffett Field, Calif.
HANDLING QUALITIES REQUIREMENTS FOR SHIP-BASED VTOL
B. H. Wick 415-965-5066
(505-10-12; 505-10-26; 760-62-02)

Solutions will be sought to the special problems involved in manual control of the takeoff, approach, and landing of VTOL aircraft operating from the Navy Ships under severe weather conditions. The approach to these problems will be primarily experimental, using both piloted simulations and VTOL research aircraft. An integrated approach will be taken in the simulations, whereby, the ship systems, the aircraft systems, and the guidance systems are studied in combination with one another. Parallel flight investigations will follow using existing VTOL aircraft. The unique aspect of the ship landing problem which will be emphasized, as distinguished from VTOL terminal area research under RTOP 505-10-21, is the nonstationary landing and take-off surface.

W75-70136 **505-10-34**
Ames Research Center, Moffett Field, Calif.
SIMULATION MATH MODELS OF ADVANCED TRANSPORTS
B. H. Wick 415-965-5567
(505-10-23)

Simulation models of all important aircraft concepts in the CTOL, RTOL, STOL and V/STOL commercial transport classes are required to support the study of terminal area efficiency factors. To permit valid comparisons, the models of all competing concepts must be designed to the same level and technology and, where possible, for the same mission. Computer storage for each element of the terminal area study must be minimized to avoid exceeding the computer capacity. Aircraft models therefore, must be as simple as possible consistent with the aim of providing representative pilot handling qualities.

W75-70137 **505-10-41**
Ames Research Center, Moffett Field, Calif.
POWERED-LIFT (STOL/RTOL) AERODYNAMIC PERFORMANCE
B. H. Wick 415-965-5036
(505-06-23)

This RTOP covers Ames efforts in R/STOL aerodynamics and noise. The goal is to provide aerodynamically efficient, quiet, and mechanically simple powered lift systems having RTOL and STOL performance. Studies show that the augmentor wing can meet noise goals and that augmentor nozzles may also be used for cruise propulsion. The experimental investigation at large scale of several types of augmentors and complementary theoretical and small scale experimental studies for improving augmentor performance and acoustics will be continued. The study of quiet augmented jet flap thrust reversers will be included. Acoustics and performance of USB concepts will be studied in the 40- by 80-Foot Wind Tunnel. Supporting investigations of wind tunnel wall effects for STOL aircraft, ground effects, and noise characteristics of STOL aircraft will be conducted under this RTOP.

W75-70138 **505-10-42**
Ames Research Center, Moffett Field, Calif.
STOL/RTOL FLIGHT DYNAMICS
B. H. Wick 415-965-5567
(766-71-02)

Generalized analytical studies, ground-based simulation, and flight research will provide data for revision and extension of existing handling qualities and certification criteria for STOL aircraft. The data will apply to the following critical areas: flight path, airspeed, and attitude control; landing flare in the presence of ground effect; roll and yaw control for cross-wind landing; and the control of a powered-lift STOL following loss of an engine. The effectiveness of a hinged plate spoiler system in improving flight path control and landing dispersion will be studied on a DHC-6 aircraft. Tentative airworthiness criteria based on studies of representative powered-lift aircraft, together with techniques for determining compliance 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. The program will be coordinated with the Flight Experiment Program for the augmentor wing jet STOL research aircraft. A simulation experiment will be conducted to develop means and procedures for minimizing landing field length for short haul RTOL aircraft.

W75-70139 **505-11-11**
Langley Research Center, Langley Station, Va.
MEDIUM AND LONG HAUL CRUISE AERODYNAMIC TECHNOLOGY - AERODYNAMIC DRAG REDUCTION RESEARCH
D. M. Bushnell 804-827-3151

The objective is to provide the technology basis for more fuel efficient energy conserving aircraft through exploitation of advanced airfoil designs, such as the supercritical airfoil, and by development, optimization and flight demonstration of skin friction reduction concepts, thus conserving our nation's energy resources and enhancing our nation's competitiveness in the international aircraft market. Experimental, theoretical, and system studies will be concentrated on transport configuration applications of such concepts as laminar flow control, gaseous slot injection, compliant wall, surface roughness drag, low drag airfoils, wing vortex diffusers, and other innovative techniques. The most promising of these concepts will be carried into flight test phases where the tests will typically be conducted on wing panel sections.

W75-70140 **505-11-12**
Ames Research Center, Moffett Field, Calif.
SUBSONIC/SONIC AIRCRAFT AERODYNAMIC PERFORMANCE
H. M. Drake 415-965-5990
(505-06-31; 791-93-62)

The objective of this investigation is to determine by FY-76, the areodynamic performance, stability and control characteristics, and airport and community noise characteristics of the R.T. Jones oblique wing transport aircraft configuration at subsonic, transonic and low supersonic speeds, so that adequate aerodynamic prediction methods for this class of vehicle can be provided. This information will be used for mission studies to assess the potential of antisymmetric configurations for advanced transport application. Concurrently, an analytical and experimental investigation of nacelle-airframe interference effects on engine type and nacelle size, shape and location will be made using a scale wind tunnel oblique wing transport model.

W75-70141 **505-11-13**
Flight Research Center, Edwards, Calif.
OBLIQUE WING FLIGHT TEST TECHNOLOGY PROGRAM
W. H. Andrews 805-253-3311

This test program will be conducted in two phases and will be directed toward the operation of an RPV and full scale manned airplane modified to demonstrate the oblique winged configuration concept developed by R. T. Jones of the Ames Research Center. The initial program phase will consist of testing an RPV, Firebee 2, particularly in the critical regions of the projected flight envelope. The second phase will be directed to flying a manned LTV F-8 airplane to fully demonstrate and gain industry acceptance of the concept. Both vehicles will be modified to incorporate essentially an elliptical, full-span, variable-sweep wing (lambda = 0 to 60 deg) fabricated to standard structural design specifications. The incorporation of conventional lateral control and high lift devices in the wing or other alternatives will be considered in the developmental stages of these programs. Basic control and stability augmentation system modifications to the test vehicles will also be assessed in the early development phase of each vehicle, respectively. The objective of the flight programs will be to demonstrate the feasibility and utility of the concept by evaluating the following: stability and control, and dynamic behavior.

W75-70142 **505-11-13**
Ames Research Center, Moffett Field, Calif.
OBLIQUE WING FLIGHT TEST TECHNOLOGY PROGRAM
H. M. Drake 415-965-5881

The primary objective of this project is to develop and improve analytical and empirical prediction techniques that will provide more accurate estimation of aircraft dynamic flight behavior from static wind tunnel data. Investigations of the currently used methods for predicting dynamic derivatives from static aerodynamic data and methods based on wind tunnel/flight-data correlations will be made, and effort will be made to improve these methods and develop new methods where appropriate. Initial efforts under this project will be directed at developing the NASA capability for predicting the dynamic behavior of oblique wing aircraft based on static wind tunnel and calculated data. An oblique wing remotely piloted aircraft will be wind tunnel tested and the aerodynamic data will be used to develop a simulation of the aircraft. This simulation will permit prediction of the dynamic flight behavior of the aircraft. The aircraft will then be flown to generate the actual dynamic behavior. The dynamic derivatives will be extracted from the flight test data. Correlation of the flight determined values with the wind tunnel data and the predicted derivatives will be used as a guide in the effort to develop improved prediction techniques.

W75-70143 **505-11-14**
Ames Research Center, Moffett Field, Calif.
CIVIL AIRCRAFT DEVELOPMENT TESTING - INDUSTRY AND OTHER GOVERNMENT AGENCIES
H. M. Drake 415-965-5850

Civil aircraft research and development generally require supporting wind tunnel investigations. In particular, Reynolds number effects on high-lift system characteristics at take-off and landing speeds, and performance, stability and control characteristics and aerodynamic loads assessment at transonic and supersonic speeds need experimental evaluation. Notably the 12-foot pressure wind tunnel and the unitary plan wind tunnel are well-suited for such investigations and, when technically appropriate, are utilized accordingly. Proprietary testing at the request of a particular company is charged for in accord with NASA policy. Testing for other government agencies is done without transfer of funds.

W75-70144 **505-11-15**
Langley Research Center, Langley Station, Va.
HIGH-SPEED AERODYNAMICS
R. E. Bower 804-827-3285
(743-35-01)

The technical objective of this work is to provide the analytic methodology and a background of aerodynamic data throughout the speed range (up to about M = 4.5) for defining and optimizing the aerodynamic performance of high-speed aircraft configurations. The approach to be used will employ both theoretical and experimental investigations of generalized aircraft configurations to develop techniques for increasing aerodynamic efficiency; to determine means of managing the aerodynamic center variation with Mach number to attain low static margins without encountering regions of static instability; and, to develop new aerodynamic control concepts to provide maximum aerodynamic control effectiveness with a minimum of control force. Attempts will be made to formulate original theories and to adapt existing theories to practical usage in computing programs. Limited wind-tunnel tests will be made to verify, to establish limits of, and where appropriate, provide empirical corrections to theoretical results. Interactive computer graphics will be developed for efficient use of both manpower and computer power.

W75-70145 **505-11-21**
Ames Research Center, Moffett Field, Calif.
MILITARY AIRCRAFT - AERODYNAMICS
Leonard Roberts 415-965-5861
(505-06-81; 505-04-11)

Experimental and analytical studies will be made to provide the aerodynamic technology for design of advanced military aircraft. Large scale wind tunnel studies will be conducted on components and integrated configurations to determine the mutual aerodynamic interference effects between the airframe and propulsion system for conventional aircraft at subsonic, transonic, and supersonic speeds. The effect of fuselage geometry and inlet location on aircraft and inlet performance will be determined. Various numerical analysis and approximation techniques will be employed. The approximation techniques will serve as a basis for the detailed numerical study, and will aid in defining cost effective experimental programs. Wind tunnel studies will be made over the Mach number range to verify the analysis and to evaluate the mutual aerodynamic interference effects between the airframe and propulsion system that are beyond the scope of present analytical methods. It is estimated that this effort will extend thru FY-77.

W75-70146 **505-11-21**
Langley Research Center, Langley Station, Va.
MILITARY AIRCRAFT - AERODYNAMICS
R. E. Bower 804-827-3285

The technical objectives of this work are to develop advanced concepts which will provide the aerodynamic technology for the design of future military aircraft, and to assess the impact of advanced technology on combat performance. Research conducted under this RTOP will provide the configuration aerodynamics and performance technology for the NASA Highly Maneuverable Aircraft Technology Program. The approach to be used will combine both analytical and experimental studies of the integration of advanced aerodynamic concepts such as supercritical aerodynamics, wing warp, maneuver devices, thrust-induced lift, and component interference in the design of complete aircraft configurations. Particular emphasis will be placed on the improvement of performance and stability-and-control characteristics in the high angle-of-attack range at subsonic, transonic, and supersonic speeds.

W75-70147 **505-11-22**
Langley Research Center, Langley Station, Va.
MISSILE AERODYNAMICS
M. L. Spearman 804-827-3134

The objective is to develop advanced concepts which will provide the aerodynamic research and technology for the design of improved missile systems. The approach to be used will combine both analytical and experimental techniques. Studies 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. Studies will include

rocket as well as air-breathing systems with special consideration being given to inlet-airframe integration.

W75-70148 **505-11-23**
Langley Research Center, Langley Station, Va.
MILITARY A/C VECTORED THRUST MANEUVERABILITY
R. E. Bower 804-827-3285

The objective is to expand VIFF studies of the Harrier aircraft to maximum speed and thrust. Flight trails of the Phase 2 Joint NASA/U.K. VIFF flight research program will be completed in the U.K. using a modified Harrier aircraft supplied by the U.K. These trails will be in two parts: (1) air-to-air, and (2) air-to-ground. Both research and services (USMC and RAF) pilots will take part in the trials. During FY-1976, radar data from these trials will be analyzed by McDonnell Douglas utilizing techniques developed for analyzing Harrier simulator and Phase 1 data.

W75-70149 **505-11-24**
Flight Research Center, Edwards, Calif.
F-15 STALL/SPIN-RPV FLIGHT TESTS
G. P. Layton 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, flow 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 and departure. The overall objectives are to develop a remote controlled test technique that is 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, pre-spin conditions; and to assess advanced control systems in pre-stall, post-stall, and pre-spin flight.

W75-70150 **505-11-31**
Langley Research Center, Langley Station, Va.
HYPERSONIC AIRCRAFT AERODYNAMIC TECHNOLOGY
R. E. Bower 804-827-3285
(505-04-31; 501-22-06)

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 potentially capable of providing a truly low cost space logistics system can fill an expected need in the NASA/DOD program in the post 1990 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 synergistic 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 high speed research aircraft (HSRA) will be used as a focal point in the technology development.

W75-70151 **505-11-41**
Langley Research Center, Langley Station, Va.
DOD ASSISTANCE - SPECIFIC MILITARY DEVELOPMENT PROGRAM
R. E. Bower 804-827-3285

The objective is to determine, at specific request of DOD, the aerodynamic characteristics of models and model components at subsonic, transonic, and supersonic speeds. Current emphasis is focused on the USAF B-1, USAF YF-16, USAF YF-17, USN XFV-12A and several missile concepts. Anticipated emphasis will be focused on DOD requested (program of interest to NASA) generalized research programs on methods to improve aircraft maneuverability. 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 selected results will be documented.

W75-70152 **505-11-41**
Ames Research Center, Moffett Field, Calif.
DOD ASSISTANCE
L. Roberts 415-965-5850
(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 military aircraft and missile development programs. Included are research efforts to aid in assuring satisfactory aerodynamic and handling qualities of piloted aircraft and to define and develop techniques for improvement of marginal or unsatisfactory characteristics of new airplane designs. Wind tunnels and flight simulators will be employed as required. Specific weapon systems programs for which support is planned during FY-1975 include the B-1, Advanced Harrier, Advanced Navy Fighter, AFTI, and YF-16 CCV.

W75-70153 **505-11-41**
Lewis Research Center, Cleveland, Ohio.
OUTSIDE AGENCY SUPPORT AERONAUTICS TESTING
D. N. Bowditch 216-433-6123

The objective is to support requests from the Department of Defense, Department of Transportation and other Federal agencies outside of NASA for Aerodynamic testing in the facilities of the Lewis Research Center.

W75-70154 **791-40-03**
Ames Research Center, Moffett Field, Calif.
ANALYSIS OF FUTURE CIVIL AIR TRANSPORTATION SYSTEMS AND CONCEPTS
L. J. Williams 415-965-5887

The objective of this RTOP is to provide systems 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, CTOL, STOL, and VTOL transports, advanced subsonic/transonic transport aircraft, and advanced supersonic transports will be conducted. 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). In addition, studies of a short term nature will be conducted in support of the aeronautical program planning activities of ARC and OAST to perform the necessary studies in support of the more general total systems studies.

W75-70155 **791-40-04**
Ames Research Center, Moffett Field, Calif.
DEVELOPMENT OF METHODOLOGY TO AID IN DEFINING TECHNOLOGY NEEDS FOR FUTURE MILITARY AVIATION SYSTEMS AND CONCEPTS
L. Roberts 415-965-5881

The objective of this RTOP is to develop a methodology to aid in defining the benefits of new aeronautical technology and to increase the value of NASA's research to the DOD for preliminary design studies and evaluations. The approach will be continued incorporation of advanced technologies into in-house aircraft synthesis programs and exercising these programs by analysis of aircraft systems intended to meet mission requirements obtained from or developed in cooperation with appropriate DOD planning personnel. Historically, NASA has supported the DOD by generating advances in technology and by providing analytical and test assistance during the development of specific designs. NASA does not become involved in assessment of technology advances as they affect military requirements. This is a prime responsibility of the military planners and industry designers.

W75-70156 **791-40-05**
Flight Research Center, Edwards, Calif.
HIGHLY MANEUVERABLE AIRCRAFT TECHNOLOGY (HIMAT) - STUDY PROGRAM

D. R. Bellman 805-258-3311
(501-06-44)

This RTOP covers a contractual and in-house study program to provide improved technology for the design of highly maneuverable aircraft. Present design constraints will be relaxed to permit complete freedom in the application of state-of-the-art systems such as integrated computerized controls, composite structures, supercritical airfoil technology, vectored thrust and the like in order to achieve the maximum benefits from synergistic effects. In an initial procurement, 9 contractors were asked to bring forth their ideas, possible innovations, and general approach towards the improvement of the design technology for highly maneuverable aircraft. In a second phase, three contractors will be given $330,000 each to study and develop a conceptual design of a full-scale, manned, highly maneuverable aircraft. Emphasis will be on achieving superior performance through discipline interactions and through promising but untested concepts where the technical and financial risk is unusually high. In a third plan under RTOP 723-77-01, one of the three phase 2 contractors will be asked to complete the design and construct a scaled version which will be tested in free flight at FRC using remotely-piloted research vehicle (RPRV) techniques.

W75-70157 **791-40-15**
Ames Research Center, Moffett Field, Calif.
CIVIL AIR TRANSPORTATION SYSTEM STUDIES
H. M. Drake 415-965-5881

The objective of this research is to develop and use an overall system synthesis capability which can identify the best aircraft characteristics for any air transportation system. Mathematical models of the air vehicle elements will be used and verified by comparison with operational situations. Quick response studies of civil air transports will be conducted to identify critical research areas, assess energy consumption and provide information for cost benefit studies. Specific studies of aircraft optimized for cargo, reduced energy consumption and reduced noise and wake-vortex hazard will be initiated. These in-house studies will provide guidance for possible future contract studies.

W75-70158 **791-40-18**
Ames Research Center, Moffett Field, Calif.
STUDY OF POTENTIAL UTILITY OF RPV'S (REMOTELY PILOTED VEHICLES) FOR CIVIL APPLICATIONS
H. M. Drake 415-965-5881

Studies will be conducted to identify and describe the potential civil market for RPV's, to assess the associated benefits and costs of using these vehicles, and to identify likely candidate vehicle concepts and the technology required to satisfy civil markets. In addition, the study will include an assessment of the impact of safety, reliability and environmental requirements on the future use of civil remotely piloted vehicles. Study to be completed by mid-FY-1976.

W75-70159 **791-40-19**
Flight Research Center, Edwards, Calif.
ANALYSIS OF REMOTE-PILOTED (RP) VERSUS PILOTED (P) RESEARCH AIRCRAFT TO CONDUCT AERONAUTICAL FLIGHT RESEARCH
J. Weil 805-258-3311

Remotely piloted research aircraft have been considered, and used, as a means of reducing the time, cost, and risk of conducting aeronautical flight research. A systematic analysis is desired to document the technical, operational, and economic tradeoffs affecting the choice between remote-piloted and piloted aircraft. The unique capabilities, advantages, and weaknesses need to be clearly identified for both the RP and P classes of research aircraft. This in-house study will compare, throughout the aeronautical flight-test regime, the cost and benefits of using RP versus P research aircraft to conduct aeronautical research. All aspects (i.e., aircraft, ground control, command facilities, test ranges, safety, recovery techniques, research data acquisition, etc.) will be considered in this study. The remote-piloted versus piloted technique will be analyzed by developing case studies of the remote-piloted 3/8-scale F-15 and manned aircraft programs. Also, information regarding RPRV cost, development, and capabilities will be provided by the three contractors involved in Phase II of the HiMAT program. The limited number of FRC RPRV flights conducted by the end of this study will not provide sufficient statistical information from which to evaluate the remote-piloted technique.

W75-70160 **791-40-22**
Ames Research Center, Moffett Field, Calif.
ROTORCRAFT MAINTENANCE COSTS
B. H. Wick 415-965-5044
(505-10-22; 505-10-21)

This RTOP covers evaluation of current rotorcraft maintenance cost experience of both civil and military operations and the establishment of statistical techniques for projecting maintenance cost of advanced rotorcraft, in particular the tilt rotor concept. Commercial and military operations will be surveyed to provide a data base on current experience. Projections of likely technological developments on subsystem design will be made in conjunction with rotorcraft manufacturers. Multiple regression techniques will be used to develop the importance of parameters such as vibration level, mission cycle vs. flight hours, etc. as well as the effects of major technical design differences if pertinent, in determining good maintenance cost estimating relationships.

W75-70161 **791-40-23**
Ames Research Center, Moffett Field, Calif.
TECHNOLOGY ASSESSMENT OF FUTURE INTEGRATED TRANSPORTATION SYSTEMS
H. Hornby 415-965-5894

The objectives of this RTOP are to enhance NASA's contribution to our nation's ability to provide adequately for its future transportation needs and to determine the possible impact of the more promising future integrated transportation systems and corresponding urban structures on aviation and air transportation R and T planning. The approach will be based on a technology assessment encompassing energy requirements, environmental and societal constraints and barriers, and political and economic considerations and on studies of component systems, air ground, and water vehicles for integrated transportation system applications, including short and long haul. The roles of more promising vehicle and system concepts in the integrated transportation system will be identified. This work will also support and extend the development of a comprehensive OAST paper on transportation mode energy consumption.

W75-70162 **791-40-24**
Ames Research Center, Moffett Field, Calif.
TECHNOLOGY ASSESSMENT OF PORTABLE ENERGY RDT AND P
H. Hornby 415-956-5895

The objectives of this RTOP are to determine the impact of promising future portable energy options on aviation and air transportation R and T planning and to enhance NASA's contributions to our nation's ability to provide adequately for its future portable energy and mobility needs. These objectives will be established consistent with environmental standards and constraints, politico-economic considerations, and the sustenance and amelioration of our quality of life. The approach is to: (1) perform systems analysis at the Ames Research Center on the economics of aircraft fuel futures in support and extension of the evolving OAST transportation energy paper; and (2) improve the basis for aviation and air transportation R and T and alternative fuels decisions by extending the technology assessment of portable energy RDT and P into phase 2 activities. Phase 2 shall include the selection and initiation of follow-on studies of critical issues, constraints, and barriers (identified during the phase 1 workshop and subsequent analyses of results) which require further definition upon future objectives of the NASA aeronautics program.

Aeronautics Systems Technology Programs

W75-70163 **510-51-01**
Langley Research Center, Langley Station, Va.

COMPOSITE MATERIALS APPLICATION TO THE C-130 CENTER WING STRUCTURE
G. W. Brooks 804-827-2042
(505-02-41; 766-77-01)

The objective 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, and deliver aircraft to Air Force; and (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.

W75-70164 **510-52-01**
Langley Research Center, Langley Station, Va.
COMPOSITE PRIMARY AIRCRAFT STRUCTURES FLIGHT PROGRAM
G. W. Brooks 804-827-2042
(766-74-01; 501-22-03)

The objectives and approach are to establish a confidence level and economic base for filamentary composite primary structures that will warrant a production commitment by airframe manufacturers to incorporate these structures in future commercial transport aircraft. This objective will be accomplished by demonstrating weight savings of about 25% with composite materials, by accumulating operation and maintenance experience in an airline environment, and by developing the design and manufacturing technology required to lower the acquisition cost of composite primary structure as well as to achieve life-cycle costs comparable to current metal aircraft structure. The flight components will be replacement parts on existing commercially operated aircraft.

W75-70165 **510-53-01**
Lewis Research Center, Cleveland, Ohio.
MATERIALS FOR ADVANCED TURBINE ENGINES (MATE)
N. T. Saunders 216-433-6676
(505-01-12)

This program involves the application of at least five new materials and manufacturing processes for aircraft turbine engines. It will cover the advanced development, rig, and engine testing necessary to demonstrate the potential of new materials technology for use in future engines. The purpose of this program is to accelerate the application of new materials technologies to aircraft engine use in order to achieve improved engine performance benefits. The program will be conducted primarily through contracts with domestic engine manufacturers and their vendors. New materials and processes that have shown laboratory feasibility in exploratory development programs will be selected for further development and evaluation under this program. Cost/benefit and risk analyses will be conducted to help guide the selection of the best candidate materials. The selected materials will then be scaled-up, manufactured into appropriate engine hardware, extensively evaluated to provide preliminary design data, and tested in both engine-simulation rigs and experimental engines to demonstrate their potential for future engine use.

W75-70166 **510-54-01**
Langley Research Center, Langley Station, Va.
INTEGRATED PROGRAMS FOR AEROSPACE-VEHICLE DESIGN (IPAD)
G. W. Brooks 804-827-2042
(505-02-51; 743-32-01)

This RTOP is to develop by 1980 a system of Integrated Programs for Aerospace-Vehicle Design (IPAD) for use by aerospace industry as a tool to reduce cycle time by 50 percent and costs by 25 percent for design of large, complex vehicle systems. IPAD is intended to provide the most effective combination of man and computer to accomplish the total design task. Specific targets are: (1) by early FY-75, complete definition of most promising concepts for IPAD and issue RFP; (2) award development contract by mid-FY-75; (3) have initial incremental release for first level IPAD ready by early FY-78; (4) by FY-80, make a general release to aerospace industry of first level IPAD system.

W75-70167 **511-51-01**
Lewis Research Center, Cleveland, Ohio.
ADVANCED MULTISTAGE AXIAL FLOW COMPRESSOR
M. J. Hartmann 216-433-6650
(505-04-21)

Compressors for advanced military and commercial aircraft must be lightweight and efficient and capable of operating over a wide range of conditions. Hardware, maintenance, and operational costs and fuel consumption must all be reduced below present levels. Besides achieving high component performance levels the compressor must be selected to be compatible with expected advancements in the related technology areas of materials, structures, acoustics, fans, combustors, turbines, controls, bearings and seals. To meet these requirements high pressure stages must be properly matched in a multistage compressor operating at high rotational speeds. The compressor is the pacing item in advanced engine development programs. From program risk and schedule considerations, it is necessary to select a compressor design that has demonstrated suitable performance or to minimize modifications to such compressors. To provide an advanced compressor utilizing high levels of stage pressure ratio, the performance of a multistage compressor designed for 20:1 overall pressure ratio will be determined. A preliminary design and definition study will investigate compressors with as few as six stages which to achieve 20:1 overall pressure ratio requires an average stage pressure ratio of 1:65 as compared to 1.3 or less utilized in existing multistage compressors. The compressor indicated in the preliminary study as providing the greatest benefit to advanced transport aircraft of the mid 1980's will be built and tested at the contractor's site.

W75-70168 **512-51-02**
Flight Research Center, Edwards, Calif.
DIGITAL FLY-BY-WIRE FLIGHT EXPERIMENT
C. R. Jarvis 805-258-3311
(766-75-02)

The overall objective of this effort with LaRC is to provide the technology necessary for the implementation of advanced reliable digital fly-by-wire systems in future aircraft. Negotiations are also currently underway with JSC to include as an additional objective, flighttest verification of key space shuttle flight control system software, hardware, and redundancy management concepts. The program is to be carried out in accordance with the schedules and resources identified by the digital fly-by-wire project plan which is currently being revised. The Phase 1 flight-test program to establish digital fly-by-wire systems feasibility has been completed. In Phase 2, a multichannel digital system is to be developed and flight tested in the F8C aircraft. This will be a three-channel system utilizing redundancy managements developed for space shuttle application. Provisions will be made to evaluate, in flight, advanced control laws being developed by LaRC in accordance with the project plan schedule.

W75-70169 **512-51-02**
Langley Research Center, Langley Station, Va.
DIGITAL FLY-BY-WIRE FLIGHT CONTROL SYSTEMS RESEARCH AND DEVELOPMENT
G. B. Graves 804-827-3745
(501-23-31; 501-23-32)

The objective is to provide a design base for reliable, cost-effective digital fly-by-wire flight control systems for commercial and military aircraft applications. A cooperative program of theoretical and experimental research and demonstra-

tion in DFBW flight control will be carried out by the Flight Research Center and the Langley Research Center. As presently conceived this program has two phases, Phase 1 of which is an initial demonstration and exploration program using Apollo hardware. This program is currently underway at FRC, and responsibility for this program lies largely with FRC. Experimentation in control law software will take place during Phase 2. The phase 2 program, in addition to experimentation in advanced control laws will involve researches into digital actuators and sensor systems that will benefit the flight control task with a view of providing improved systems to be incorporated into the last portions of the Phase 2 program.

W75-70170 **512-52-01**
Ames Research Center, Moffett Field, Calif.
GENERAL AVIATION - ADVANCED AVIONICS SYSTEMS TECHNOLOGY
Leonard Roberts 415-965-5427

The overall objective of this program is to provide the critical information required for the design of a reliable low-cost avionics system applicable to general aviation aircraft which would enhance the safety and utility of this mode of transportation. Sufficient data would be accumulated upon which industry could base the design of a reasonably priced system having the capability required by general aviation in and beyond the 1980's. It should also be emphasized that this program is directed at establishing the technology for a total avionics systems design (i.e., navigation, guidance, control, powerplant management, displays, etc.) as opposed to singling out a particular subsystem, or function, upon which the research effort would be concentrated. The proposed program will include: analysis, system concept studies, piloted simulation and component research and development. Throughout the program, active coordination will be maintained with the DOT-FAA. It is recognized that an essential ingredient in this program is the strong and direct participation of the general aviation industry and its representatives.

W75-70171 **512-53-02**
Ames Research Center, Moffett Field, Calif.
ACTIVE CONTROL AIRCRAFT FLIGHT EXPERIMENT
Bradford H. Wick 415-965-6383

The objective is to apply Active Control Technology (ACT) to STOL, VTOL, and Oblique Wing aircraft to assess potential benefits, identify technology requirements, provide a test bed for verification and application of technology, and provide a data base on which design criteria for these aircraft can be developed. Provide a proven methodology to apply advanced control concepts to these aircraft, with attention to aircraft and control system modeling, simulation, testing hardware development and flight verification of systems. Develop a data base for both non-powered and powered lift aircraft which will include economic justification, technical feasibility, ride quality control, gust load alleviation, aircraft handling qualities, effects of failure modes on controllability, redundancy requirements, ATC coupled systems, and interactions of these concepts. The methodology will be applied to develop an ACT configured STOL design. The approach will be to integrate the relevant computer programs used in aerodynamics, structure, propulsion, control and economics into a single interdisciplinary active control systems design program that is applicable at any stage in the aircraft design cycle. The design program will be evaluated by simulation and flight test using a DHC-6 with modified control surfaces. A conceptual design of an optimally ACT-configured short-haul non-powered lift transport will be developed and evaluated. In addition design methodology for total active control systems for powered lift STOL, VTOL, and Oblique Wing aircraft will be developed. This design methodology will be evaluated by simulation.

W75-70172 **512-53-03**
Flight Research Center, Edwards, Calif.
ACTIVE CONTROLS TECHNOLOGY DEVELOPMENT
D. A. Deets 805-258-3311

A coordinated program is planned in conjunction with LaRC and ARC to supplement, validate, and demonstrate the design techniques required to incorporate active control into the design of future civil aircraft. The specific FRC the objectives include: (1) design and test simple aeroelastic wind-tunnel models and RPRV flight test models to demonstrate flutter suppression concepts as they are developed; (2) conduct studies to determine the most effective means for demonstrating and transferring active controls technology to industry; and (3) conduct flight demonstration tests of a special ACA research vehicle. Theoretical and wind tunnel work will be performed under research grants. Studies and fabrication of demonstrator will be done by contractor.

W75-70173 **513-50-50**
Langley Research Center, Langley Station, Va.
TRAVELER ACCEPTANCE - LOW-DENSITY SHORT-HAUL SYSTEMS
R. E. Bower 804-827-3285

The objective is to identify, study in detail, and model those factors influencing acceptance and use of aircraft as the preferred model of travel by the public in the low- to medium-density short-haul market. Appropriate information will be compiled through literature search, traveler questionnaires, and measurements aboard low- to medium-density, short-haul airline systems. Limited information will also be obtained concerning competing modes of transportation which could influence choice of travel. The data will be analyzed and mathematically modeled. Some existing types of aircraft used in low-density, short-haul service will be evaluated using this model. The majority of effort will be carried out under grant.

W75-70174 **513-50-51**
Langley Research Center, Langley Station, Va.
VLF WIDE AREA NAVIGATION FOR LOW-DENSITY SHORT-HAUL TRANSPORTATION
G. B. Graves 804-827-3745
(505-07-12)

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 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.

W75-70175 **513-50-52**
Ames Research Center, Moffett Field, Calif.
MARKET SURVEY OF MEDIUM DENSITY SHORT-HAUL AIR TRANSPORTATION
Susan Norman 415-965-5887

This study will concentrate on preliminary parametric aircraft synthesis studies and aircraft/airline interface studies. Medium density short-haul air transportation refers to service conducted by local service or commuter carriers using 30 to 70 passenger aircraft. An airline/aircraft interface analysis including trunk, local service and commuter type operations will be performed. A parametric analysis of various aircraft configurations will be included and a system analysis indicating the aircraft impact on actual airline operation will be studied. At least three passenger sizes will be included as well as a number of aircraft configuration concepts such as families of aircraft sizes. In addition, the economics of both the operating and initial investment costs will be examined. This is expected to be a critical decision factor since current operational requirements indicate that such service is sensitive to initial aircraft purchase costs and operating costs. A realistic outlook concerning actual airline operation will be encouraged throughout the study and the actual participation by an airline will be considered.

W75-70176 **513-51-01**
Ames Research Center, Moffett Field, Calif.

NOISE REDUCTION FLIGHT PROCEDURES EXPERIMENTS
Bradford H. Wick 415-965-5427
(505-08-21)

This program will further develop and evaluate the feasibility of using operational procedures as a means of reducing aircraft noise. The first phase of the program is aimed at determining the feasibility of using the two-segment approach for aircraft noise abatement during routine scheduled service. The program calls for seperate flight evaluations using a Boeing 727-200 aircraft equipped with a special purpose computer for the approach guidance, and a DC-8-61 aircraft equipped with a modified area navigation system. The results of these tests will be extrapolated to other aircraft in the current fleet inventories. The second phase of the program will be directed towards determining the noise reduction potential of other operational procedures. The relationship between aerodynamic and propulsive noise for these other techniques will be assessed with the objective of defining a procedure that will result in further noise abatement.

W75-70177 **513-52-01**
Langley Research Center, Langley Station, Va.
TERMINAL CONFIGURED VEHICLE PROGRAM
G. B. Graves 804-827-3745
(768-83-04)

The TCV Program is an advanced technology activity focused on Conventional Take-off and Landing (CTOL) Aircraft that will be operating in reduced weather minima in the future high-density terminal areas equipped with new landing systems, navigational aids, and increased surveillance and automation under development by DOT/FAA. The broad objectives of the program are to provide improvements in the airborne systems (avionics and air vehicle) and operational flight procedures for reducing approach and landing accidents, reducing weather minima, increasing air traffic controller productivity and airport and airway capacity, saving fuel by more efficient terminal area operations, and reducing noise by operational procedures. This involves research analyses, simulations, and flight studies. A modified Boeing 737 airplane, (Research Support Flight System, RSFS), equipped with highly flexible display and control equipment being made available by DOT/FAA, will be used to study operations in simulated future terminal area environments. Active coordination will be maintained with DOT/FAA and DOD. Particular emphasis will be given to compatibility with the microwave landing system (MLS) under development by DOT/FAA and with future air traffic control systems.

W75-70178 **513-52-09**
Wallops Station, Wallops Island, Va.
WALLOPS SUPPORT OF MLS FEASIBILITY DEMONSTRATION
G. E. Godwin 804-824-3411
(768-81-09)

The Microwave Landing System (MLS) is a civil/military aircraft approach and landing system which is being developed in a joint DOD/DOT/NASA program. Needs of the military and civil aviation, at domestic and foreign airports until at least the year 2000, are to be met by MLS. Development is being accomplished under a three step, five year plan. The steps are described as follows: Step 1 - technique analysis and control definition, Step 2 - development of feasibility demonstration models and feasibility demonstration, and Step 3 - development and evaluation of preproduction engineering prototypes. NASA, Wallops Flight Center has been requested to serve as one of the test sites for the Step 2 - feasibility demonstration of the MLS by the FAA, prime government agency responsible for the development of the MLS. The FAA NAFEC at Atlantic City, NJ will serve as the other feasibility demonstration site. This RTOP will cover the Wallops Flight Center support of the feasibility demonstration portion of the MLS development.

W75-70179 **513-53-01**
Ames Research Center, Moffett Field, Calif.
TECHNOLOGY FOR ADVANCED INTEGRATED AVIONICS FOR TERMINAL AREA FLIGHT EXPERIMENTS IN STOL AIRCRAFT
Bradford H. Wick 415-965-5428
(768-83-03; 768-83-02)

The 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). 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, (and perhaps the MLS) 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/MLS, 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 the contractor, will be supported by relatively complete fixed base and moving base simulations of the aircraft and avionics system at Ames Research Center.

W75-70180 **513-53-02**
Ames Research Center, Moffett Field, Calif.
MICROWAVE LANDING SYSTEM VALIDATION FOR STOL AIRCRAFT APPLICATIONS
Bradford H. Wick 415-965-5428
(768-83-01; 768-83-03)

The overall objective is to support the FAA in the task of developing the Microwave Landing System (MLS). Specific objectives include assessing the MLS requirements for STOL operations, assisting the FAA in the S.E.B. technique selection process, establishing the MLS/STOL evaluation criteria, and evaluating the prototype MLS for STOL operations. The basic approach is to utilize analysis, piloted and computer simulations, and the results of the Joint STOL Operating Systems Experiments to refine the MLS operational requirements and evaluation criteria for STOL operations. The results of the MLS Feasibility Demonstration tests and the Joint STOL Experiments will be incorporated into the simulations. The suitability of the MLS for STOL applications will be evaluated utilizing representative STOL aircraft, the experimental STOLAND avionics system, and a prototype K (STOL) configuration MLS.

W75-70181 **513-53-03**
Ames Research Center, Moffett Field, Calif.
STOL OPERATING SYSTEMS EXPERIMENTS USING MODILS AND THE CIVIL MILITARY MICROWAVE LANDING SYSTEM (MLS)
Bradford H. Wick 415-965-5428
(768-83-01)

Experiments will be conducted on navigation, guidance, control, and flight management systems for STOL aircraft using advanced airborne avionics and a Microwave Landing System. The results will be used to evaluate system concepts and define design criteria and operational procedures for STOL aircraft. This program is part of the Joint DOT/NASA Operating Systems Experiments Program. Investigations will be conducted encompassing analysis, simulation, flight experiments, and supporting studies. These investigations will emphasize the therminal area navigation, guidance, control and flight management problems which must be solved to take maximum advantage of STOL capabilities for making steep ascents and descents, tight turns, and slow speed approaches and landings. The flight experiments will be conducted using a flexible research avionics system, referred to as STOLAND, in conjunction with appropriate STOL aircraft. The complete research system comprises STOL aircraft, avionics system, instrumentation, and the following navigation aids: VOR/DME, Tacan, and a microwave landing guidance system to be provided by the FAA.

W75-70182 **513-53-04**
Langley Research Center, Langley Station, Va.
V/STOL - AIR TRAFFIC CONTROL INTEGRATION STUDIES
G. B. Graves 804-827-3745

(768-82-02; 768-83-04; 505-07-41)

This research is concerned with the problems of integrating V/STOL aircraft and their air traffic control system into the total air traffic control environment of the terminal area. The objectives are to determine: (1) aircraft design and equipment requirements; (2) operating procedures and airspace volumes; (3) ATC equipment and handling procedures, and (4) requirements for compatibility and integration of the V/STOL system with the total ATC complex. Real-time simulations are being conducted of a VTOL aircraft operating in the New York metropolitan area and performing precision approaches at high-density airports. These simulations will be improved to include new terminal area routings and approach concepts based on the low-speed and maneuver capabilities of V/STOL configurations. Increased reality will be obtained by linking the Langley simulator with the FAA's ATC simulator at Atlantic City, followed by the eventual linking of a V/STOL aircraft operating at the Wallops Radar Flight and being provided simulated total terminal-area traffic environment by linking to the ATlantic City ATC simulator.

W75-70183 **513-53-05**

Ames Research Center, Moffett Field, Calif.

INVESTIGATION OF THE USE OF STRAPDOWN INERTIAL SENSOR UNITS FOR THE INTEGRATION OF FLIGHT CONTROL, GUIDANCE AND NAVIGATION FUNCTIONS

Bradford H. Wick 415-965-5426

(768-83-01)

In-flight investigation of specific current system technologies all given for a lowcost, 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 digital computer for navigation, guidance and flight control. A candidate system is being developed by ARC-CSDL which will replace the standard set of inertial sensors with a multiple 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 performance and system requirements through computer analysis for the ARC-CSDL advanced inertial sensor systems. Task 3 comprises the investigation of this system through a comprehensive simulation, laboratory, and flight test program to confirm and refine the SIRU performance. Task 4 is the development of aided inertial Kalman filters for an advanced technology low cost redundant strapdown system through computer and motion simulation studies and flight tests.

W75-70184 **513-53-06**

Ames Research Center, Moffett Field, Calif.

TERMINAL AREA EFFECTIVENESS PROGRAM - OPTIMIZATION OF FLIGHT PROCEDURES OF SHORT HAUL TRANSPORT AIRCRAFT

Leonard Roberts 415-965-5569

(768-83-01)

The overall objective of the program is to provide guidance to NASA's aeronautical research and technology efforts by developing techniques and facilities for determining the effectiveness of future short haul aircraft and aircraft system. The criteria for effectiveness will include such factors as fuel usage, noise and pollution impact, terminal area capacity, airspace and ground space usage, pilot and passenger acceptance, operating economics, etc. Mathematical models required for effective studies will be developed for: future short haul transport aircraft, their noise and energy usage characteristics, and for the future air traffic environment as well as for other elements of the short haul system. These models will be used in fast and real time simulations to develop optimum flight procedures. System studies will be conducted to determine the capacity of future terminal areas as a function of implementation alternatives. A Methodology will be developed for integrating the effectiveness measures in order to obtain a total assessment of terminal area effectiveness. A terminal area simulation consisting of a piloted simulation at Ames and a FAA-NAFEC directed ATC simulation will be conducted to evaluate future short haul operations and systems in a high traffic density area.

W75-70185 **513-54-01**

Ames Research Center, Moffett Field, Calif.

VTOL OPERATING SYSTEMS EXPERIMENTS

Leonard Roberts 415-965-5066

(786-83-01; 768-83-03)

The objective is to develop a data base for use in establishing system concepts, design criteria, and operational procedures for VTOL aircraft. This technology base will aid the development of efficient, economical VTOL short-haul operations with minimum adverse environmental impact. The objective also includes a research and technology program to support military requirements for assuring a VTOL operational capability into a wide variety of landing sites, under reduced visibility conditions. The approach will utilize: analytical studies, piloted closed-loop simulations, and flight experiments. Analytical studies will be carried out in-house and under contract. Piloted simulation studies will be accomplished at Ames prior to flight tests. Flight experiments will be carried out in the Tilt Rotor Research Aircraft (XV-15) using V/STOLAND. Two avionics systems (V/STOLAND) will be procured. The first system will be installed in a fixed-base simulator at Ames for development of computer software programming and piloted simulation studies. This system will then be checked out in an Army UH-1 prior to installation of the second system in the XV-15. The XV-15, with avionics system, will be used to investigate alternative avionics functional configurations, flight paths, operational procedures, levels of automation, and landing aids. Time constrained flight paths, steep curved, decelerating, and omnidirectional approaches, and the effects of winds will be investigated. This RTOP describes the NASA tasks in a joint program with the Army. The systems will be also used by the Army for simulation and flight investigations of tactical helicopter missions not described herein. Joint funding is shown.

W75-70186 **513-54-02**

Langley Research Center, Langley Station, Va.

ROTARY WING VTOL OPERATING SYSTEMS EXPERIMENTS

G. B. Graves 804-827-3745

(505-10-23; 505-10-24; 505-07-41)

The program will encompass the investigation of operating systems and piloting techniques for operations from downtown vertiports under all-weather conditions. Terminal air traffic procedures, airspace requirements, the avionics system requirements for navigation, guidance, flight control, and displays for takeoffs, cruise and landing will be defined. Flight vehicles and simulation facilities equipped with electronic display systems and advanced control concepts will be used to define the degree of automation required in the aircraft control system and in the guidance, display, and communication systems onboard the aircraft for VTOL terminal area operations. Operating procedures and piloting techniques for curved, decelerating approach trajectories will be explored for application to steep-gradient operations into congested areas. As part of the joint NASA/Army program in which a CH-47 is being provided, studies will be made of pilot cueing requirements for improved handling qualities, warning for critical envelope limits and for aiding the pilot in interfacing with the automated or partially automated control systems.

W75-70187 **514-51-01**

Ames Research Center, Moffett Field, Calif.

FLIGHT EXPERIMENT PROGRAM - AUGMENTOR WING JET STOL RESEARCH AIRCRAFT

B. H. Wick 415-965-5567

(766-71-01; 505-10-42)

Flight experiments will be essential to verify and refine propulsive lift jet STOL handling qualities, design, and certification criteria. These criteria are under development through analysis and ground-based piloted simulation under RTOP 505-10-42 The program will use the Augmentor Wing Jet STOL Research Aircraft to verify analysis and simulation. In addition, it will use in-flight simulation to provide a wide variation in parameters required to satisfy the generalized objective and to assist in planning the

flight program for the Augmentor Wing Aircraft. This 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.

W75-70188 **514-52-01**
Ames Research Center, Moffett Field, Calif.
WAKE VORTEX MINIMIZATION FLIGHT RESEARCH
B. H. Wick 415-965-5567
(505-08-02; 505-06-02)

A vigorous intercenter program is in progress to define aerodynamic techniques and devices to alleviate the trailing wake vortices as a constraint in airspace or airport operations. A flight research program will investigate, varify, and demonstrate the effectiveness of promising aerodynamic devices or concepts developed in ground facilities. For these purposes, Ames Research Center will obtain and analyze flight data, using both conventional aircraft response instrumentation and hot-wire anemometry techniques. Flight Research Center has the responsibility for installation of the alleviation devices and for operational planning and conduct of the flight tests.

W75-70189 **514-52-01**
Flight Research Center, Edwards, Calif.
WAKE VORTEX MINIMIZATION FLIGHT EXPERIMENTS
M. R. Barber 805-258-3311
(505-06-22)

This RTOP covers FRC activities related to full-scale flight-test evaluations of various aerodynamic wake vortex alleviation devices. These devices have been, and/or, are being developed in ground facility tests under the related RTOP (505-06-22). The approach taken will be that of testing the devices on actual transport aircraft (e.g., 747's, 727's, L1011's etc.). Comparisons of the vortex characteristics with and without the devices will be made by probing the aircrafts wake with a specially instrumented probe aircraft.

W75-70190 **514-52-01**
Langley Research Center, Langley Station, Va.
WAKE VORTEX MINIMIZATION FLIGHT RESEARCH
R. E. Bower 804-827-3285
(505-06-22)

The objective is to develop and demonstrate wake vortex minimization device(s) acceptable for routine aircraft operations. Laboratory and flight tests conducted over the past 18 months have established the feasibility of modifying the trailing vortex system of an aircraft by aerodynamic means. Laboratory testing will continue to develop an alleviation system that will allow safe and economic operation of aircraft with separation distances of 2 nautical miles. Flight evaluations will be conducted as required to demonstrate the effectiveness and operational suitability of the alleviation system(s).

W75-70191 **514-53-01**
Langley Research Center, Langley Station, Va.
ROTOR SYSTEMS FOR ROTOR SYSTEMS RESEARCH AIRCRAFT
R. E. Bower 804-827-3285

In order to insure timely rotorcraft technology development and demonstration and to provide maximum efficiency of utilization of the Rotor Systems Research Aircraft (RSRA), research rotor systems will be selected, designed, fabricated, and flight tested. A technology program for hardware development and flight experiments will be defined for testing of current and advanced technology rotor systems through a broader flight envelope to define and document technological advancements for rotors and rotorcraft. Through a series of advanced systems design study contracts, definitive program plans will be developed in order to establish both technical and budgetary data necessary for initiating the initial major rotor system design and fabrication. Parallel effort will be continued to provide the design verification information required for both the variable geometry rotor and the composite structure rotor. Predesign studies leading to definition of effective manufacturing techniques for the aero/acoustic rotor will be carried out.

W75-70192 **516-50-10**
Ames Research Center, Moffett Field, Calif.
OBLIQUE WINGED AIRCRAFT SYSTEM STUDIES
H. M. Drake 415-965-5881

The objective of these studies is to provide configuration definition and detailed analysis in selected technical areas of oblique winged transport aircraft. Previous contract system studies identified promising high transonic speed, oblique winged aircraft at the conceptual design level. An ongoing study of FY-1974 will also identify a similar subsonic aircraft. Studies this year will provide technical and economic depth to the understanding of both the high transonic and the subsonic speed concepts. Particularly, contracts will be initiated to perform an economic assessment of potential benefits from M = 1.2 flight, to evaluate the oblique wing concepts studied from an airline operator's viewpoint, and to perform refined technology studies for both the high transonic and subsonic speed vehicles. Additionally, the ongoing study will be extended to provide better definition of the M = 1.2 design. The economic assessment of M = 1.2 flight will be a contracted study extending over a 4 month period ending in January 1975. The airline evaluation of oblique winged aircraft will be a competitive contract extending over a 6 month period ending in June 1975. Technical refinement of the subsonic concept will be an extension to the current contract, to be completed in a 6 month period ending in May 1975. Extension of the ongoing contract will be a 65K$ study through December 1974. Refinement of other key technical areas will be a competitive contract of 50K$ ending in April 1975.

W75-70193 **516-51-01**
Flight Research Center, Edwards, Calif.
YF-12 FLIGHT OPERATIONS
Gene 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. The airplanes will be used in support of numerous Supersonic Cruise Aircraft Research projects.

W75-70194 **516-51-02**
Ames Research Center, Moffett Field, Calif.
YF-12 DISCIPLINARY RESEARCH
H. M. Drake 415-965-5880
(766-72-01; 766-72-02)

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. 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 on theory. Current prediction techniques will be improved and resulting technology provided to industry for use in design of future supersonic cruise aircraft.

W75-70195 **516-51-02**
Lewis Research Center, Cleveland, Ohio.

YF-12 PROPULSION RESEARCH
M. O. Dustin 216-433-6136
(505-05-11)

The objectives are: (1) to evaluate the capability of currently available computer simulation techniques to determine the dynamic behavior of a high Mach number mixed compression inlet to downstream and upstream disturbances; (2) to determine the steady state performance of a high Mach number, mixed compression inlet and compare the performance with a similar inlet in flight; and (3) to study existing aircraft control systems and investigate alternate techniques that minimize the propulsion system-airframe interaction.

W75-70196 **516-51-02**
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, 1/12 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 with 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 of the YF-12 propulsion system. Other research includes: boundary layer experiments, base drag measurements, and aerothermodynamic tests performed in the Mach 3 flight environment for correlation with theoretical and wind tunnel predictions.

W75-70197 **516-51-02**
Langley Research Center, Langley Station, Va.
YF-12 DISCIPLINARY RESEARCH
M. L. Spearman 804-827-3134
(766-72-02; 766-72-02; 766-72-02)

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; to define and provide solutions for unknown problems in flight, and to evaluate the application of experimental wind tunnel results to flight conditions. Approach will be to conduct pertinent ground-based analyses and wind-tunnel tests on a boundary layer test component (hollow cylinder 10 ft. long and 1.5 ft. in diameter) that will be flight tested on the YF-12 aircraft. Analyze and correlate these data with those from flight tests on the same component.

W75-70198 **516-52-01**
Langley Research Center, Langley Station, Va.
ADVANCED ACOUSTIC-COMPOSITE NACELLE PROGRAM
A. L. Braslow 804-827-3838

The objectives are to demonstrate the noise reduction potential as well as the savings in cost, fuel, and weight which can be achieved utilizing acoustic-composite materials for quiet nacelle construction; to demonstrate on a modern wide-body transport in airline operation the long-term durability and maintainability of the advanced acoustic-composite nacelle; and establish confidence in the technology such that its application will be implemented by the aircraft and airline industries. Conceptual design studies of cost and weight-effective means of integrating into nacelle design various promising acoustic-composite material concepts for reducing noise will be conducted. These studies will include tradeoff evaluations in which the sensitivity to noise reduction of such factors as direct operating cost, takeoff gross weight, and fuel consumption are determined. Complementary in-house research will also be accomplished. The experimental flight program will be carried out in four major elements: preliminary design, detail design and fabrication, ground and limited flight tests, and in-service evaluation.

W75-70199 **517-51-01**
Flight Research Center, Edwards, Calif.
TRANSONIC AIRCRAFT TECHNOLOGY (TACT)
Weneth D. Painter 805-258-3311
(766-76-02; 766-76-03)

The objectives of this effort are: (1) to demonstrate the Supercritical Wing improved transonic drag rise and lift levels for buffet onset shown in wind-tunnel investigations; and (2) establish the desired level of confidence in prediction of Supercritical Wing characteristics for future applications. This is a joint NASA/USAF program being conducted in accordance with a Memorandum of Understanding dated 16 June, 1971. The Supercritical Wing and associated parts were provided by Convair Division of General Dynamics under Air Force Contract AF 33615-71C-1912. The left-hand wing was structurally proof tested at the AFFDL Wright-Patterson AFB. NASA FRC will supply and install the basic instrumentation as well as perform the aircraft modification and wing installation. NASA FRC will also be responsible for the flight test and total program management beginning at the end of the envelope expansion phase of the flight test.

W75-70200 **517-51-02**
Ames Research Center, Moffett Field, Calif.
F-111 TACT RESEARCH AIRCRAFT
H. M. Drake 415-965-5987
(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 leading to the development of design criteria for future military and civil aircraft. Specifically, the effort at the Ames Research Center will be to provide thorough wind tunnel investigations as the basis for a prediction of aerodynamic performance, stability, control, buffeting characteristics, and structural loads of the TACT airplane. Correlation of the predicted characteristics based on the wind tunnel results with full-scale flight test data is a further major objective. Current projections are that all wind tunnel test data required for the correlation of wind tunnel and flight test results will be obtained by end of FY-76.

W75-70201 **517-51-03**
Langley Research Center, Langley Station, Va.
TRANSONIC AIRCRAFT TECHNOLOGY (TACT)
T. G. Ayers 804-827-2631
(766-76-01; 766-76-02)

The overall objective of the Transonic Aircraft Technology (TACT) program is to provide proof-of-concept of supercritical airfoil technology in the transonic and low supersonic flight regimes and to provide design criteria for the design of future military and civil aircraft. The effort at the Langley Research Center will be to analyze and document wind tunnel test results of the nozzle thrust-minus-drag and fuselage afterbody drag coefficients for use in correcting static aerodynamic data to full scale airplane values for various engine power settings. The Langley effort will also provide technical assistance for the correlation and analysis of the wind tunnel and flight aerodynamic data.

W75-70202 **723-01-01**
Flight Research Center, Edwards, Calif.
HIGHLY MANEUVERABLE AIRCRAFT TECHNOLOGY (HIMAT) - FLIGHT RESEARCH PROGRAM
G. Layton 805-258-3311
(505-06-44)

This RTOP covers the flight test phase of a program to provide improved technology for the design of highly maneuverable aircraft. Present design restraints will be relaxed to permit complete freedom in the application of state-of-the-art system such as integrated, computerized controls, composite structures, propulsion augmentation of lift and control and the like in order to achieve

maximum benefits from synergistic effects. Flight tests of the complete airplane must be conducted to prove most of these concepts. The high technological risk involved in applying such concepts precludes their application to prototype aircraft because of the enormous cost of these aircraft. This program will use large-scale free-flying models controlled by remote-piloting techniques to acquire actual flight test data at a minimum cost. The facility for these tests exists at FRC and is currently being extended to handle supersonic vehicles.

W75-70203 **723-01-02**
Langley Research Center, Langley Station, Va.
HIGHLY MANEUVERABLE AIRCRAFT TECHNOLOGY (HIMAT)
R. E. Bower 804-827-3285

The objectives are: (1) to support the HiMAT project through directed research and actual evaluation of HiMAT configurations, (2) to systematically study advanced, novel and innovative concepts of aircraft and systems that will improve the combat effectiveness of future air-combat aircraft and also provide guidance to advanced design and test teams, (3) to evaluate the effects of handling qualities on combat effectiveness and to apply nonlinear programing theory to design of stability augmentation systems for control of maneuvering aircraft, (4) to support DOD with research relating to improvement in current operating aircraft, evaluation of new prototype designs and modifications, training simulation requirements, weapons systems, and guidance and display systems. Advanced Manned Simulators and analytical tools will be used to carry out the above objectives. Studies have been conducted which varied parameters pertinent to close-in air combat on an existing combat type aircraft. Reports on this work are being prepared. Similar studies are currently scheduled on an advanced baseline configuration, incorporating design features of the lightweight fighter prototypes. Results of the studies will be utilized by NASA and company design teams to aid in---

W75-70204 **738-01-01**
Lewis Research Center, Cleveland, Ohio.
QUIET, CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE)
Raymond J. Rulis 216-433-6651

The objective of this program is to design, build and test experimental engines to consolidate and demonstrate the technology needed for very quiet, clean and efficient propulsion systems for economically viable and environmentally acceptable powered lift short-haul aircraft. Two experimental propulsion systems, engines and nacelles, one for under-the-wing and one for over-the-wing installation, will be designed, built, tested and delivered to the Lewis Research Center. Acoustic and aerodynamic performance testing in wing/flap system installations will be conducted to verify system characteristics and achievement of program goals.

W75-70205 **739-01-01**
Lewis Research Center, Cleveland, Ohio.
JT8D RETROFIT DEMONSTRATION
Robert W. Schroeder 216-433-6654

Develop modifications for the JT8D engine that can be produced as retrofit kits, develop nacelles with acoustic treatment for the modified engines, and demonstrate DC-9 airplane performance and reduced noise levels by flight demonstration and 727 performance and noise levels by ground tests. Modifications of the JT8D engine include replacement of its two-stage fan with a larger diameter single-stage fan employing inlet guide vanes and wide spacing between vanes and rotor. Core engine pressure and flow is maintained by installation of two booster stages in front of the compressor. The fan turbine and exit strut assembly are being revised. These changes are designed to increase engine thrust and lower the core jet velocity for the same cycle temperature. The lower jet velocity results in decreased jet noise. New engine nacelles include acoustic treatment in the fan ducts and may include other acoustic devices for optimum performance and acoustic suppression. Demonstration of aerodynamic and acoustic performance of the modified engines and new nacelles is accomplished through engine component and engine ground tests, flight tests of a modified DC-9 airplane, and ground tests of a 727 nacelle and center duct installation.

W75-70206 **743-01-01**
Langley Research Center, Langley Station, Va.
SCAR STRUCTURAL CONCEPT STUDIES
G. W. Brooks 804-827-2042
(743-32-11; 743-32-22)

This RTOP will assess relative merits of various structural arrangements, concepts, and materials for advanced supersonic aircraft configurations, and determine the best structural approaches. Under contract, structural concepts will be developed for a prescribed arrow-wing aerodynamic configuration. These concepts will be evaluated through design studies making use of the best available design tools and criteria, and materials technology. Concepts that merit further evaluation by component testing will be identified, and in-house work will include planning for fabrication and test of such a component. Future design studies will be performed in-house using analysis tools both purchased and in-house developed to study arrow-wing and other advanced configurations. Specific targets are: (1) by FY-75, identify best structural approach for arrow-wing configuration aircraft; (2) by FY-75, develop computerized structural model to represent aeroelastic behavior of arrow-wing configurations; and (3) by FY-76, identify structural component for test.

W75-70207 **743-01-02**
Ames Research Center, Moffett Field, Calif.
FUEL TANK SEALANTS
Dean R. Chapman 415-965-5065

The objective of this RTOP 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 the 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 and kinetics 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.

W75-70208 **743-01-11**
Langley Research Center, Langley Station, Va.
SCAR COMPUTER-AIDED STRUCTURAL DESIGN METHODS
G. W. Brooks 804-827-2042
(743-32-01)

This RTOP will develop computer-aided design methods with multidisciplinary capabilities for supersonic cruise vehicles with particular attention to aeroelastic, flutter, thermal stress, and fatigue and fracture considerations. Implement design methodology into operational modules (software) tailored for iterative design. Modules will be suitable for incorporation into integrated design systems or may be used as stand-alone design programs. Provide results useful for assessment of the modules from design studies of candidate airframe designs for supersonic cruise aircraft configurations. Under contract, improve unsteady aerodynamic loads and flutter calculation procedures for use in computer-aided design. In-house, develop improved techniques for sizing structural members under aeroelastic constraints and thermal stress. Under contract, develop computerized analysis for damaged composite structural elements. Specific targets are: by FY-76, have improved unsteady aerodynamic and flutter calculations and sizing algorithms in hand for use in computer-aided design.

W75-70209 **743-01-12**
Langley Research Center, Langley Station, Va.
SCAR - LOADS AND AEROELASTICITY TECHNOLOGY
G. W. Brooks 804-827-2042

(743-32-11; 743-32-13)

The objective of this plan 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 aircraft. Technical areas of interests include loads due to steady and unsteady motions of the aircraft and its component parts, high frequency acoustic pressures and landing, takeoff and taxiing. Promising new approaches to the needed aerodynamic, dynamic and acoustic analyses will be vigorously pursued and focused on the needs of supersonic cruise aircraft through a combination of in-house and contract research. The development of advanced flutter analysis theories will provide improved inputs to the flutter design module now being developed (743-32-11) particularly in the transonic and low supersonic speed regimes. Loads analysis techniques to include aeroelastic and nonlinear transonic effects will be developed. Both existing and new wind tunnel experimental results will be used to verify and improve analysis techniques. Acoustic pressure inputs from the engine exhaust will be quantified and the response of various structures will be analyzed. A program to predict aircraft landing, taxi and takeoff motion will be formulated and the benefits of an active landing gear on the ride quality and loads will be determined. Related work is being done at Langley, Ames and Flight. The DOD/SST technical follow-on program has related tasks which have been considered in developing this program.

W75-70210 **743-01-13**

Langley Research Center, Langley Station, Va.

SCAR - ATMOSPHERIC TURBULENCE

G. W. Brooks 804-827-2042

The objective is to obtain detailed definition of power spectra of turbulence and wave motion characteristics present in the atmosphere in various meteorological conditions. Special emphasis will be placed on the determination of the spectral shape at wavelengths of 30,000 ft or greater and altitudes of 30,000 to 65,000 ft. Meteorological conditions will include jet stream, mountain waves, gravity waves, and near thunderstorms as well as earth boundary turbulence measurements, the latter primarily for instrumentation verification. Consistency of spectra and directional characteristics of wave phenomena will be investigated. All measurements will be made with the same type airplane (B-57), the same instrumentation and same data processing procedure. Instrumentation includes low inertia flow vanes, an inertial platform for measuring aircraft motion angles, platform-mounted accelerometers integrated for aircraft velocities, and rate gyros for angular rates. A total of 60-90 flights over a two-year period should yield sufficient data to accomplish the objectives.

W75-70211 **743-01-22**

Langley Research Center, Langley Station, Va.

SCAR - MATERIALS APPLICATION

G. W. Brooks 804-827-2042

(505-01-31)

The objective of this program is to advance composite and titanium materials and structural component technology to achieve longtime structural integrity and low weight in supersonic cruise aircraft structures. The technology development program will consist of development of advanced fabrication methods; performance of strength, fatigue, and fracture tests to establish structural integrity of materials and representative components; development of methods for acceleration of fatigue tests; performance of time-temperature-stress investigation to determine limitations of advanced materials; development of new or improved resins, adhesives, and coatings; and fabrication, ground test, and installation of components on the YF-12 and Boeing 737 aircraft for flight service evaluation. It is anticipated that these programs will provide important advances in materials and structural component technology; help establish the future role of advanced composite materials; and indicate approaches for achieving lower structural weight, improved structural integrity, and lower fabrication costs for supersonic cruise aircraft.

W75-70212 **743-01-23**

Flight Research Center, Edwards, Calif.

AST STRUCTURES AND MATERIALS TECHNOLOGY

Alan L. Carter 805-258-3311

(501-32-05; 501-32-06)

This RTOP is 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. This RTOP will 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.

W75-70213 **743-01-24**

Lewis Research Center, Cleveland, Ohio.

SCAR - MATERIALS

R. H. Kemp 216-433-4000

(505-01-34)

The overall objective of these studies is to develop high temperature resistant polymers for use as matrix materials in advanced resin/fiber composites for AST structures. High temperature resistant polyphenylquinoxalines and polyimides with improved processability, elevated temperature strength retention and significantly reduced thermoplasticity at elevated temperatures in fiber composites will be developed. Studies currently underway directed toward improving the thermo-oxidative stability, processing characteristics and high temperature creep resistance of polyphenylquinoxalines will be continued. Studies to improve the autoclave processing characteristics and upper continuous use temperature of addition-type polyimides will be continued. The work proposed in this RTOP differs from the work at Langley Research Center in the following two respects: (1) polyphenylquinoxaline polymers will not be studied by Langley, and (2) the polyimides being studied by Langley are of the conventional condensation type in contrast to the addition-type polyimides which are being studied at Lewis under this RTOP.

W75-70214 **743-02-22**

Flight Research Center, Edwards, Calif.

AST/STRATOSPHERIC EMISSION IMPACT (MINI-SNIFFER)

Robert D. Reed 805-258-3311

The objective of this RTOP is to develop a small remote piloted sampling vehicle (Mini-Sniffer) capable of encountering and sensing both natural and man-made atmospheric contaminates and fine turbulence in the altitude ranges from 50,000 to 100,000 feet. Since the vehicle will fly at low expected speed it will provide precise positioning and maneuvering in segmented atmospheric pollution concentrations at these altitudes as well as defining the basic fine atmospheric turbulence characteristics at these altitudes. The Mini-Sniffer is the only stratospheric sampling platform that can gather both fine turbulence data in aircraft wakes as well as ambient atmospheric data (gust velocities less than 0.1 foot per second and wave lengths less than 200 feet) in horizontal and vertical surveys. The design target is to develop an inexpensive vehicle and an operational technique requiring only a one- or two-man crew to operate in addition to radar and payload support personnel.

W75-70215 **743-02-22**

Ames Research Center, Moffett Field, Calif.

AST - STRATOSPHERIC EMISSION IMPACT

D. R. Chapman 415-965-5065

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 composition of the jet wake and the perturbations (chemical, hydrodynamic) in the stratosphere caused by the passage of supersonic aircraft in a specified air corridor, and develop and apply advanced instrumentation to measure these trace constituents in the stratosphere. The Stratospheric Jet Wake Program will continue its studies in two parts: near-wake

assessments into FY-78, and far-wake evaluations through FY-79. Integral with these activities is an advanced instruments development program. The near-wake studies involve the use of available instruments on a U-2 aircraft flown into the visibly-marked wake of a supersonic aircraft in the stratosphere to measure exhaust gases. These data are being used to improve and verify mathematical models of engine exhaust wake chemistry. Hydrodynamic models of the wake are being verified by photographic methods which provide wake dimensions with time. Far-wake studies require new types of instruments being developed in the advanced instruments development program. These devices will provide sensitive measurements of very dilute exhaust gases and atmospheric constituents with which the exhaust may react. Improved wake visualization methods are also necessary so aircraft can be directed into and near aging exhaust plumes.

W75-70216 **743-02-22**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
STRATOSPHERIC EMISSION IMPACT
R. R. McDonald 213-354-6186
(505-03-31; 506-21-63)

This work addresses itself to the task of establishing an inventory of trace gases existing in the stratosphere at altitudes between 10 and 25 km. Concentration levels of molecular species which are of particular interest to the assessment of the effects of engine emissions into the higher levels of the atmosphere will be determined to accuracies of a few percent. These gases include H2O, CO2, CO, O3, CH4, NO, N2O, NO2 and HNO3, which have already been observed; as well as others as, for example H2CO and HCl, for which, so far, only upper limits of their abundance can be given. Measurements of the absorption of infrared solar radiation by the molecular transitions of these trace species in the 1.2 to 8 micron region will be made from airplanes flying at stratospheric altitudes. A high efficiency interferometer spectrometer will observe the rising or setting sun through long stratospheric paths at high spectral resolution during two flight periods in the third and fourth quarter of FY-75. Analysis of the spectra obtained will result in determinations of mixing ratios in the ten to the minus 8 to ten to the minus 10 range and their variations with altitude.

W75-70217 **743-02-22**
Lewis Research Center, Cleveland, Ohio.
SCAR STRATOSPHERIC EMISSIONS IMPACT
R. A. Rudey 216-433-6160

An objective is to evaluate and develop techniques to analyze and describe the possible detrimental effects of aircraft exhaust emissions from fleets of supersonic aircraft on the natural stratosphere. An additional objective is to support the Stratospheric Jet/Wake Experiment currently being planned. Ground tests are needed to identify the engine exhaust pollutant character and level and the chemical processes that they may undergo with the natural environment over a period of time. Flight tests are needed to validate the ground tests and the developed analytical models of the upper atmosphere characteristics.

W75-70218 **743-02-22**
Langley Research Center, Langley Station, Va.
STRATOSPHERIC EMISSION IMPACT
E. S. Love 804-827-2893
(506-20-14)

The objective of this research is to develop laser flight instrumentation to measure trace constituents in stratospheric jet wakes and the effect of these constituents on the ambient stratosphere. This RTOP continues a program initiated in FY-73 (501-24-20). A feasibility study under that program identified tunable laser instruments which are capable of measuring jet wake constituents with greater sensitivity than currently available in-house techniques. Under an FY-74 program (743-34-22) a Phase A contractual design and cost study of a flight instrument for two ended diode laser absorption measurements was initiated. The approach of this program will be to contract for the development of a flight instrument using the results of the Phase A study as an input for design and cost. Under the guideline funding flight instrument development will be accomplished by a series of phased contracts. Phase B will be for procurements of detectors, lasers, and preliminary electronics testing; Phase C for instrument packaging; and Phase D for flight tests. In-house studies of advanced instrumentation including heterodyne radiometry will continue with emphasis on using the high spectral resolution available to measure wake or ambient constituent concentrations through absorption of solar radiation.

W75-70219 **743-03-11**
Ames Research Center, Moffett Field, Calif.
SCAR PROPULSION TECHNOLOGY
B. H. Wick 415-965-5036
(505-10-41; 505-03-12)

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. From the standpoint of compressor noise, distortion at the compressor face arising from aircraft attitude and flow around the airframe can increase noise. It 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. Studies in Fy-1974 have served to develop techniques for measuring noise in wind tunnels. The results have been encouraging and have provided much useful data. However, the problem of relating near field measurments to far field measurements needs additional work. It is planned to test several 6' diameter nozzles in the Ames 40- by 80-Foot Wind Tunnel, in both the near and far field. This test will provide scale effect data and relative velocity effects on advanced mixer suppressor nozzles, as well as a basis for the development of techniques to extend near field jet noise measurements to the far field.

W75-70220 **743-03-11**
Lewis Research Center, Cleveland, Ohio.
SCAR NOISE REDUCTION TECHNOLOGY
U. H. Von Glahn 216-433-6658

Objective is to develop the technology required to quiet both conventional and advanced supersonic transport engines to levels acceptable to the community. Areas of particular concern include noise suppression of high velocity jets and choked inlet suppression of turbomachinery noise. Particular emphasis will be focused on the external flow effects on various jet noise suppressor types and on the acoustic characteristics associated with engine cycles of interest for this application. Moving frame acoustic tests will be initiated using scale-model nozzles developed for advanced duct-burning turbofan engines.

W75-70221 **743-03-21**
Lewis Research Center, Cleveland, Ohio.
SCAR POLLUTION REDUCTION TECHNOLOGY
R. A. Rudey 216-433-6160
(505-03-32; 505-04-31; 743-33-22)

The objective is to minimize the amounts of pollutants being discharged by aircraft engines into the upper atmosphere, by improving combustor and/or augmentor designs. Achieving low levels of exhaust emissions from high altitude aircraft by improving combustion design principles is needed in order to minimize any potential interaction of combustion products with the ambient atmosphere. Reductions in combustor exhaust emissions will be sought in two efforts. The first will be directed toward modification to combustor hardware presently being developed in the Clean Combustor Program with emphasis placed on reducing oxides of nitrogen (NO sub x) at supersonic cruise conditions. The second approach is to evaluate novel and unique techniques to minimize NO sub x to the lowest values possible in combustion systems eventually applicable to aircraft jet engines. The first effort is aimed at the near term emission reductions that may be practical, whereas the second effort is geared toward developing technology for future supersonic aircraft engines. The evaluation of potential augmentor emission reductions is needed to assess the impact

that well designed augmentors, used during cruise, would have to total engine emission levels.

W75-70222 **743-03-21**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
AST POLLUTION REDUCTION
R. R. McDonald 213-354-6186
(505-03-31; 506-21-63)

The objective of this task is to obtain an inventory of the trace gases occurring in the stratosphere between 10 and 25 km over a wide range of latitudes. This inventory will consist of the unambiguous identification and accurate determination of concentration levels of those trace species already known to be present and judged to be of importance in the assessment of effects of travel in the stratosphere by high altitude aircraft. Among these gases are those occurring naturally, such as H2O, CO2, CO, O3, CH4, and N2O, as well as others which have been observed, as NO, NO2, HNO3 and HCl. Measurements of the absorption of infrared solar radiation caused by the molecular transitions of these species in the 1.2 to 8 micron region will be made from airplanes flying at stratospheric altitudes with a high resolution (0.25 cm-1), high throughput interferometer spectrometer, the High Speed Interferometer. Analysis of the spectra obtained will result in determinations of mixing ratios in the 10 to the minus 8th power to 10 to the minus 10th power range, and their variation with altitude.

W75-70223 **743-03-31**
Lewis Research Center, Cleveland, Ohio.
SCAR INLET STABILITY SYSTEM
M. O. Dustin 216-433-6136

The objective is to demonstrate an improved inlet stability system for supersonic, mixed-compression inlets. The system will allow the inlet to operate at a higher pressure recovery with fewer inlet unstarts than for the present inlet system. The development of a shock stability bleed system using mechanical relief valves will be accomplished in wind tunnel tests using a full-scale YF-12 inlet. If successful, the stability system will be evaluated in flight on the YF-12 aircraft.

W75-70224 **743-03-41**
Lewis Research Center, Cleveland, Ohio.
SCAR ENGINE STUDY
R. J. Weber 216-433-6273

Advances in propulsion system technology will be required to permit the development of a quiet, clean, economical commercial supersonic transport. Contracts for the study of such airplanes will be let by Langley Research Center and other supporting work will be performed by LaRC, LeRC, ARC, FRC, and DOT. As part of this effort, LeRc will let contracts to study various types of propulsion systems that might be applied in the advanced aircraft. The studies will determine the desirable characteristics of the engines, assess the benefits of advanced technology, and identify the needs for future research. They also will be used to define the content of an experimental engine program.

W75-70225 **743-03-51**
Lewis Research Center, Cleveland, Ohio.
SCAR - TECHNOLOGY-UNIQUE COMPONENTS
M. J. Hartmann 216-433-6650

Advanced aircraft that must perform efficiently over a wide range of subsonic and supersonic flight speeds may employ variable bypass engine cycles which require a number of unique components. These components include fans, flow diverters, and sound suppression systems which must provide a high level of performance over a very wide range of flow conditions. The large complex sections must be fabricated with lightweight structural materials capable of operating at the high temperatures encountered at high flight speeds and in the hot section of the engine. Advanced composite materials provide the most promising materials for these structures. To provide the necessary high levels of performance and advanced materials for these unique components of variable bypass engines, the following major thrusts are included: (1) advanced Boron/Aluminum composite materials for lightweight fan blades with improved impact resistance will be evaluated; (2) structural and fabrication properties of an applicable high temperature composite material (Silicon Carbide in metal matrix) will be evaluated for use in the hot sections of the engine; and (3) performance characteristics of potential flow diverter and fan systems will be evaluated.

W75-70226 **743-04-01**
Langley Research Center, Langley Station, Va.
SUPERSONIC TECHNOLOGY: SYSTEMS-INTEGRATION STUDIES
R. E. Bower 804-827-3285

The work performed under this RTOP will address the impact of advanced technologies applied to supersonic cruise aircraft by studying their effects on the overall characteristics and mission capabilities of promising aircraft concepts. Integration studies will typically evaluate advances in aerodynamics/configurations, propulsion, structures, materials, and avionics. These studies will not only indicate the most favorable design trade-offs, but will also point out the directions for productive future research and technology activities. Throughout the studies, major considerations will be the meeting or exceeding of current noise and pollution levels and improving the energy utilization. The work will be carried out in two ways. In one, the ASTO will direct and in-house study team which makes use of nonpersonal services contract manpower. The emphasis will be on providing early assessments of new approaches on the characteristics of the total aircraft, and defining reference configurations for future comparison purposes. In the other approach, industry expertise will be utilized by awarding contracts in areas of particular company capability or initiative, and where practical design and construction methodology needs to be applied.

W75-70227 **743-04-11**
Ames Research Center, Moffett Field, Calif.
ADVANCED SUPERSONIC TECHNOLOGY--OPTIMUM DESIGN/CCV
H. M. Drake 415-965-5881
(791-93-06; 505-26-07)

This RTOP is to provide information in areas where experience has shown that design knowledge for advanced supersonic cruise aircraft is incomplete. Specifically: (1) determine the liquid hydrogen fueled configuration which minimizes the mission energy consumption; and (2) define a refined liquid hydrogen fueled configuration which incorporates advanced technology in engine design and installation insulation materials and arrangements, aerodynamics, stability and structures. Using the results of the LH2 fueled aircraft study of FY-73, a study will be made to assess the impact of several design considerations on the aircraft configuration and its fuel consumption. This will be an add-on to contract NAS2-7732 of FY-73 and will be a 75K$, 6 month study ending in December 1974. A second study will be performed to further refine the LH2 supersonic cruise aircraft concept. This design study will explore the advantages of the applications of such concepts as LH2 fueled variable cycle engines, advanced high temperature composite materials and different aerodynamic configurations resulting from the high volume requirements of liquid hydrogen. This will be a competitive contract study of 125K$ extending over a 6 month period, ending in June 1975.

W75-70228 **743-04-12**
Langley Research Center, Langley Station, Va.
SCAR - AERODYNAMIC PERFORMANCE TECHNOLOGY (CONCEPTS)
R. E. Bower 804-827-3285
(743-35-21; 743-35-11; 743-35-21)

The objective of this program is to develop advanced supersonic cruise vehicle concepts and to provide a source of experimental data which can be used in the optimization of these concepts. The goal is to provide fully integrated configurations which provide at least a 30 percent improvement in supersonic cruise efficiency while meeting the requirements of other disciplinary areas such as structures, flight controls and propulsion. The approach of the effort will be conducted in two ways. In one approach, in-house developed concepts will be analyzed and tested extensively at subsonic, transonic, and supersonic speeds. Iterations will be made on the concepts and

wind tunnel models to establish trade information and to establish cause and effect relationships. In the other approach, cooperative NASA/Industry programs will be established to develop data bases and trade information on promising airframe industry supersonic cruise vehicle concepts.

W75-70229 **743-04-21**
Ames Research Center, Moffett Field, Calif.
AERODYNAMICS AND PERFORMANCE (THEORY)
B. H. Wick 415-965-5033

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, propulsive flow effects, airframe acoustic shielding effects, and ground effects. The overall objective is to provide the theoretical technology for design of advanced supersonic technology aircraft having acceptable aerodynamic and acoustic characteristics during landing, take off, and subsonic flight operations.

W75-70230 **743-04-21**
Langley Research Center, Langley Station, Va.
SCAR - AERODYNAMIC PERFORMANCE TECHNOLOGY (THEORY)
R. E. Bower 804-827-3285
(501-06-01; 743-35-21)

The objective of this program is to develop and validate methods for use in predicting overall aerodynamic characteristics and detailed load distributions, for design and off-design conditions, of advanced supersonic aircraft configurations. The approach of theoretical methods will be developed through contract and in-house studies and then evaluated with in-house tests of representative models of advanced supersonic aircraft. The studies will involve improvements to existing linearized-theory area-rule methods and to the inclusion of local Mach number effects to allow prediction of detailed surface loadings and flow fields of complete configurations. The off-design and critical design load problems will be approached by including leading edge separation and reattachment in finite-element lifting surface theories.

W75-70231 **743-04-31**
Langley Research Center, Langley Station, Va.
SONIC BOOM
R. E. Bower 804-827-3285

This RTOP is in support of the objectives of the System Technology Program Supersonic Cruise Aircraft Research. An in-house program, based on analytic studies and wind-tunnel experimentation, will be employed to develop improved methods for prediction and to provide definition of configuration requirements for minimization. This in-house research will be supplemented and augmented by a University Grant program and by Airframe Industry Contracts. Studies of sonic boom acceptability, with particular emphasis on low intensity non-N wave signatures will be conducted under NASA contracts

W75-70232 **743-05-01**
Ames Research Center, Moffett Field, Calif.
STABILITY AND CONTROL PREDICTION OF FLEXIBLE AIRCRAFT
H. M. Drake 415-965-5880
(766-72-02)

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.

W75-70233 **743-05-04**
Langley Research Center, Langley Station, Va.
SUPERSONIC CRUISE AIRCRAFT RESEARCH - ACTIVE CONTROL OF AEROELASTIC RESPONSE
George W. Brooks 804-827-2042

In order that dynamically scaled aeroelastic wind tunnel models may be used to study and validate active control applications for the minimization of aircraft aeroelastic response, the state-of-the-art of modeling technology, including model design and construction and testing techniques, will be advanced as required for active control applications. In addition to basic technique development considerable emphasis will be placed on validating model procedures by correlating wind tunnel results with analytical and flight data. In order that future supersonic cruise aircraft can take full advantage of the potential benefits of active control for the minimization of aeroelastic response technology, research will be conducted to develop new active control concepts and approaches that are particularly applicable to SCAR class aircraft.

W75-70234 **743-05-11**
Ames Research Center, Moffett Field, Calif.
SCAR-HANDLING QUALITIES CRITERIA FOR ACT-CONFIGURED ADVANCED SUPERSONIC AIRCRAFT
B. H. Wick 415-965-5567

Studies on the Ames piloted motion simulators and a corresponding analytical effort will be directed toward the development of handling qualities and control system criteria for ACT-configured advanced supersonic cruise aircraft. The initial simulations will use existing mathematical models of large supersonic aircraft supported by analytical studies to correlated qualitative and quantitative experimental results. The entire operational flight envelope will be considered, and emphasis will be on handling qualities with greatest impact on configuration design and mission performance. Stability characteristics and operating procedures will be systematically varied. Satisfactory handling qualities and minimum-safe levels for SAS-failed operations will be defined. Results will be utilized in a tradeoff study to determine performance gains to be realized through configuration changes that employ active controls. Later program phases will include simulator investigations of prospective new designs, of structural flexibility effects on controllability, and of control system failure transient effects utilizing a secondary actuator hardware model (minirig) interfaced with the computer simulation. A related NASA/FAA in-house effort will be continued which utilizes piloted simulator studies to develop airworthiness standards for supersonic cruise aircraft and associated flight test procedures for compliance demonstration.

W75-70235 **743-05-12**
Ames Research Center, Moffett Field, Calif.
AST CONTROL SYSTEM MECHANIZATION TECHNIQUES
Bradford H. Wick 415-965-5428
(743-36-11; 501-23-33)

The objective is to investigate redundant surface actuation systems concepts for an active control configured supersonic transport aircraft. Explore system failure modes, ability of the crew to react to these failures, and the resultant effect on control system design requirements. The approach of piloted motion simulator studies will be conducted to investigate the acceptability of various redundancy concepts needed for active controls in terms of control stability and responses in normal operation, and the ability of the pilot to detect and react to failure in the systems. These studies will use math models and hardware mechanizations (mini-rigs) of the candidate control systems, developed on the basis of contracted efforts by Boeing extending current Phase I and Phase II SST technology follow-on efforts sponsored by DOT, and study of alternate concepts by another contractor, 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 complementary to RTOP 743-36-11 and will be carried out jointly with that RTOP.

W75-70236 **743-05-22**
Flight Research Center, Edwards, Calif.

AST-COOPERATIVE AUTOPILOT/SAS/PROPULSION CONTROL SYSTEM

G. J. Matranga 805-258-3311

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 is developing wind-tunnel and analytical techniques for predicting airframe/propulsion system interactions of advanced supersonic aircraft and determining the feasibility and benefits of a cooperative autopilot/SAS/propulsion control system. This goal is being pursued 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 are being let for the design, construction, and installation of such a system on the YF-12. Flight tests are planned to verify the benefits that can be obtained by such a system in an operational environment.

W75-70237 **744-01-01**

Ames Research Center, Moffett Field, Calif.

V/STOL TILT ROTOR RESEARCH AIRCRAFT PROGRAM

W. L. Cook 415-965-5442

Technical approach is to design, develop and conduct flight research on two Tilt Rotor Research Aircraft to prove the Tilt Rotor V/STOL concept for potential military and civil missions. A program of direct supporting technology is also a part of this RTOP. The Project Plan for Development of V/STOL Tilt Rotor Research Aircraft, Revision 2, dated January 1974, addresses the technical objectives, approach, justification, the operating plan, environmental impact statement, Milestone schedules and the review and reporting for the subject project.

W75-70238 **745-01-01**

Langley Research Center, Langley Station, Va.

ROTOR SYSTEMS RESEARCH AIRCRAFT

R. E. Bower 804-827-3285

(505-10-21; 505-10-23; 505-10-24; 505-10-26)

The Rotor Systems Research Aircraft (RSRA) 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 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. This is a joint program with the Army, in accordance with the Memorandum of Understanding between NASA and the Army, dated November 1, 1971. The program will be managed through a joint Project Office in accordance with the NASA/Army Rotor Systems Research Aircraft Project Plan which was jointly approved by NASA and the Army on February 23, 1973, and updated February 7, 1974, by the NASA/Army RSRA Project Office.

W75-70239 **769-01-02**

Langley Research Center, Langley Station, Va.

AMST EXPERIMENTS PROGRAM PARTICIPATION

R. E. Bower 804-827-3285

The objective is to obtain, through participation in the U.S. Air Force Advanced Medium STOL Transport (AMST) prototype aircraft program, upper-surface blowing and externally blown flap propulsive-lift flight research data. The Langley Research Center will participate in the AMST flight research program by supplying principal investigators to plan and help execute specific experiments in various discipline areas. A Langley representative will serve on the inter-Center Quiet Propulsive-Lift Technology (QPLT) Flight Experiments Working Group where the NASA experiments will be planned, evaluated, and integrated into the AMST flight experiments program.

W75-70240 **769-01-03**

Lewis Research Center, Cleveland, Ohio.

AMST EXPERIMENTS PROGRAM PARTICIPATION

Michael F. Valerino 216-433-6280

This RTOP provides for Lewis Research Center participation in the joint Air Force/NASA AMST Program which includes definition of flight research experiments in the areas of propulsion system performance and noise to be conducted using the Boeing YC-14 and Douglas YC-15 prototype aircraft. LeRC will define, develop, and implement NASA propulsion-related flight experiments to be conducted during the Air Force-led portion of the AMST flight test program and during the subsequent NASA-led flight research program.

W75-70241 **769-02-01**

Lewis Research Center, Cleveland, Ohio.

QSRA PROPULSION SUPPORT

Michael F. Valerino 216-433-6280

This support has included the study of engines potentially suitable for the research aircraft in achieving its powered lift, noise, and near terminal performance goals such that the most attractive concept can be selected. Based upon the results of these and the aircraft studies, the hybrid upper surface blowing system has been selected for incorporation into the Buffalo aircraft. These selections then resulted in the selection of the Lycoming 502 series turbofan engine as that most suited for the intended application. The continuing engine support will then include further determination of modifications required to the engine to accommodate the needs of the research aircraft, exploring alternate approaches to provide the engines (refurbishment of YF102's, new engine procurement, leasing) and then those follow-up activities required to insure delivery of four (4) engines plus a spare to the aircraft hardware contractor in a time frame consistent with his needs. The effort also includes participating in all other propulsion aspects of the aircraft program. In addition, assistance will be provided to the QPAT Office in its staff support role to the OAST Transport Technology Programs Office in carrying out the vertical cut responsibilities for the Short-Haul Transport Technology Program. This includes participation in the development of a Short-Haul Transport Technology Program Plan.

W75-70242 **769-02-02**

Ames Research Center, Moffett Field, Calif.

QUIET SHORT-HAUL STOL RESEARCH AIRCRAFT (QSRA)

W. L. Cook 415-965-5486

This RTOP covers the design, fabrication and test of a quiet propulsive-lift research aircraft which will permit flight research beyond the flight regimes of the AMST and the existing augmented jet flap Buffalo aircraft. The approach stresses low-cost modification of an existing aircraft. Key design simplification guidelines are use of fixed landing gear, 160 knot maximum speed, +2g, -0.5g limit load, and design life of 500 flight hours. The flight research will advance technology for future development of reliable, quiet, and economical propulsive lift transports. The test program will provide specific information on flight characteristics, and powered lift performance, as well as information on design, noise, operational features and propulsive-lift system economics, all needed variously by designers, regulatory agencies and operators. The research aircraft will be capable of useable approach lift coefficients greater than 4.6 and 90 EPNdB noise footprints smaller than one square mile. Preceding the RFP for the aircraft, eight month design studies by two contractors are developing information for configuration selection. The completed Task 1 required each contractor to consider as a baseline the modification of a Buffalo aircraft with an augmented jet flap (AJF), and another aircraft/propulsive-lift combination of their choice. Candidate existing aircraft included the Buffalo, F-27, Jetstar and S-3. Each contractor chose the upper surface blown hybrid (USBH) concept to study in addition to the AJF. Each contract has recommended that the continuing Task 2 design studies be based on the USBH propulsive lift concept, modification of the existing C-8A Buffalo aircraft, and use of off-the-shelf Lycoming engines.

Space and Nuclear Research and Technology Base

W75-70243 **506-16-11**
Ames Research Center, Moffett Field, Calif.
SURFACE PHYSICS
Dean R. Chapman 415-965-5065

Studies will be initiated to expand the understanding of surface and interfacial properties and surface-environment interactions to determine their effects on material behavior. These studies range from describing the changes in surface properties that result when atomic and molecular beams interact with solid surfaces to the study of the growth characteristics of thin films and to the nature of composite interfaces. In addition, a study will be initiated to correlate grain boundary segregation and embrittlement of structural materials. This study will use an in-situ Auger analysis system and will have the capability of fracturing and examining a variety of metal alloys in aggressive environments. Other experimental studies will involve in-situ high resolution electron microscopy of thin film nucleation and growth phenomena in ultra-high vacuum under well controlled experimental conditions. The LEED/Auger/work function/thermal desorption studies of the interaction of metal vapors and gaseous species with metal and graphite surfaces will continue and the Auger-microprobe capability will be improved.

W75-70244 **506-16-12**
Ames Research Center, Moffett Field, Calif.
PHYSICS AND CHEMISTRY OF SOLIDS
Dean R. Chapman 415-965-5065

The objective is to exploit the unique capability of the Illiac 4 computer to calculate the reliable wave functions for ground and excited states of atoms, diatomic molecules, linear polyatomic molecules, and ultimately solid state matter. These wave functions will in turn be the basis for precision calculation of many basic properties of matter such as bond dissociation energies, radiation transition probabilities, dipole moments, Auger transitions, chemical rate coefficients, and ultimately solid state properties such as electronic band gaps and conductivities. Computer codes for calculating wave functions using the parallel processing feature of the Illiac 4 will be developed. These codes will be compared with the best available numerically computed wave functions, to assure the coding is reliable, then they will be used to calculate larger expansions of these wave functions, which will be more precise than heretofore, and also wave functions for species which have not yet been computed. The lowest state of each symmetry type will be computed, and optical transition probabilities between these states will be evaluated. The work will concentrate on molecules such as HF, CO, CN, NO, N2, O2, C2, etc. which are of current interest with regard to planetary entry, heat shield ablation, upper atmosphere pollution, or gas lasers. Eventually the theory will be extended to include excited states of these species.

W75-70245 **506-16-12**
Lewis Research Center, Cleveland, Ohio.
PHYSICS AND CHEMISTRY OF SOLIDS
R. A. Lad 216-433-6601

The objectives are to: (1) to increase the base of understanding of the relationships between the electronic, atomic, molecular and microscopic structures of solids and their useful mechanical, structural, and chemical properties, and (2) to provide information that will lead to advanced materials development, in areas of particular importance to Lewis' programs. Data cover: (1) metal matrix composites - study of factors which control fiber and matrix behavior; internal friction studies - measurement of stress distribution in B fibers, effect of thermal fatigue and corrosion atmospheres on integrity of the composite, calculation of fiber-matrix bond strength, preparation of B on surface modified substrates, and effect of coatings on fiber on bond strength and ductility; (2) hot corrosion of turbine alloys gravimetric studies of bare, preoxidized and coated alloys, thermochemical calculations to predict chemical species, and high pressure mass spectrometry of gas phase species; and (3) battery separators - mechanism studies related to control of ionic conduction and morphology of zinc growth during charging.

W75-70246 **506-16-13**
Langley Research Center, Langley Station, Va.
MATERIAL FOR ELECTRONIC APPLICATIONS
E. S. Love 804-827-2893

Four research efforts are covered by this Material Science program and are related by their common approach to obtain improved, useful materials through research on material properties. (1) The GaAs solar cell research is directed toward achieving high efficiency, high temperature, radiation stable solar cells for space and terrestrial application. Improvements are being made in junction formation, surface properties, and electrical contact technologies with in-house and contractual research. (2) The objectives of research and development on delayed chemiluminescence pollution detectors are to develop rubrene as an ozone detector and to assess the use of other materials for detection of other atmospheric pollutants (e.g., diaminobenzoic acid for NO2). An indepth study of the reaction of ozone with strongly chemiluminscent rubrene is being made to discover if this process is suitable for use such as an EPA personal pollution exposure monitor. An EPA has indicated sufficient interest to co-sponsor this investigation. Practical measurements of reaction rates as functions of temperature, time, O3 concentration, etc., and fundamental measurements of reaction products and the chemical mechanism are being made. (3) The photoexcitation due to sunlight is thought to lead to a reaction between excited O2 and NO in the photochemical formation of NO2 and decay of NO in smog. A similar effect has been suggested for the reaction of photoexcited SO2 with molecular H2O. Detailed quantum calculations of the energies of reaction and of the reaction products will yield information critical to the proper detection and of the reaction products will yield information critical to the proper detection and alleviation of NO and SO2. (4) The ab initio floating Gaussian orbital computations of solids and surfaces effort is developing a method for computing energy and structure of solids and surfaces to obtain general chemical trends and to predict chemical behavior.

W75-70247 **506-16-13**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
PROPERTIES OF MATERIALS FOR ELECTRONIC APPLICATIONS
R. R. McDonald 213-354-6186
(502-33-99; 506-18-33)

This program is aimed at obtaining the fundamental information needed to guide the selection and development of electronic components for the next generation of NASA missions. The program broadly covers the investigation of semiconductor interfaces and superconducting junctions. Basic studies are being conducted on the interactions of electrons with defects in metal-dielectric-silicon (MDS) structures, in a closely coordinated effort with another NASA program aimed at long-life microelectronics. These studies focus on relating the chemical and defect structures to failure mechanisms induced by electrical, thermal and radiation stress. The approach emphasizes the application of new and unique experimental methods to the study of MDS structures processed under controlled conditions. The methods include tunneling effects, time-dependent breakdown and photoelectron-, photoemission-, and secondary-ion-mass-spectroscopies. Another effort is directed at optimizing metal-semiconductor or Schottky barrier solar cells on III-V compounds. This approach eliminates the recombination problems of GaAs junction solar cells. Superconducting quantum detectors are being investigated for applications in the infrared and millimeter region. The approach includes the study and fabrication of both superconducting weak-link junctions and Josephson tunnel junctions to determine the fundamental and practical limitations of detectors based on these structures.

W75-70248 **506-16-14**
Lewis Research Center, Cleveland, Ohio.
INTERDISCIPLINARY LABORATORIES FOR MATERIALS RESEARCH
R. A. Lad 216-433-6601
(506-16-12)

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 of direct interest to NASA programs. Interdisciplinary research involving several departments is conducted at 3 universities in areas recommended by consulation with a committee composed of representatives from Headquarters, LeRC, LaRC and ARC. Research areas under study are as follows: at Rensselaer Polytechnic Instutute - (1) mechanical and structural properties of metals, composites, and polymers, (2) surfaces and interfaces of crystalline solids; and (3) relaxation and transport properties of amorphous solids; Rice University - (1) stress corrosion and hydrogen in metals, (2) optical and magnetic memories, and (3) polymers and high temperature materials; and at the University of Washington - (1) solid electrolytes; (2) ceramic fibers; and (3) ceramic processing. The results are disseminated in summary reports, journal publications and topical conferences.

W75-70249 **506-16-15**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
NON-METALLIC SUPERCONDUCTORS
R. R. McDonald 213-354-6186

The primary objective is to determine the feasibility of synthesizing a high temperature superconductor. The approach involves a coordinated experimental and theoretical effort. The experimental effort will be directed towards investigation of high temperature excitonic superconductivity of quasi one dimensional organic metals (e.g., TCNQ-polarizable cation radicals). Emphasis will be placed upon evaluating the contribution of cation and anion radicals to the organic metalic state and the excitonic interaction. Single crystal structures will be stressed in the quasi one dimensional organic metals program. Resistivity, superconductivity, X-ray, and chemical measurements, as well as chemical synthesis, will be involved in the experimental effort. Prof. A. Hermann of Tulane University, under a subcontract, will measure the Hall effect in quasi one dimensional organic systems and, in addition, evaluate the narrow gap semiconductor-metal structure, Pb-PbTe, as a possible excitonic superconductor (Bardeen model). The potential of an excitonic superconductor formed by the intercalation of a one dimensional polymeric metal (polysulfur nitride) into an excitonic layered semiconductor (Ginzburg model) will be evaluated in collaboration with Prof. M. Labes of Temple University whose work is supported by non-NASA funds. Work will be continued on the one dimensional excitonic model under subcontract to Prof. W. Little, Stanford University. He will evaluate the platinum cyanine dye complexes as possible superconductors by utilizing X-ray diffuse scattering, normal reflectivity measurements and theoretical calculations involving the use of computer assisted molecular modeling to estimate Tc for the excitonic mechanism. An additional theoretical effort by J. Zmuidzinas at JPL will involve a coordinate investigation of high temperature superconductivity via the Dielectric function approach. This approach allows a generalized study of high temperature superconductivity independent of assumptions concerning particular mechanisms or models.

W75-70250 **506-16-16**
Lewis Research Center, Cleveland, Ohio.
RELATIONSHIP OF ATOMIC STRUCTURES WITH MATERIAL PROPERTIES
W. D. Klopp 216-433-6676
(506-16-21)

The objective of this program is to elucidate the relations between atomic and microstructural properties for refractory, iron-, and nickel-base alloys in order to relate these to useful engineering materials properties to help guide the development of these materials for advanced space applications. The approach consists of: (1) determination of the relationship and mechanism of grain-size effects and the threshold stress for diffusional creep in creep of nickel and binary-nickel alloys, including solid-solution-strengthened, precipitate-strengthened, and dispersion-strengthened alloys, and (2) investigation of the correlation between electronic properties (such as locations and widths of solute d-bands) and low temperature solution softening in dilute body-centered-cubic alloys (including Mo, Nb, and Fe-base alloys).

W75-70251 **506-16-17**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
VISCOELASTIC PROPERTIES OF POLYMERS
R. R. McDonald 213-354-6185
(506-21-52; 506-21-32)

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 rubbery 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. At the same time a modified theory must be developed to describe crystalline and polyphase systems. The general 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, morphology and property relationships. Applications for the mechanical properties work might range from improved solid propellants, expulsion bladder and valve seat materials for liquid propulsion systems, sealants for high-speed aircraft, new types of reinforced plastics, and high reliability belts and tapes for spacecraft magnetic recorders.

W75-70252 **506-16-21**
Langley Research Center, Langley Station, Va.
ADVANCED MATERIALS FOR SPACE
G. W. Brooks 804-827-2042

The objectives of this research are: (1) to develop improved materials and materials combinations for advanced space applications, (2) to apply the numerical methods which have been developed in other disciplines, and thereby to achieve better understanding and more effective application of materials, (3) to develop in-house capability for determining thermal, physical, and mechanical properties of materials. Concepts for improved structural or protective materials will be developed and evaluated. Basic processes, such as diffusion and chemical reactions which occur during materials processing or in service, will be studied, and based on a better understanding of these mechanisms, modifications in composition or processing will be made to improve performance. New or more accurate methods will be developed to measure key materials characteristics as required.

W75-70253 **506-16-21**
Lewis Research Center, Cleveland, Ohio.
ADVANCED MATERIALS AND MANUFACTURING PROCESSES
W. D. Klopp 216-433-6676
(506-16-16)

The objectives of this program are to characterize the suitability of present materials and to develop improved materials and manufacturing processes for advanced space systems, such as power-generation systems, communications systems, propulsion systems, and re-entry vehicles. The approach consists of: (1) development of new iron-base alloys with high fracture toughness over a wide range of temperatures (-423 F to 1000 F), (2) determination of space environmental effects on properties of columbium-base and nickel-base alloys, (3) improvement of the long time, high power transmission properties of laser window materials, (4) determination of the feasibility of developing chemical vapor deposition techniques for depositing high strength alloys, and (5) completion of the evaluation and characterization of ceramic fiber systems for advanced reusable surface insulation heat shield concepts.

W75-70254 **506-16-22**
Lewis Research Center, Cleveland, Ohio.
MATERIAL FOR LUBRICATION AND WEAR IN MECHANICAL COMPONENTS
R. L. Johnson 216-433-4000
(505-04-41)

The objectives are to: (1) obtain greater understanding of the structure of materials to eliminate empirical approaches in the selection of materials for lubricants, seals, bearings and other mechanical components; (2) extend the technology of application methods to improve materials including designs for optimized solid and fluid mechanics in mechanical components for the

real and anticipated extreme environments of aerospace devices; also, the utilization of aerospace materials and tribological concepts for the general benefit of mankind; and (3) pursue solutions to anticipated lubrication, hydraulics and mechanical components problems for the space shuttle engine and vehicle as well as for advanced aircraft.

W75-70255 **506-16-31**
Lewis Research Center, Cleveland, Ohio.
THERMAL CONTROL-HEAT PIPE MATERIALS
J. F. Morris 216-433-4000

The objective is to establish materials and designs for efficient, durable heat pipes and to understand corrosion mechanisms in operating ranges from cryogenic to high temperatures. The general approach includes evaluating NASA-contractor heat pipes as well as determining materials and designs for effective new heat pipes. The resulting technology must provide heat pipes with efficient performance, long lifetimes, suitable fabricating and processing techniques, and economy for thermal control in all operating ranges. A major heat pipe problem is internal corrosion, which affects both efficiency and durability through dimensional changes, gas evolution, and deposit accumulations. These mechanisms and those of environmental interactions with heat pipes must be understood and counteracted. Performance and life testing in appropriate environments reveal such effects through thermal sensing of vapor, gas interfacial movements and through careful before-and-after examinations. Specific problem areas under investigation are gas generation in stainless steel and aluminum heat pipes, deposits in ammonia, aluminum heat pipes, and corrosion in liquid metal refractory alloy heat pipes. Another approach to eliminate some refractory alloy difficulties is the development of alkali metal, superalloy heat pipes for high temperature terrestrial and space applications.

W75-70256 **506-16-31**
Ames Research Center, Moffett Field, Calif.
THERMAL CONTROL-HEAT PIPE TECHNOLOGY
John V. Foster 415-965-5083

The objectives are: (1) to develop basic control mechanisms by which heat pipes may achieve variable conductance, feedback control, or thermal diode performance, (2) to improve liquid transport capacity and reliability, and (3) to participate in flight tests of advanced heat pipe technology to establish flight level confidence. The Ames Research Center shall act as the lead OAST Center and provide guidance to OA, OSS, and OMSF in this capacity as a means of extrapolating basic understanding into practical missions. Development of basic control techniques will be continued with increased emphasis on cryogenic thermal diodes and vapor controlled variable conductance heat pipes. Investigation of feedback control will also be continued, but the development of gas-controlled variable conductance heat pipes will be concluded. Liquid transport capacity and reliability will be increased through the development of higher performance non-arterial heat pipes and a deeper understanding of gas occlusions in arteries, development of gas invulnerable and flexible arteries, and continued research into electrohydrodynamic pumping. Emphasis will be increased in the cryogenic region where liquid transport capacity is currently limited. The Ames heat pipe experiment (AHPE) on OAO-C and the advanced thermal control flight experiment (ATFE) on ATS-F will be supported. A new experiment to flight test a cryogenic diode and a vapor controlled variable conductance heat pipe will be developed for the ATS-F' spacecraft.

W75-70257 **506-16-31**
Goddard Space Flight Center, Greenbelt, Md.
THERMAL CONTROL-HEAT PIPES MATERIAL
Stanford Ollendorf 301-982-5228

The objectives of this task are to improve both the capability and reliability of spacecraft temperature control in the following manner: develop more reliable heat pipes and vapor chambers in the ambient and cryogenic temperature range. The approaches considered are to: (1) develop reliable high performance heat pipes for ambient temperature; and use this technology to develop isothermal vapor chambers and extend the temperature range to the cryogenic region, and (2) investigate the problems associated in integrating a cryogenic heat pipe and IR type detectors.

W75-70258 **506-16-32**
Langley Research Center, Langley Station, Va.
THERMAL CONTROL-SECOND SURFACE MIRRORS
G. W. Brooks 804-827-2042

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.

W75-70259 **506-16-33**
Marshall Space Flight Center, Huntsville, Ala.
THERMAL CONTROL SURFACES AND THERMAL ENERGY STORAGE DEVICES
D. R. Wilkes 205-453-3090
(909-51-02; 502-21-27)

Thermal control surfaces are required on all spacecraft in both active and passive thermal control systems. Presently, thermal control surfaces are available that should meet the thermal requirements of missions that are now planned. Use of these thermal control surfaces require that three specific conditions be met: (1) the optical and thermal properties of thermal control surfaces and the changes in these properties due to natural and induced environments must be well defined, (2) the thermal control surfaces must be protected from prelaunch handling and launch contamination, and (3) the thermal control surfaces must not contaminate other optical systems of the vehicle by outgassing optically damaging materials. Tasks covered in this RTOP are directed toward meeting these conditions. Thermal energy storage devices such as phase change materials have been used successfully as thermal capacitors. Another task of the RTOP is to improve knowledge of present phase change materials' properties and to investigate other systems to use as thermal energy storage devices with additional efficiency, weight and cost savings, and wider range of use.

W75-70260 **506-16-35**
Marshall Space Flight Center, Huntsville, Ala.
SPACECRAFT INDUCED ENVIRONMENT AND SURFACE EFFECTS (OPTICAL CONTAMINATION)
H. M. Weathers 205-453-3040

The objectives of this research are: (1) to re-evaluate the effects of length of exposure, temperature cycling, and radiation level on material outgassing rates, (2) to determine the interaction between (effects of) the surface of deposition and (upon the) deposited material itself, (3) to develop methods of predicting particle sites, production rates and velocity distribution as a function of the source and process of particle production, (4) to develop comprehensive optical effects models, and (5) to develop methods and techniques for optical contamination control. The approach being pursued is that of conducting, primarily in-house, a number of related, complementing studies in which factors such as outgassing rates for sample materials are determined as functions of exposure environment parameters, in which accommodation coefficients are determined, in which surface structures are investigated. As data are obtained they are used to test models which have been hypothesized to explain phenomena observed in space. Additionally they are used to develop techniques and establish criteria for optical contamination control.

W75-70261 **506-16-36**
Langley Research Center, Langley Station, Va.
SPACE DEBRIS STUDIES

E. S. Love 804-827-2983

The broad objective of this RTOP is to provide to spacecraft designers on a continual basis sufficient knowledge of the meteoroid environment, man-made earth orbital debris, and the effects of these on space operation 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 the space near major planets planned as targets for future flight investigation. Man-made debris in earth orbit is currently being modeled because of its potential hazard to space operations. The hazard man-made debris poses to spacecraft must be evaluated at present and in the future. This evaluation will form the core of a technical report to be disseminated to all nations probably by the UN. The effects of meteoroid and man-made debris impacting on spacecraft and schemes to protect spacecraft against these hazards will be studied both analytically and experimentally. Langley Research Center has been the lead OAST Center in meteoroid research and the inclusion of research on man-made earth orbital debris is a natural extension of Langley work.

W75-70262 **506-16-37**
Langley Research Center, Langley Station, Va.
RADIATION SHIELDING AND DOSIMETRY
E. S. Love 804-827-2893

The objectives are to: conduct basic research on nuclear reaction and transport theory in order to improve biological dose calculations and dosimetry for manned space flight and airplane flight, develop a real-time REM dosimeter spectrometer system for space shuttle and future long-term manned space flights, theoretically estimate the structural damage by heavy ions for composites, develop models for the interactions of heavy ions with heavy nuclei, and prepare a nuclear data library for high energy transport studies. The Physics Department of the Old Dominion University, under contract, will develop a REM dosimeter for realistic body geometry to monitor the radiation dose to blood forming organs in real time. This is in collaboration with JSC and McDonnell-Douglas Aircraft Co. in developing dosimetry for future shuttle missions. In-house efforts were continued so as to up-grade computer codes for shielding analysis and codes for proton-neutron transport. A grant was made to Old Dominion Univ. to develop heavy-heavy reaction model to study atmospheric radiation levels and contract to LASL to prepare nuclear data library.

W75-70263 **506-16-38**
Goddard Space Flight Center, Greenbelt, Md.
ENVIRONMENTAL DESIGN CRITERIA
Scott A. Mills 301-982-4246

The objectives are: to develop, publish, and keep current NASA design criteria monographs that present state-of-the-art models of terrestrial and extraterrestrial environments; to increase space vehicle reliability; and to achieve design and management economies. The published environmental models are providing an established reference for the designers, mission planner, and experimenters in NASA, industry and universities who are participants in flight programs. As lead center, GSFC initiates, coordinates, and reviews the support of the centers associated in the program (MSFC and JPL) and the efforts of participating scientist, engineers and contractors. A related task that also aims to improve space vehicle reliability is formulation of GSFC general specifications for testing spacecraft and components. Revisions are made in response to findings from test and flight experience or when NASA adopts new or modified launch vehicles. Revisions also are expected because of the changing test philosophy and requirements that are associated with efforts for greater cost effectiveness.

W75-70264 **506-16-41**
Ames Research Center, Moffett Field, Calif.
PLANETARY ENTRY TECHNOLOGY
Dean R. Chapman 415-965-5065

The objective is 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 achieve the following: (1) define the heating environments to be encountered, (2) minimize the heating rates and total heat loads by proper choice of trajectory, vehicle shape, and heat shield material, (3) evaluate available materials in simulated environments including a number of different atmospheric compositions and combined convective and radiative and convective heating loads, and (4) develop new materials tailored to provide maximum heat protection in given environments. Heat shield materials capable of the severe entry conditions of the outer planets will be tested in arc jets and their performance evaluated. A comprehensive realistic description of the gas cap radiation environment coupled to the material response for graphitic, reflecting and transpiration cooled heat shields will be performed by carrying out computations on the Illiac computer. Proof of concept for reflecting heat shields has been demonstrated and development of more efficient reflecting heat shields will continue.

W75-70265 **506-16-42**
Ames Research Center, Moffett Field, Calif.
ADVANCED THERMAL PROTECTION MATERIALS AND EARTH ORBITAL APPLICATIONS
Dean R. Chapman 415-965-5065

The objective is to develop the thermal protection technology required for design of advanced space shuttle vehicles and earth-orbital spacecraft for the late 1980's. This program will address (1) the improvement of current reusable surface insulation (RSI) materials and development of new RSI materials, and (2) the evaluation of advanced thermal protection concepts and materials that have promise for improved performance, weight and cost savings. The effects of cyclic arc plasma exposure on new TPS materials will be studied to determine changes in crystallinity, morphology, chemical and physical properties that are related to TPS performance. The initial specific focus of the program shall be in two areas: (1) improvements to current shuttle TPS and (2) advanced TPS for the aerobraking space tug. In both efforts, analytical and experimental studies will be conducted in-house. For the space shuttle effort advanced RSI materials such as silicon carbide, impregnated silica RSI, foamed black silica glass and semi-rigidized fiberous mullite RSI will be evaluated. Low density polybenzimidazole foam will also be studied as a candidate low temperature RSI for the current shuttle. For space tug TPS, the initial objective will be to identify systems that have failsafe capability, low cost and weight, and ease of inspectability for re-flight certification.

W75-70266 **506-16-43**
Langley Research Center, Langley Station, Va.
SPACE SHUTTLE THERMAL PROTECTION SYSTEMS
G. W. Brooks 804-827-2042
(506-26-10; 506-26-30)

The objectives of this RTOP are to provide heat shield testing to support the space shuttle program, and to develop improved thermal protection materials and systems for advanced vehicles such as flyback booster. Available arc-tunnel and other facilities will be used as required to validate the space shuttle thermal protection system. If problems are discovered in the course of this testing, in-house studies will be undertaken to find solutions. Environmental exposure testing of RSI will continue. Technology studies of alternate shuttle TPS will be completed. For advanced vehicles, new materials and materials configurations will be developed with emphasis on metallic systems. Foil packaged metal wool insulation will be explored as an alternative to rigid metallic heat shields. Thin, uniform reliable coatings will be developed for high temperature metals in foil and thicker gauges. High temperature creep will be studied; data will be generated on various alloys, and a design methodology will be developed based on statistical analysis of the available data. Thermo-mechanical processing techniques which improve the creep resistance and other properties of materials will be developed. Methods will be developed and equipment will be installed to measure temperature and emittance in situ during arc tunnel tests.

W75-70267 **506-16-44**
Ames Research Center, Moffett Field, Calif.
SPACE SHUTTLE THERMAL PROTECTION SYSTEMS
Dean R. Chapman 415-965-5065

The performance, including reusability, of candidate heat shield materials and configurations will be evaluated and failure modes and material modifications identified that would increase the performance potential. Immediate objectives for FY-75 include completion of materials evaluation leading to materials selections and continued reusable surface insulation (RSI) and reinforced carbon/carbon (RCC) exposure to arc plasma flows leading to material characterization. This is the determination of the residual thermophysical and mechanical properties after 100 simulated flights and is required for final TPS design. These material evaluation tests will be done in the Ames Aero and 20 MW Pilot TPS Test Facilities. Details of the shuttle TPS designs result in elements that require evaluation in the appropriate environments. These evaluations are referred to as design development tests--an example being tile-to-tile gap joint design. Tests to support this activity will be performed in the Ames Aero 60 MW pilot TPS test facility and 60 MW interaction heating shuttle panel test facility.

W75-70268 **506-17-11**
Lewis Research Center, Cleveland, Ohio.
LARGE LASER MIRROR FOR SPACE
D. L. Nored 216-433-6948
(506-21-40; 506-25-51; 506-16-21)

The objective of this program is to complete by FY-77 exploratory investigation of the feasibility of concepts suitable for erectable large space-based mirrors for high power laser transmission. This program will investigate preliminary conceptual feasibility of large structures to support and point large (approximately 30 meter diameter) mirror systems in space for the purpose of transmitting high power laser beams. Workable concepts for the packaging and deployment of such structures will be investigated (such structures to maintain the spacing of various elements of a transmission system to within a fraction of a wavelength). A detailed analysis will be performed to catalog significant parameters, define operational criteria, and select or conceive new structural concepts. A conceptual design will be performed to the extent necessary to instill an acceptable level of confidence of feasibility.

W75-70269 **506-17-11**
Langley Research Center, Langley Station, Va.
LARGE ERECTABLE SPACE STRUCTURES
G. W. Brooks 804-827-2042

The objective is to develop technology necessary to make feasible consideration of exceedingly light space structures which could be erected in space. The approach involves (1) investigating applications of graphite composites as ultra lightweight material to meet thermal distortion and stiffness requirements for space structures, (2) evaluating mechanical properties of impregnated graphite cloth as low cost material for large panel construction, and (3) performing in-house studies of effects of curvature to stabilize large sandwich panels and conduct crippling tests on ultra-light sandwich structure. Efforts were continued to define larger, a large geometry erectable space structures experiment for shuttle. Under contract, a survey of existing and possible future national needs for large space structures will be made. In-house and contractual studies will be performed on various structural concepts for supporting flexible paddles and for providing hard, thermally inert supporting structure. Preliminary industry systems studies will be initiated to determine critical controls and thermal requirements for the experiment. Dynamic response problems unique to large area structures will be identified and investigations initiated.

W75-70270 **506-17-12**
Lewis Research Center, Cleveland, Ohio.
COMPOSITE TANK TECHNOLOGY
R. H. Kemp 216-433-4000

Composite pressure vessels and propellant containment tanks offer a variety of attractive advantages in space vehicle applications. Due to the high structural efficiency of the constituent materials, a composite vessel is significantly lighter than an all-metal vessel. Even relatively small weight savings can be significant for upper stage vehicles such as the shuttle orbiter ($30K/lb) and tug ($160K/lb). The catastrophic shrapnel-type failure of a metal vessel can be prevented by using composite vessel technology. This can provide a reliability advantage which is not directly relatable to a cost savings but is considered a major factor in selection of candidate system configurations. In addition, composite vessels have an inherent design flexibility in providing optimum combinations of thermal, structural, and weight characteristics. The principal objective of this program is to develop structurally efficient, reliable, low cost composite vessels from a variety of composite materials including S-glass, Kevlar 49, and graphite fibers in epoxy resin matrices. In this context, a pressure vessel is considered to be a complete structural system. Due to the porous nature of high performance composite vessels, liners are required. Both structural (load-bearing) and non-structural (thin-metal or polymeric) liners are therefore a part of this program. Candidate liner materials for load-bearing and non-load bearing lined vessels are aluminum Inconel, cryoformed stainless steels, titanium, and polymers such as Saran. The latter liner types have an excellent potential for providing a minimum weight composite vessel design for storage of gaseous nitrogen or helium at essentially room temperature.

W75-70271 **506-17-14**
Lewis Research Center, Cleveland, Ohio.
COMPOSITE MATERIALS APPLICATION TO STRUCTURES
R. H. Kemp 216-433-4000

Composite materials offer a high potential for reducing the weight of many 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 composites structures for minimum weight, cost or maximum efficiency, (3) develop (in-house) testing facilities for measuring the mechanical properties of fiber composites under complex loadings, environments, and high velocity impact, (4) determine (by contract) the effects of 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 analysis of fiber composite components, (6) develop (by contract) improved composite analysis capabilities for high velocity impact, flaw growth and arrest, and (7) develop (by contract) composite systems with improved impact resistance and the methodology for assuring structural integrity. The studies outlined above have been reviewed and coordinated with cognizant Langley Research Center personnel and do not duplicate work at that center.

W75-70272 **506-17-15**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
ADVANCED CONCEPTS FOR SPACECRAFT ANTENNA STRUCTURES
R. R. McDonald 213-354-6186
(506-20-22)

Outer planet and planetary orbit missions in the 1975-1985 period will require substantially increased communication capabilities. The JPL studies indicate that optimum telecommunication design for these missions is realized with antennas having much higher gain than those now used on Mariner type 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 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 of entire antennas or components and to design and fabricate larger models as close to flight hardware as possible. A 14-foot diameter furlable conical

antenna and a 12-foot non-furlable flight-like conical antenna were fabricated. The design of a 5-m flight-like furlable conical antenna is in progress and fabrication is scheduled for FY-75. Line source feed concept is emphasized. The technology will then be investigated for extrapolation to antennas of larger size. Criteria include: weight (goal is 0.25 lb/sq ft), surface accuracy in the operating environment, reliability of deployment, long life, and amenability to preflight verification by analysis and tests. This effort will be coordinated with Microwave Techniques And Components, RTOP Code 506-20-22. Another objective of this RTOP is to improve and maintain structural analysis techniques permitting better definition of loads, response analysis and test simulation of the entire antenna subsystem.

W75-70273 **506-17-21**
Langley Research Center, Langley Station, Va.
GENERAL PURPOSE ANALYSIS AND DESIGN METHODS
G. W. Brooks 804-827-2042
(505-02-51)

To provide computer-aided analysis, design, and optimization techniques to improve capabilities for development of efficient, reliable, cost-effective space vehicle structures. To develop advanced computer-aided structural methods and explore the impact of fourth-generation computers on structural methods. Specific targets are to: (1) satisfy shuttle requirements for up-graded NASTRAN capability by increasing efficiency by factor of 5 by close of FY-75, (2) complete development of an advanced level of NASTRAN in FY-75, and (3) determine by FY-76 potential impact of fourth-generation computers on NASTRAN.

W75-70274 **506-17-22**
Langley Research Center, Langley Station, Va.
TPS DESIGN TECHNOLOGY
G. W. Brooks 804-827-2042

The objectives are to: evaluate the integrity and aerothermal performance of shuttle TPS concepts by tests in the 8-foot high temperature structures tunnel (HTST) and the thermal protection system test facility (TPSTF), maintain, operate, and improve these facilities and conduct analytical and experimental studies required to establish design technology for advanced TPS concepts for future high speed vehicles such as fly-back boosters and advanced spacecraft.

W75-70275 **506-17-23**
Lewis Research Center, Cleveland, Ohio.
FRACTURE CONTROL TECHNOLOGY
R. H. Johns 216-433-6380

The major objective of this work is the technology development necessary for effective design, evaluation, and maintenance of structurally efficient and damage tolerant aerospace components. Both primary structure and propulsion system components are included. Fracture control developments oriented by the requirements of advanced space transportation systems will be emphasized. To achieve these objectives, programs structured to provide fracture control methodology, supporting test data, and definition of the NDE capability necessary to assure reliable, long life, and lightweight structures for reusable weight critical vehicle components will be conducted. A 100 mission reuse and 10-year operational life capability will be targeted as minimum objectives. Specific tasks will develop fracture control methods (including advanced fracture mechanics data and techniques when required) and provide failure criteria for structural metallic alloys.

W75-70276 **506-17-24**
Lewis Research Center, Cleveland, Ohio.
NONDESTRUCTIVE EVALUATION FOR FRACTURE CONTROL OF SPACE STRUCTURES
R. L. Davies 216-433-6608
(506-17-21)

This program involves the development of advanced technology and adaptation of current technology to provide improved nondestructive evaluation (NDE) for fracture control plans applied to future space vehicle structures. The main thrust of this work will be the improvement of reliability and detection limits of inspection methods by the transfer of advanced NDE techniques and procedures from the laboratory to practical field use. This will include: (1) improvement of the reliability of commonly-used NDE techniques, and (2) development of automated-signal processing and analysis methods to put inspection on a more quantitative basis and eventually reduce the time and costs of inspection. The program will be conducted through in-house and contractual programs for improvement of NDE techniques. The work will be first aimed at idealized materials and parts and then directed at specific requirements of advanced space vehicles.

W75-70277 **506-17-31**
Langley Research Center, Langley Station, Va.
SPACE PAYLOAD DYNAMICS
G. W. Brooks 804-827-2042
(506-17-32)

The objectives are: to develop dynamics technology to control and minimize payload response to dynamic launch loads, and to develop test techniques to make the payload integration cycle more routine and cost effective. The approach is to continue development of technology to properly define the dynamic environment experienced by a payload during shuttle launch. Studies will be conducted to define and verify dynamic measuring schemes to obtain flight data for payloads in the shuttle orbiter. The effects of scaling of payload dynamic environment will be investigated. Studies of payload test techniques will be continued. The feasibility of controlling a multiple dynamic shaker system by a digital computer will be investigated. Studies of techniques for testing with controlled values of force/velocity (impedance) will be continued. Dynamic response of a sample payload structure will be analysed and construction of a 1/8-scale payload model will be initiated.

W75-70278 **506-17-31**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
SPACE VEHICLES DYNAMICS
R. R. McDonald 213-354-6186

The principal objective of this five-year effort is to perform research and advanced development in structures and dynamics design, analysis, and testing in order to reduce the cost of future spacecrafts and shuttle payloads. Shuttle payload related activities are to be coordinated with OMSF. The total effort in establishment of design criteria, loads, design, development tests, and qualification tests have been reviewed with constraints such as weight, schedule, risk, and cost. The research and advanced development plan coordinated with NASA Headquarters and other NASA Centers will be pursued. Wherever feasible, the tasks will use Viking Orbiter's existing load analysis, test data, flight data, and schedule data.

W75-70279 **506-17-31**
Ames Research Center, Moffett Field, Calif.
SPACE VEHICLE DYNAMICS
H. M. Drake 415-965-5880
(505-02-02)

The objective of this research is to provide improved prediction methods and data on the dynamic loads resulting from aerodynamic noise, and exhaust plume interactions with the flow field and the resulting effects on dynamic loads. The research on dynamic loads will include basic experimental studies of surface pressure fluctuations due to attached and separated boundary layers and shocks waves at transonic supersonic, and hypersonic speeds. Empirical formulae that predict the temporal and spatial characteristics of the nonsteady loads will be derived from these data.

W75-70280 **506-17-31**
Goddard Space Flight Center, Greenbelt, Md.
SPACE VEHICLE DYNAMICS
J. P. Young 301-982-4964

The overall objective is to reduce cost and increase effectiveness of structural evaluation and reliability demonstration services for spaceflight hardware. This objective will be approached through a study of means to improve the cost effectiveness of both test and analysis services. During FY-75, contributions to the above objective will be met by concentrated activity in the following areas: (1) continued study of cost optimized test levels, (2) development of more cost effective test specifications for

components, (3) study of low cost conversion of existing large enclosed volumes as suitable dual use acoustic test chambers, (4) demonstration of how the use of common subsystem module hardware can result in a substantial cost reduction in the environmental test/analysis process, and (5) development of spacecraft past performance data from which cost versus risk tradeoffs can be made on future pre-shuttle programs.

W75-70281 **506-17-31**
Marshall Space Flight Center, Huntsville, Ala.
SPACE VEHICLE DYNAMICS
R. W. Schock 205-453-4387
(502-22-11)

The general objective is to derive and develop space vehicle structural dynamics technology to effect reduction of spacecraft and payload program costs. Implied in this objective is the requirement to verify and qualify the payload with a minimum test program. Methods for accomplishing space vehicle dynamics cost reductions are discussed in the following approach. Candidate solutions for reducing program costs associated with space vehicle dynamics will be evaluated under this RTOP. These candidate solutions are the development of new and/or improved qualification test philosophies and techniques which will provide more exact simulations of operational environments, reduce test costs, and provide quantifiable factors of safety such that redesign and retest costs can be minimized. More accurate methods of predicting dynamic loads and the response of the structure, subsystem, or payload will be developed. This will be done by a well planned effort to measure the shuttle payload bay dynamic environment and improved methods for combining parameter variations which affect loads and response. Improved methods for analytically calculating high fidelity mathematical models of the payload are also planned.

W75-70282 **506-17-32**
Langley Research Center, Langley Station, Va.
SHUTTLE DYNAMICS AND AEROELASTICITY
G. W. Brooks 804-827-2042
(506-17-31)

Objectives are to develop critical technology to determine loads, dynamics, acoustic and aeroelastic response of the space shuttle system; to investigate dynamic behavior using advanced techniques, and conduct key tests and develop critical advanced hardware. In-house studies of shuttle loads will be continued; results of measured and predicted pressure distributions in the jet plume model will be compared; transient and steady state loads in decelerator system for booster recovery will be investigated; and tests will be conducted in the LaRC 16-Foot Transonic Dynamics Tunnel. In-house studies of vibrations of 1/8-scale shuttle system model will be continued and vibration test data on orbiter, external tank and solid rocket boosters will be obtained on coupled and uncoupled configurations. Critical frequencies and mode shapes will be compared with NASTRAN analyses. Development and tests of dynamic flowmeters to detect POGO-type oscillatory flow rates in shuttle propulsion system fluid lines will be continued, and candidate flowmeter designs employing sensing techniques such as ultrasonics or Doppler-shifted lasers will be calibrated and tested to develop suitable hardware for shuttle boost system. In-house studies of thermo-acoustic response of shuttle TPS/ structural panels will be continued, and tests conducted in the LaRC High Intensity Noise Facility to define ambient and elevated temperature response. Use of advanced inspection techniques such as infrared scans to detect failures will be investigated. In-house investigations of potential aeroelastic problems associated with space shuttle vehicles will be continued, and critical flutter tests in the LaRC Transonic Dynamics Tunnel will be conducted. New methods for testing aeroelastic models will be investigated.

W75-70283 **506-17-32**
Ames Research Center, Moffett Field, Calif.
SPACE SHUTTLE DYNAMICS AND AEROELASTICITY
H. M. Drake 415-965-5880

Wind tunnel test support and analysis will be provided to investigate transonic buffet (including aeroelastic effects), aerodynamic noise inputs and response, and flutter of a space shuttle vehicle. Rocket exhaust plumes will be simulated by cold jets so that static and dynamic loads can be measured in a realistic launch environment. The dynamic response of representative skin panels will be determined in wind tunnel tests which simulate the actual launch environment. The flutter of representative skin panels will be evaluated and a computer program for predicting the flutter of space shuttle type panels including boundary layer effects will be validated. Aeroelastic effects on the stability and control of the space shuttle will be determined using the FLEXSTAB computing program. Additional models will be tested as needed to investigate panel response, buffeting and flutter, and pressure fluctuations will be measured in regions of high intensity noise to evaluate aerodynamic noise inputs.

W75-70284 **506-17-33**
Goddard Space Flight Center, Greenbelt, Md.
STOP (STRUCTURAL-THERMAL-OPTICAL-PROGRAM)
H. P. Lee 301-982-5275

The objective is to advance analytical capabilities in combined disciplnes by developing methods in respective areas and unified computer programs. The resulting capabilities are suitable for use in both design and evaluation. The degradation in performance of a spaceborne telescope or a RF antenna is chiefly due to thermal loads caused by the varying orbital conditions. The approach is to develop a general purpose finite element heat transfer computer program compatible with the structural version of NASTRAN which, by its intrinsic characteristics, is suitable to computer automation and extremely versatile in regard to variations in configuration, properties, etc. The unified thermal-structural model simplifies the discipline interface and permits a virtually unlimited problem size. The structural analysis uses the computed termperature distribution as the input of thermal loads and its deformation results are then used in an associated ray trace computer program to analyze optical or RF performance. Analytical capabilities to assess sensitivity of temperature and displacement variances of thermal and structural analyses due to uncertainties inherent in input values of the system parameters are also pursued in this RTOP.

W75-70285 **506-18-11**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
ADVANCED IMAGING SYSTEMS TECHNOLOGY
R. V. Powell 213-354-6586
(186-68-52; 185-50-73)

The long-term objective is the development of an 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. The current objective is the development of solid state imaging sensor technology for both Mariner and Pioneer class spacecraft, based upon charge-coupled device (CCD) technology. These devices have the potential advantages of small size, reliability, scan versatility, geometric fidelity, magnetic cleanliness, and very high sensitivity. Furthermore, they are expected to lead to an integral solid-state camera (excluding optics) with major cost savings to future missions. A near-term target is to provide, by FY-77, a CCD imaging sensor with 10 to 100 times the sensitivity of the Mariner vidicon for outer planet flybys. The approach includes a three phase contractual program coupled to an in-house analysis and test program.

W75-70286 **506-18-12**
Langley Research Center, Langley Station, Va.
HIGH RESOLUTION ENVIRONMENTAL SENSORS
G. B. Graves 804-827-3745

The objective is to develop advanced sensors and sensor systems technology for remote and in situ sensing of the earth, aircraft, and spacecraft environments. Technology areas to be investigated are: (1) hydrographic LIDAR techniques for the measurement of chlorophyll A concentration, salinity, and turbidity of bodies of water; (2) continuously tunable infrared diode lasers

for high resolution absorption and emission spectroscopy of low concentration atmospheric constituents; (3) atmospheric LIDAR techniques for determination of slant range and runway visibility at airports; (4) diode lasers with visible emission and operation at 293 K for sensor and optical data processing applications; (5) ultrasonic sensors for particulate detection in turbid fluids; (6) ultraviolet absorption sensors for smoke stack effluent monitoring; and (7) satellite mass spectrometer calibration techniques.

W75-70287 **506-18-13**
Goddard Space Flight Center, Greenbelt, Md.
ASTRONOMICAL HIGH RESOLUTION SENSORS
Jack T. Williams 301-982-5095

The purpose is to develop high performance optical image recording systems for advanced astronomical space telescopes. In order to realize the observational potential of these optical telescopes, current technology must be extended and improved in order to provide sensors with quantum detectivity, the 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 for advanced missions. These techniques in conjunction with realtime image processing are used to enhance the system performance and increase the design capability of the space telescopes.

W75-70288 **506-18-15**
Wallops Station, Wallops Island, Va.
HIGH RESOLUTION ENVIRONMENTAL SENSORS
H. H. Kim 804-824-3411
(506-18-12)

The primary objective is to develop high resolution sensor technology which can be applied to NASA's research and applications programs in remote sensing of earth and planetary environments. Specifically, the aspects of using lasers for the measurements of ocean depth, fertility, and oil spills in the ocean will be studied. Its application in remote detection of phytoplankton and oil in the water from low flying aircrafts has been demonstrated. Extended effort will be focused on laser bathymetry. Underlying principles of this lidar technique can be undoubtedly extended into the remote probing of planetary environments from a manned or unmanned spacecraft.

W75-70289 **506-18-21**
Langley Research Center, Langley Station, Va.
ELECTRONIC DEVICES AND COMPONENTS
G. B. Graves 804-827-3745
(750-51-01)

The objective is to develop advanced electronic devices and components required for application in future aerospace missions. Analytical studies and laboratory investigations in selected areas of electronic materials and processes will be conducted, and research contracts will be used to develop these materials and processes to provide new electronic devices and components. Those material and process technologies, with the potential for providing improved and reliable electronic performance in cost effective devices and components, will be emphasized. Current research efforts include the investigation of new materials and processes for developing improved infrared detectors, strain and heat flux sensors, and filament materials for calibrating mass spectrometers. Organic materials as a storage medium in optical mass memories and garnet films for magnetic bubble storage systems are being investigated. Liquid crystal and light emitting diode modules for application in flat panel cockpit displays, charge coupled devices for buffer memory and filtering applications, and solid state photosensor arrays for planetary imaging and spectrometry are being developed. Graded band gap materials are being investigated to develop solar cells with improved power conversion efficiencies.

W75-70290 **506-18-22**
National Aeronautics and Space Administration, Washington, D.C.
ELECTRONIC DEVICE AND SYSTEMS SUPPORT
C. E. Pontious 202-755-2440
(506-18-21; 506-18-31)

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 DOD and other government agencies. Through associate membership on the advisory group on electron devices and it constituent working groups, NASA program managers receive expert advice on the feasibility, currency and soundness of planned R and D procurement activities, long range R and F requirements, complementary work in other government agencies, and forecasts of new technical developments.

W75-70291 **506-18-31**
Marshall Space Flight Center, Huntsville, Ala.
DESIGN, PROCESSING AND TESTING OF LSI ARRAYS
G. A. Bailey 205-453-3770
(502-23-51)

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 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.

W75-70292 **506-18-32**
Marshall Space Flight Center, Huntsville, Ala.
SCREENING AND RELIABILITY TESTING OF MICROCIRCUITS AND ELECTRONIC DEVICES
L. C. Hamiter 205-453-3986
(506-18-31)

The objectives are to develop approaches for assessing and assuring predictable long operating life of microcircuits and other electronic devices used in aerospace applications. Evaluation test programs are being conducted to define relationships of applied voltages and temperature to accelerated life test failure rates. The results will be used to develop effective and economical accelerated life test methods that will provide more accurate and quicker assessments of microcircuit and semiconductor device long life stability and characteristics. An all antalum wet slug capacitor that does not degrade with shelf life and nominal use stresses is being developed and qualified. The capacitor effort also consists of developing more explicit application and derating criteria for tantalum capacitors to improve their long life characteristics. A program to identify the acceptable designs and materials for solid encapsulated microcircuits for use in long term space applications is being continued. The program also includes developing the necessary lot controls, qualification criteria, screening, and inspection methods necessary to assure reliable solid encapsulated devices.

W75-70293 **506-18-33**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
PREDICTABLE LONG-LIFE COMPONENT TECHNOLOGY
R. V. Powell 213-354-6586

The goal of this effort is to develop a microelectronics technology which will provide the reliability that is necessary to achieve the mission objectives of a wide range of future space missions, including those involving unusually long flight times. The approach will be to thoroughly investigate those technologies which NASA will be utilizing on future missions and to identify the life limiting mechanisms inherent in the basic processes involved. Generalized device models will be developed which will incorporate models of specific failure mechanisms. These models will be used to predict the probability of device failure and their specific behavior under varying environmental stresses. This understanding will promote constructive feedback to the fundamentals of processing which will then further enhance device

reliability. The near-term objectives will focus specifically on standard CMOS Technology and appropriate hybrid packaging techniques which will take full advantage of the CMOS potential. Specific investigations of failure processes will center around: oxide stability, charge migration, metallization, and silicon defects. The work is being conducted in close cooperation with the MSFC to satisfy the specific NASA objective, Long Life Reliable Circuit Technology. Specific RTOP target objectives are: (1) by late FY-75 complete the development of a preliminary CMOS model. This model will be flexible enough to allow the inclusion of failure models as they are developed and refined; (2) by late FY-75, correlate failure modes of selected CMOS IC's to their associated failure mechanisms (including beam leads); (3) by late FY-75, complete the feasibility demonstration of AVIS; (4) by mid FY-76, complete the CMOS accelerated test definition. (5) by FY-76, report on the selection of thick versus thin film for long-life applications.

W75-70294 **506-18-34**
Goddard Space Flight Center, Greenbelt, Md.
HI REL SEMICONDUCTOR MANUFACTURING INVESTIGATION
J. C. Lyons 301-982-2204
(502-23-57)

In order to procure hi rel semiconductors, a manufacturer must include process controls and inspection steps which deviate from his normal manufacturing routine. This requirement is disruptive and expensive because the portion of work requiring hi rel controls is small compared to the portion destined for the commercial market. This RTOP will investigate the feasibility of buying parts from the commercial manufacturing line and qualifying them to hi rel standards at Goddard.

W75-70295 **506-19-11**
Marshall Space Flight Center, Huntsville, Ala.
INERTIAL COMPONENTS
B. F. Walls 205-453-0793
(502-23-42)

The objectives are: (1) to produce an operational laser gyro with high accuracy and reliability that can be used in future systems to precise rate and position sensing; the unit can be easily adapted to navigation systems as well as rate and position sensors and position trackers; (2) to produce a three-axis strapdown inertial navigation system with performance that exceeds the presently available high quality inertial systems in accuracy and reliability with a considerable reduction in weight, size and cost; and (3) to produce a redundancy strapdown inertial measurement unit using six laser gyros and six accelerometers for a highly reliable low cost navigation system for future NASA missions. Investigation of fabrication techniques and environmental parameters effects on the ultimate performance and stability of the laser gyro components are being continued, and the test and evaluation of the three-axis laser gyro strapdown navigation system in the mobile van and aircraft flight is scheduled for completion in CY-74. Fabrication and test of a six-pack redundant strapdown laser gyro navigation system is continuing.

W75-70296 **506-19-12**
Goddard Space Flight Center, Greenbelt, Md.
ADVANCED COMPONENTS FOR PRECISION CONTROL SYSTEMS
H. E. Evans 301-982-5194
(502-23-44)

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 perturbating forces due to friction, wear, thermal effects and transmissibility. The ultimate objective is a cost effective system with a 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 directly support unmanned earth orbital and planetary missions and the manned earth orbital and shuttle programs.

W75-70297 **506-19-13**
Langley Research Center, Langley Station, Va.
ADVANCED SPACECRAFT AND EXPERIMENT CONTROL SYSTEMS
G. B. Graves 804-827-3745
(909-74-35)

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 laboratory development to establish feasibility. This effort is directly coordinated with GSFC, JSC, MSFC, and JPL. GSFC developed components will be integrated into Langley control actuator hardware.

W75-70298 **506-19-14**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
EXTENDED LIFE ATTITUDE CONTROL SYSTEM (ELACS) FOR UNMANNED PLANETARY VEHICLES
R. 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, and other space programs. In combination, these missions demand longer life, improved accuracy, lower weight, less power, and greater cost effectiveness. Specific program targets are: (1) by FY-76, complete development of flexible body control analysis technology for predicting induced angular rates of planetary science instruments to better than 1 sec/sec; (2) by mid FY-77, mechanize and test a breadboard programmable attitude control electronics with fault tolerant capability with a life potential of greater than eight years; (3) by end of FY-78, develop and demonstrate a Long Life Dry Gyro Inertial Reference Unit (DRIRU) to achieve a weight savings of 45 percent, and a cost reduction of 43 percent as compared with the present Mariner/Viking dual IRU; (4) derive and demonstrate a final design by end of FY-78 of control filters and state estimation algorithms for fault tolerant programmable electronics to meet science pointing requirements for rate settling to 2 sec/sec in less than 10 seconds; (5) by early FY-78, develop and demonstrate an engineering model Long Life Reaction Wheel with life potential greater than eight years; (6) by mid FY-79, develop and demonstrate an engineering model Star Tracker for Economical Long Life Attitude Reference (STELLAR) with a cost saving greater than 50 percent (1,200k reduced to less than 500k) of a typical Mars orbiter program; and (7) By FY-79, mechanize and test a breadboard Extended Life Attitude Control System (ELACS) with a 0.1 deg pointing accuracy and a lifetime potential of more than 10 years with functional redundancy.

W75-70299 **506-19-15**
Ames Research Center, Moffett Field, Calif.
VIDEO INERTIAL POINTING SYSTEM FOR SHUTTLE ASTRONOMY PAYLOADS
J. V. Foster 415-965-5083
(506-19-14; 502-23-47; 975-20-02)

The objective is to develop and flight demonstrate an attitude reference system that will satisfy the acquisition and pointing requirements of shuttle attached astronomy payloads, including the Shuttle Infrared Telescope Facility (SIRTF). The Video Inertial

Pointing (VIP) System will provide computer generated error signals for three-axis stabilization and pointing of the astronomical telescope. In addition, system outputs will drive a video display for use in star field identification and manual pointing control. The star field sensed by a video camera coaligned with the optics of the astronomical telescope will provide the basis for a three-axis attitude reference system. The relative positions of two or more bright stars in the field will be combined with the outputs of a triad of rate integrating gyros (RIG's) in an onboard digital computer to generate pointing and stabilization error signals. The output of the video sensor will also drive a CRT display at the operator's console to facilitate guide star acquisition and/or manual positioning of the experiment. The VIP System will be developed in several stages with each stage culminating in a flight evaluation on the Ames Infrared Balloon-Borne Telescope (AIROscope). Analysis and simulation will be used to develop the multiple star processing capability. The final AIROscope flight evaluation will utilize an advanced CCD sensor to be developed by JPL.

W75-70300 **506-19-21**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
GUIDANCE AND NAVIGATION FOR UNMANNED PLANETARY VEHICLES
R. V. Powell 213-354-6586
(186-68-74; 310-10-60)

Objectives are to derive and verify advanced navigation techniques incorporating new ground and on-board measurements and software into a navigation system which minimizes trajectory correction delta V requirements, enables efficient gravity-assists, and permits precise scientific observations, resulting from improved field of view delivery capability, increased mission opportunities, and lower operational cost for future exploration. Specific targets are: (1) by FY-75, demonstrate the ability of S-X band multi-station radiometric data and long focal length bright target/star imaging data to reduce effects of dominant error sources by a factor of ten and yield increases in accuracy, reliability, propellant savings and mission design flexibility; (2) derive and validate in-flight approach guidance techniques which yield 25 micro-radian measurement accuracies in six-hour turnaround times and can allow up to 50 percent payload increases through on-board propellant savings for outer planet missions; with available satellite/star techniques and comet and asteroid measurement technology to be available in late FY-76; (3) by FY-79, demonstrate outer planet satellite ephemerides programs, which improve present (FY-74) ephemerides by factors of 5-20 and allow a factor of 50 reduction in the time required to generate satellite trajectories resulting in project cost savings and increased mission operations flexibility; (4) by FY-80 demonstrate in the laboratory an optical navigation system using simulated flight data processing which reduces the measurement processing time from the six hours currently required to two minutes while retaining the accuracy to within 20 percent. By FY-86 design and validate in flight a fully autonomous system with the capability of on-board flight path control to 1 km within two minutes of final measurement for small body rendezvous or flyby missions.

W75-70301 **506-19-22**
Langley Research Center, Langley Station, Va.
VIDEO GUIDANCE, LANDING AND IMAGING SYSTEM FOR SPACE MISSIONS
G. B. Graves 804-827-3745

The objectives of the present study are threefold. The first objective is to investigate in greater depth the problems associated with a video landing site selection system for post- '75 Viking lander missions. It has been statically demonstrated that a video system scanning two-dimensional terrain photographs is capable of selecting a safe or the least hazardous landing site on the photograph (Roger Schappell - Martin Marietta). However, more realistic studies must be conducted with a dynamic system and three-dimensional terrain models in order to properly evaluate the concept. The second objective is to investigate the use of a video system for rendezvous and/or landing on small planetary bodies (asteroids, comets, small moons, etc. during the terminal guidance phase (< 10 km)). The third objective is to investigate the use of a video system for rendezvous of unmanned earth-orbiting spacecraft during the terminal guidance phase (< 1 km). All three of the above tasks are somewhat similar in that the video data will be processed on-board the spacecraft and guidance corrections will be performed autonomously. Some of the video images of the target bodies will be of great interest to the scientists and engineers, and therefore, additional studies will be undertaken to determine the best method of obtaining and transmitting these images.

W75-70302 **506-19-31**
National Aeronautics and Space Administration, Washington, D.C.
ARTIFICIAL INTELLIGENCE
C. E. Pontious 202-755-2450
(506-19-32)

The objectives of this RTOP are to improve our ability to manage large amounts of data, to effectively utilize sensed information, and to provide more efficient methods for processing information. Near term targets include development of automated problem-solving systems and techniques for maching perception and analysis of scenes. The technical approach is to develop computer models which simulate intelligent system operations such as perception, question-answering and learning and test these models with various real or approximately real functional problems. The results will provide guidelines for the development and exercise of autonomous or robotic systems such as the JPL robot rover project. The work will be performed through a series of research grants and contracts with academic and industrial laboratories recognized for their competency in automated information systems R and D.

W75-70303 **506-19-32**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
ARTIFICIAL INTELLIGENCE FOR INTEGRATED ROBOT SYSTEMS
R. V. Powell 213-354-6586

The long-range objective is to establish a technology base in robotics and semiautonomous control of unmanned machines or vehicles to support lunar and planetary surface explorations. The results will also be applicable to other remote systems, automated fabrication facilities, and other systems and activities of importance to NASA and the nation as a whole. At JPL, a robot roving vehicle is being assembled to demonstrate semiautonomous operations, provide practical tests of machine intelligence concepts, define research requirements, and develop design guidelines for system applications. During FY 1975, a four-wheeled vehicle, a manipulator, a laser rangefinder, stereo TV, and navigational and proximity sensors will be integrated with each other and with a computer system, and tethered operations will begin in an indoor laboratory. In FY 1976, this 'breadboard' system will be extensively tested to evaluate controlling software, system operational procedures, and strategies for coordinating sensors and effectors to accomplish such tasks as moving from one location to another and picking up a rock or tool without operator assistance. In FY 1977, semiautonomous operations of an untethered vehicle in increasingly complex outdoor settings will be demonstrated. In FY 1978 and subsequent years, new concepts in manipulators, sensors, and control strategies will be incorporated and evaluated; studies will be made to determine the balance between autonomous control and interactive (man-machine) control for the efficient conduct of remote operations; and data and engineering criteria will be provided to guide the design of lunar and planetary rovers and other remotely controlled machines.

W75-70304 **506-20-11**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
ADVANCED DIGITAL DATA SYSTEMS FOR DEEP SPACE
R. V. Powell 213-354-6586

The goal is development of advanced technology for integrated spacecraft data systems, including the functions of control, automation, data acquisition and processing and data storage. Work is focused on achieving a unified data system (UDS) approach for post Mariner Jupiter Saturn (MJS) 77 missions. Specific targets include achieving a UDS design by mid FY-75 and a breadboard test and evaluation in FY-76. The effort

encompasses the consolidation of hardware, the application of mini processors, simplification of software, and incorporation of fault tolerance. The justification for a new UDS design is based on a cost savings goal of approximately $1300K per mission for the six mission set listed in 15.B of this plan. The $1300K per mission saving represents $500K saving in flight software costs, $400K saving in support equipment and support software costs, and $400K saving in hardware costs due to the common processor and standardized S/C interfaces. Work is also focused on the development and application of high performance data compression algorithms and the development of compression techniques which are applicable to high rate imaging radar data. By late FY-75 the preliminary design and analysis of a new image data compressor designated RM2 will be completed. The capability to extend the performance of the compressor to include feature recognition will be investigated, and by late FY-76 a report will be published on the results. A definition of the imaging radar data handling problem will be reported by mid-FY-75. The architecture for a static memory using bubble technology will be completed by late FY-75 with a BB targeted for late FY-76. This is in cooperation with the Langley effort and for application to the UDS.

W75-70305 **506-20-14**
Goddard Space Flight Center, Greenbelt, Md.
AUTOMATED DATA HANDLING TECHNIQUES AND COMPONENTS (HIGH CAPACITY DATA SYS.)
David H. Schaefer 301-982-5184
(175-31-42)

In a continuation of FY-74 RTOP 502-23-32, the focus of this RTOP is to develop methods of onboard analysis of data generated in earth resource and other image sensing missions. The primary task is the hardware development of 'parallel' image processing systems. Such systems process all points of an image simultaneously. Priority is being given to the development of a digital type of parallel image processor known as a 'TSE computer'. Such computers are two dimentional analogs of conventional digital computers. These computers will process from sixteen thousand to one million points simultaneously. It is the aim of the RTOP to develop TSE systems that have an effective bit rate of 10 bits per second. Real time image processing systems that utilize coherent optical phenomena are also being developed. In addition to the above image processing tasks, a small effort will be devoted to developing components to increase the utility of the 'mu-scope' microprocessor that has been developed in previous years under this RTOP.

W75-70306 **506-20-21**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
MICROMINIATURE TRANSPONDER DEVELOPMENT
R. V. Powell 213-354-6586
(186-68-53; 506-20-22)

The objectives of this RTOP and OSS RTOP 186-68-53 are to jointly develop microwave radio transponder techniques, components, and subsystem technology required for NASA planetary missions in the period 1977 to 1982. Particular emphasis will be placed on substantially reducing the cost of transponders, while improving performance capability, reliability, and lifetime and reducing size, weight, volume, and power consumption. By the end of FY-74 the technology readiness of the S/X-band multimission transponder in a discrete component-printed circuit board miniature version appropriate for flight missions beginning in 1977 will have been demonstrated. This version has the following advantages over the Viking Oribiter design: an order of magnitude improvement in differential phase and group delay stability; and reductions of 35 percent in per unit cost; 80 percent in power consumption; 72 percent in volume; and 64 percent in weight. Key future targets are: (1) in FY-75, demonstrate an order of magnitude improvement in transponder turnaround phase delay stability (through the use of quartz surface wave filters); and (2) by the end of FY-76 demonstrate the technology readiness of the transponder in a micromin version (beam-leaded parts on ceramic substrates) for flight missions beginning in 1979 which has the following advantages relative to the discrete component version: a doubling of mission life potential (adequate for 10-year missions without additional redundancy); and reductions of 56 percent in weight and volume.

W75-70307 **506-20-22**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
MICROWAVE COMPONENTS AND TECHNIQUES
R. V. Powell 213-354-6586
(506-20-21; 645-25-02; 186-68-53; 506-17-13)

Microwave components and techniques necessary to provide the data transfer and tracking capability for NASA planetary missions from 1977 to 1982 are developed. Specific targets are: Antenna: (1) in FY-75 complete RF test of 5m unfurlable conical antenna, demonstrate ability to determine far-field gain from near-field measurements; (2) in FY-75 complete systems tradeoff and functional design of pointing system; (3) in FY-76 complete functional specification for 60 db antenna; (4) in FY-77 complete development of S/X-band tracking feed with error less than 1/15 of S-band beamwidth; and (5) in FY-78 demonstrate 60 db X-band unfurlable antenna with S/X feed. Propagation: (1) in FY-75 use MVM occultation data to verify weak-turbulence model; (2) in FY-77 complete strong-turbulence solar corona model; and (3) in FY-79 verify strong-turbulence model with solar occultation data. Coding and Corona Communication: (1) in FY-75 assess effects of weak turbulence on coded communication; (2) in FY-75 complete software for noncoherent coded telemetry system development; (3) in FY-75 assess soft decision decoding of block codes; (4) in FY-76 perform design tradeoffs for noncoherent solar corona link; (5) in FY-77 select design of solar corona telemetry/command link and perform demonstration; (6) in FY-77 design solar corona telemetry experiment for MJU'79; and (7) in FY-80 demonstrate reduced telemetry/command blockout due to solar corona using MJU-79. Microwave Radio Techniques and Components: (1) in FY-76 demonstrate RF digital phase detector; (2) in FY-78 demonstrate breadboard electronic antenna beam steering systems; and (3) in FY-78 demonstrate micromin transponder with digitized baseband and low frequency portions and with monolithic UHF multiplier and amplifiers.

W75-70308 **506-20-23**
Lewis Research Center, Cleveland, Ohio.
MICROWAVE AMPLIFIER TECHNOLOGY
R. E. Alexovich 216-433-6689
(643-40-10; 643-60-01)

Objectives are to advance the state-of-the-art of microwave power amplification for space and terrestrial applications above one GHz. To achieve this objective, research and technology development programs will be undertaken on microwave amplifiers, high current density electron emitters and high power microwave passive components. Studies and investigations of space-earth propagation and interference will be undertaken to guide high power communication component and subsystem investigation. Specific techniques, such as multi-stage depressed beam collection and beam refocusing for linear and crossed-field amplifiers, are among promising techniques being investigated in addition to circuit and electron gun optimization studies.

W75-70309 **506-20-24**
Goddard Space Flight Center, Greenbelt, Md.
MICROWAVE NEAR EARTH DATA TRANSFER AND TRACKING
F. J. Logan 301-982-4901

The objective is to achieve technology advances in data transfer and tracking systems in order to satisfy the demanding communication requirements for future space flight projects, such as space shuttle, Earth Observation Satellite program and TDRS. The capability and performance requirements on the communication links for these advanced projects are characterized by high data rates (up to 200 Mb/s) simultaneous multi-link operation, and reliable long life operation. The attainment of these parameters requires technological advances in spacecraft techniques and hardware. High power efficient solid-state amplifiers 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. These advances will be utilized in the development of a high data rate spacecraft transmitter package

capable of direct communication to ground or to a data relay spacecraft. Room temperature parametric amplifiers for spacecraft receivers at S-band, C-band, and Ku-band having noise temperatures of 150 degrees Kelvin or less will be developed employing 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.

W75-70310 **506-20-31**
National Aeronautics and Space Administration, Washington, D.C.
OPTICAL DATA TRANSFER RESEARCH
C. E. Catoe 202-755-2450

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 late 1970 to 1985 time period. The future requirements for high data rate communication may possibly 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.

W75-70311 **506-20-32**
Goddard Space Flight Center, Greenbelt, Md.
OPTICAL DATA TRANSFER SYSTEMS
J. H. McElroy 301-982-6542

NASA flight missions of the late seventies and early eighties will need high capacity data transfer systems. This RTOP is for the development of the technology to provide 400 Mbps data transfer terminals for space-to-space-to-ground relay links. The CO2 (10.6 micrometers) laser heterodyne systems and the Nd:YAG (1.06 micrometers) laser direct detection systems offer the best promise to meet these requirements and are being developed under this RTOP. Theoretical, analytical, and trade-off studies are conducted to establish system parameters. Research and Development (R and D) is carried out to advance the state-of-the-art of critical components such as waveguide lasers, optical mixers for 10.6 micrometers, diode-pumped lasers and III-V detectors for 1.06 micrometers, modulators, etc. Acquisition and tracking techniques for spacecraft terminals are being developed and incorporated in the development of engineering models that are in spacecraft configuration. Systems are evaluated in the laboratory to determine bit error rate and an atmospheric channel simulator is used to establish the magnitude of the effects imposed by the atmosphere. Flight experiments to measure the effect of atmospheric turbulence on optical data transfer systems are carried out using high altitude balloons (30 kilometers).

W75-70312 **506-20-33**
Goddard Space Flight Center, Greenbelt, Md.
GEOPHYSICAL MEASUREMENT TECHNOLOGY
M. W. Fitzmaurice 301-982-4948
(502-23-15; 645-40-01; 502-23-18)

The technology necessary for the development of precise space-to-space, space-to-ground ranging system and techniques for calibrating spaceborne measuring systems through the atmosphere is provided. NASA flight missions in the late 1970's require satellite-to-satellite range accuracy to 2 cm and range-rate information to .003 cm/second. A large portion of the component development being conducted under RTOP 502-23-15 has application to these requirements. The major components developed under this RTOP are for higher power CO2 transmitters (20 watts), tunable waveguide lasers to compensate for larger Doppler shifts, spaceborne neodymium laser transmitters, and image converter receivers for the detection of short laser pulses (.2 nanosecond to 3 nanoseconds pulse width). In FY-75, system analysis will be conducted for a CO2 laser range and range-rate system and the development of an extended band-width waveguide laser will be continued. The precision limits of ground based ranging systems will be improved by the start of the development of a multi-gigahertz image converter receiver system. Spaceborne ranging system concepts will be analyzed and the development activities for a space qualifiable pulsed laser initiated. The earth beacon facility at the Goddard Optical Research Facility (GORF) will be upgraded with the installation of a dye laser and the data analysis from the Skylab Experiment completed. Ground stations for laser ranging will be modified to permit pointing at the subarcsecond level using adaptive digital controllers and improved prediction up-dating techniques.

W75-70313 **506-21-10**
Lewis Research Center, Cleveland, Ohio.
ADVANCED ROCKET COMPONENTS
D. A. Petrash 216-433-6860

The general objectives are to provide the technology for improvements in performance and reusabilty of liquid rocket components and subsystems. Experimental and analytical programs will be conducted to develop (1) low cycle thermal fatigue and heat transfer technology for reusable thrust chambers, (2) improved fabrication techniques for thrust chambers and (3) reduced gravity fluid acquisition and transfer systems. In the area of reusable thrust chamber technology, efforts will be devoted to obtaining fundamental fatigue data, developing the analytical capability to predict thrust chamber life and testing materials or new designs in an inexpensive thrust chamber simulator. Advanced heat transfer techniques will also be applied to ease the severity of the thermal load of high performance thrust chambers. Improved fabrication techniques involving sputtering and electroforming will be evaluated along with new nondestructive testing methods to produce better, more reliable thrust chamber hardware. Low gravity fluid system studies will investigate critical characteristics and components for in-orbit fluid acquisition and transfer.

W75-70314 **506-21-11**
Lewis Research Center, Cleveland, Ohio.
ADVANCED LIQUID ROCKET SYSTEMS TECHNOLOGY
John W. Gregory 213-433-6849
(909-75-03; 506-21-12; 506-21-13)

Analytical and experimental efforts are being pursued to provide the technology required for advanced, reusable hydrogen-oxygen space propulsion systems, such as the space tug. The primary effort is aimed at developing the technology for small, high pressure, reusable, pump-fed, staged-combustion cycle hydrogen-oxygen rocket engines. The work during FY-72 through FY-76 will be concentrated upon critical component technology for a 20,000 lb. thrust engine operating at about 2000 psia chamber pressure. In FY-76, the components resulting from these programs will be assembled into a Powerhead Breadboard Assembly (PBA). Tests will be made to simulate operation of the actual high pressure, staged-combustion cycle engine. Critical component technology programs in the turbomachinery and thrust chamber areas as well as engine system studies will be continued this fiscal year.

W75-70315 **506-21-12**
Lewis Research Center, Cleveland, Ohio.
REUSABLE CRYOGENIC STORAGE AND TRANSFER
J. W. Gregory 216-433-6849
(180-31-51)

The technology required for the effective design and fabrication of reusable cryogenic thermal protection and fluid transfer systems is provided. The work will be conducted on thermal protection systems designed to meet the problems associated with the changing environments experienced during a typical flight cycle by a reusable high energy upper stage. Work on both a purged multilayer insulation system as well as an evacuated multilayer insulation protected by a rigit lightweight vacuum jacket will be continued. Work has started on a unique high performance load bearing insulation that shows promise of providing the high performance of uncompressed MLI while still providing all of the advantages of an evacuated system without the attendant weight penalty usually associated with rigid vacuum shells. The effort on fluid transfer systems will be applied to evaluation of the use of composite materials for the fabrication of engine feed lines, vent lines and pressurization lines. Designs will be evaluated to provide lines that are lightweight, have low axial heat conduction and provide rapid chilldown without excessive use of chilldown propellant, when compared to all metal lines.

W75-70316 **506-21-13**
Lewis Research Center, Cleveland, Ohio.
HYDROGEN-OXYGEN AUXILIARY SYSTEMS TECHNOLOGY
J. W. Gregory 216-433-6849
(506-21-11)

The objective is to provide improvements in the technology of auxiliary propulsion systems and components using hydrogen-oxygen propellants. The work is directed primarily toward development of technology for reusable space vehicles, such as space tug and space shuttle. The work includes advancement in technology of thruster assemblies, and components thereof, as well as studies of complete integrated auxiliary systems. Work on auxiliary propulsion thrusters for space shuttle, initiated in previous years, will be brought to conclusion this fiscal year. This effort included investigation of complete gaseous hydrogen-gaseous oxygen thruster assemblies to determine performance and life characteristics, evaluation of thermal fatigue life of thrust chambers, and extension of thruster operation into the regime of gas/liquid and liquid/liquid propellants with the attendant problems of ignition, stability, and pulsing performance. This work has been done using thrusters of 1000-1500 pounds thrust operating at chamber pressures of 300-500 psia. Auxiliary propulsion thrusters will be investigated at the operating conditions suitable for space tug, (30-100 pounds thrust and chamber pressure of 100-200 psia.) Evaluation will be made of steady-state and pulsing performance levels, thrust chamber cooling, injector design, and igniter design and operation. Studies will be made of the complete integrated auxiliary systems for space tug, which includes auxiliary propulsion, pressurization, fuel cell propellant supply, and main feedline chilldown.

W75-70317 **506-21-21**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
LONG-LIFE ADVANCED PROPULSION SYSTEMS FOR PLANETARY SPACECRAFT
P. J. Meeks 213-354-2546
(506-21-51)

The objective of this work is to provide for the advanced development of the liquid feed assembly components and the rocket engine assembly for advanced blowdown liquid propulsion systems that will be used on planetary missions. System level studies will be carried out to establish the criteria for the components and thrust chamber designs. Specific efforts proposed for FY-75 include: continuation of testing of space storable bimodal engine; design, fabrication, and test of a high performance liquid-liquid injector; test of thrust chamber materials with current like - doublet injector investigation of existing facilities in order to conduct altitude performance tests; obtain additional fracture mechanics data on F2/titanium; obtain design data such as contact angle and the effects of aging on contact angle for a F2 compatible Propellant Management Device (PMD); complete the design of propellant isolation/shuttoff valve; initiate a study to determine if remote operation of the oxiderizer loading valve is required; perform system level design studies of the blowdown-propulsion system with emphasis; on establishing design criteria. The study of the safety aspects of carrying LF2 in the shuttle bay will continue.

W75-70318 **506-21-55**
Marshall Space Flight Center, Huntsville, Ala.
PHYSICS AND CHEMISTRY OF CHEMICAL PROPULSION
Kalus W. Gross 205-453-3815
(502-04-21)

The objective is development of a reliable and accurate boundary layer JANNAF reference program to predict performance loss and heat transfer of rocket thrust chambers. Based upon results of various turbulence model investigations from a previous study and large area ratio hot firing tests with boundary layer measurements conducted under a separate contract (Boundary Layer Integral Matrix Program (BLIMP)), changes will be made to obtain agreement between analytical predictions and test data.

W75-70319 **506-21-30**
Langley Research Center, Langley Station, Va.
THE CHEMISTRY AND ATMOSPHERIC INTERACTIONS OF EXHAUST CLOUDS FROM ROCKET VEHICLES
E. S. Love 804-827-2893
(180-72-50)

The objective is to develop a basic understanding of the chemistry of exhaust clouds from rocket vehicles and the interactions of the exhaust clouds with the atmosphere. Although the initial composition of the rocket exhaust is readily approximated by equilibrium calculations, it is of little use in determining the ultimate chemical and physical distribution of these products in the atmosphere, or on the ground. The chemical composition of the exhaust cloud changes continually; rapidly at first as a result of high temperature reactions with atmospheric species and nucleation of condensible species, and then more slowly as a result of both ordinary and photochemical gas and condensed-phase reactions, gaseous diffusion, droplet growth and evaporation, and various other interphase and transport phenomena. Thus, a complete chemical characterization of the resulting exhaust cloud as a function of propellant, atmospheric conditions, and time is needed to properly assess the environmental impact of the exhaust products. The results of the research proposed herein will provide a critical part of the technology base required by NASA to develop and substantiate the environmental impact statements for future NASA rocket launches.

W75-70320 **506-21-31**
Langley Research Center, Langley Station, Va.
ADVANCED PYROTECHNIC/EXPLOSIVE SYSTEMS TECHNOLOGY
E. S. Love 804-827-2893

The objective is to develop and demonstrate technology for pyrotechnic systems that is needed to meet aerospace flight program requirements. Experimental programs will be conducted to develop understanding of critical performance parameters at the system level, providing advanced non-destructive evaluation techniques and performance monitoring techniques to determine the adequacy of system designs. Systems must demonstrate compatibility of initiation, combustion, energy conversion to mechanical or chemical work, and the actual accomplishment of the desired mechanical/chemical function. Studies will be directed toward validation of againg techniques and actual demonstration of highly stable pyrotechnic and explosive materials, subjected to heat sterilization cycling and long-term, deep space conditions. The effects of ignition and combustion of pyrotechnic materials will be studied, utilizing advanced performance monitoring systems, producing information on ignition, burn rate, pressure, and energy delivered in simulated flight requirements. New pyrotechnic propellants will be studied that exhibit improved resistance to electrostatic and stray voltages, as well as providing low burn rates to more effectively tailor pyrotechnics to the required mechanical/chemical functions.

W75-70321 **506-21-32**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
ADVANCED SOLID PROPULSION AND PYROTECHNIC CONCEPTS
P. J. Meeks 213-354-2546
(506-21-52)

The long-range objective is to develop and demonstrate solid rocket propulsion and pyrotechnic advanced technology that can be applied to: (1) reduce cost, improve performance, and improve reliability of existing concepts, or (2) provide new concepts for future NASA missions, in which existing propulsion and pyrotechnic mechanisms cannot be used to satisfy the mission peculiar requirements. A comprehensive approach, which employs analytical and experimental investigations, in both in-house and subcontracted modes, will be utilized to select, develop, and demonstrate the required advanced technology. Work will also be accomplished to provide solutions to solid rocket motor operational and design problems. This plan is the major component of the OAST Level IV program on 'Low Cost Solid Propulsion.' The objectives of the various efforts that are included in this RTOP are: (1) to develop new polymers with ideal characteristics for use in solid propellants, (2) obtain a fundamental understanding of the mechanical behavior of solid propellants, (3) study processes to dispose of large quantities of waste solid propellant and recover the principal ingredients in an economic and ecologically

acceptable manner, (4) establish the principles for the scientific formulating of the binders of composite modified double base propellants, (5) eliminate the performance losses of composite aluminized propellants operating near 100 psia chamber pressures, (6) improve the stability of composite propellants under heat sterilization cycling conditions.

W75-70322 **506-21-40**
Lewis Research Center, Cleveland, Ohio.
LASER PROPULSION TECHNOLOGY
D. L. Nored 216-433-6948
(506-25-51)

The objective is to evaluate the concepts and establish the feasibility of laser propulsion by 1978. The program will investigate propulsion concepts and systems based upon the energy being transmitted by a laser beam from a remote station. Space, aircraft and earth-based laser systems for potential NASA and military application will be included. A broad technology base will be developed for realistic appraisal of systems, mission application and design. Efforts will concentrate on most appropriate laser systems, beam transmission, low-beam receiver systems, efficient conversion of laser beam energy to sensible propellant enthalpy, and viable thruster design. The program approach includes: (1) identification of laser energy absorption mechanisms in propellants; (2) performance of components and system studies (synthesis, definition, design, tradeoffs, and problem area identification); (3) evaluation of potential mission possibilities; and (4) design, fabrication and evaluation of laser thruster concepts.

W75-70323 **506-21-41**
Lewis Research Center, Cleveland, Ohio.
ATOMIC AND METALLIC HYDROGEN AND ACTIVATED SPECIES
Gerald V. Brown 216-433-4000

The objectives are to produce and store hydrogen in each of two different monatomic forms, metallic hydrogen and spin-aligned atomic hydrogen. Either form would store an energy of approximately 50 K cal/gram with respect to the molecular state. Such stored energy would be recoverable by allowing reversion to the molecular state. Other objectives include investigation of superconductivity of metallic hydrogen, to determine other properties of both new allotropes, and to study high energy electronically excited species. Targets for 1975 are to determine if spin-aligned monatomic hydrogen can be stabilized by strong magnetic fields (10 tesla). Targets for 1976 are to determine if metallic hydrogen, produced by megabar pressure, is metasale at normal pressure.

W75-70324 **506-21-42**
Langley Research Center, Langley Station, Va.
PROPAGATION STUDIES USING EXTENDED WAVELENGTH RANGE OF HIGH ENERGY LASERS
E. S. Love 804-827-1893
(759-11-12; 506-25-04)

The objective is to improve atmospheric transmission of high energy lasers, primarily by extending the wavelength range of electrically excited CO lasers below approximately 5.2 micrometers where transmission can be better than that of CO2 lasers operating in the range of 10.6 micrometers. Lasers operating with DF (approximately 3.8 micrometers) and HF (approximately 2.8 micrometers) will be studied at a later date when electric excitation techniques are better developed so as to permit closed cycle operation required for most laser propulsion and energy transfer missions. The study will begin by extending the wavelength range of low energy/pressure CO lasers and verification by laboratory transmission studies. Later, high energy laser energy will be obtained by pulsed operation at high pressure greater than 1 atmosphere, using photopreionization to obtain wider wavelength range, stability and single mode output; the added benefit is obtained of providing improved transmission through continuous wavelength tuning across pressure broadened laser lines. The length of the high energy/pressure pulse can be varied for future evaluation of long (quasi-steady) and short pulse effects on transmission and laser propulsion (performed in cooperation with other NASA centers).

W75-70325 **506-21-43**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
NEW HORIZONS IN PROPULSION
P. J. Meeks 213-354-2546

The objective is to identify and conduct research on new concepts in propulsion which offer significant improvements over systems that now exist or are in development when these new concepts are applied to a variety of future propulsion requirements. The approach is to define the concepts in sufficient detail to allow initial applications analyses and then to evaluate the applications. These concepts are compared with current systems and with each other. Experimental and theoretical investigations are then conducted as required for verification of these concepts which are promising. Concepts include the investigation of the anihilation cross sections of matter-antimatter with applied fields, the definition of pointing accuracy and collector cooling requirements for beamed laser power, the potential application of nuclear fusion in space, and the evaluation of propulsion utilizing planetary atmospheres.

W75-70326 **506-21-44**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
GENERATION AND STORAGE OF ACTIVATED SPECIES
P. J. Meeks 213-354-2506

The main objective is to perform experimental and theoretical investigations of methods of producing and increasing the lifetime of excited states of helium and other atomic and molecular species in both the superfluid and solid phases of helium. A second objective is to perform experimental and theoretical investigations of producing and stabilizing solid materials containing very high concentrations of hydrogen/deuterium, and also producing and stabilizing solids which have undergone electronic collapse.

W75-70327 **506-21-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
SPACECRAFT LIQUID PROPULSION RESEARCH
Paul J. Meeks 213-354-2546
(506-21-21)

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 component/structure. The mixing effectiveness of liquid/liquid and gas/liquid propellant injection systems are being evaluated experimentally and the mechanisms that control mixing are being correlated with injector dimensions and operation 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 to bound the relevance of non-reactive data and predictions of analytical/computer models. The origin of solids deposited on low temperature surface is sought. Computer programs for the detailed analysis of liquid rocket performance are being developed and evaluated. A combustion model (Distributed Energy Release) in conjunction with 2-dimensional non-linear combustion instability models (COMB and TRDL) is being used to predict performance and stability margins. Densities and pressure within the exhaust plume (single component gas) of a small rocket nozzle have been experimentally determined in previous FY. These data are being compared with predictions from a computer model developed in FY-74. This model now is being extended to the case of multi component rocket exhaust gases.

W75-70328 **506-21-52**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
SOLID PROPELLANT RESEARCH
Paul J. Meeks 213-354-2546
(506-21-32)

The objective is to establish scientific bases for the chemical formulation, ballistic design, and mechanical design of solid propellants for rocket motors. Theoretical and experimental investigations will be performed in solid propellant chemistry and combustion to: (1) obtain a better understanding of propellant mechanical, processing, and ballistic property character-

istics to permit the formulation of techniques for the control thereof, and (2) derive information on the combustion of propellants to enable one to make a realistic prediction of combustion instability in new motor designs and an assessment of instability in existing motors.

W75-70329 **506-21-53**
Lewis Research Center, Cleveland, Ohio.
CHEMICAL PROPULSION RESEARCH
D. A. Petrash 216-433-6860

The objectives of this work are to expand the basic understanding of injection, mixing, combustion, and other chemical physical processes in chemical propulsion systems in order to provide higher performing, more reliable, and lower cost systems for future missions. These objectives will be attained through, (1) theoretical studies to delineate the important design parameters required to achieve engineering improvements, (2) experimental studies to demonstrate the validity of specific theoretical approaches and design parameters, and (3) 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 (3) thermodynamic, transport and kinetic data, (4) instrumentation, and (5) mission and system analysis.

W75-70330 **506-21-54**
Lewis Research Center, Cleveland, Ohio.
SAFETY RESEARCH
Paul M. Ordin 216-433-6941

The objectives are to obtain a better understanding of the hazards and improve the safety of NASA and contractor operations associated with oxidizer and fuel systems and related propellants for flight, research and development facilities and ground service equipment. Specific areas of current interest include: (1) preparation of standards/criteria for the design and operation of propellant systems, (2) investigations of the initiation of system failures induced by propellant properties including the effects of contaminants, (3) investigations of combustion and non-ideal explosions caused by propellant spills and tank ruptures, and (4) analysis and tests of gravity effects on fire extinguishment systems and studies of flow dynamics of multi-phase cryogenic propellants under transient conditions.

W75-70331 **506-21-56**
Lyndon B. Johnson Space Center, Houston, Tex.
ADVANCED PROPULSION TECHNOLOGY
R. C. Kahl 713-483-4671

JANNAF Performance Evaluation Methodology and computer programs will be improved by new technology developed as appropriate to allow for the experimental measurement, analytical prediction, correlation, extrapolation, and flight configuration of the performance of liquid/liquid, gas/liquid, gas/gas, solid, and hybrid rocket engines. The developed technology will define the nature and magnitude of the performance losses associated with each kind of rocket engine system and provide or improve models which describe the major physical processes.

W75-70332 **506-21-63**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
BASIC CHEMICAL REACTIONS BETWEEN ROCKET EXHAUST AND STRATOSPHERIC CONSTITUENTS
P. J. Meeks 213-354-2546
(502-21-64)

In both an experimental and theoretical approach, the experiments will include laboratory measurements of reaction mechanisms and rate constants utilizing photochemical techniques. Also, the techniques of Auger spectroscopy, photoelectron spectroscopy, electron diffraction and mass spectroscopy will be utilized in determining the nature of the HCl adsorbed on the Al2O3 surface. The theoretical calculations will be based on an electrostatic theory of absorption developed by King and Benson. Calculations will also be performed to determine residence times of Al2O3 particulates in the stratosphere.

W75-70333 **506-21-64**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
SHUTTLE SOLID ROCKET BOOSTER EXHAUST ENVIRONMENTAL EFFECTS
P. J. Meeks 213-354-2546
(506-21-63)

The assessment activities of the environmental impact of the space shuttle require characterization of the rocket exhaust with emphasis on different substances and small concentrations that were of interest in prior studies directed toward performance assessment and improvements. Aluminum oxide particles generated during the combustion of aluminized propellant in the proposed space shuttle booster rockets can participate significantly in the environmental cycle of the exhaust products. The following possible roles for Al2O3 have been indicated: (1) solar radiation scatterer, (2) water condensation nucleating center, and (3) gas reaction catalyst. The last function, because of its participation in the HCl-O3 and NOx-O3 cycles, is of paramount importance. The work proposed is directed toward an extensive characterization of the Al2O3 particulates; namely, size distribution, surface characteristics, elemental and chemical composition. An added objective is the collection of significant amounts of materials to be made available to environmental researchers in the scientific community.

W75-70334 **506-21-65**
Ames Research Center, Moffett Field, Calif.
ATMOSPHERIC EFFECTS OF SOLID ROCKET CONSTITUENTS
D. R. Chapman 415-965-5065
(176-61-11)

The objectives are to determine the effects of solid rocket exhausts on the stratosphere. The specific goals are: (1) to extend current and future stratospheric models in order to assess the effects on the stratosphere of chlorine and nitrogen compounds and alumina particles exhausted by solid rockets, (2) extend stratospheric measurements to include those needed for input and validation of shuttle impact assessment models; (this includes the development of needed instruments), and (3) measure important reaction rates. One- and two-dimensional stratospheric models now under development at Ames Research Center are being extended to include chlorine and alumina chemistry; the one-dimensional model has already been extended to include chlorine chemistry and preliminary impact assessment studies have been made. Airborne measurement missions are being implemental to study the HCL, Al2O3 and NOx exhausted by large solid rockets at the Western Test Range; the development of the additional instruments needed for these missions has been initiated. Background stratospheric measurement programs will be extended to include the additional species that are important to solid rocket impact assessment. Laboratory scale measurements are being implemented to measure homogeneous and heterogeneous reactions between chlorine, alumina and natural stratospheric constituents.

W75-70335 **506-21-68**
Langley Research Center, Langley Station, Va.
ROCKET EXHAUST PLUME COMPOSITION AND ATMOSPHERIC INTERACTIONS GROUND LEVEL TO STRATOSPHERE
E. S. Love 804-827-2893

Work will be continued on the determination of the rate constants for the seven most important stratospheric chemical reactions based on the presently defined reaction scheme, AEP meeting, 1/21-23/74. These measurements at pressures and temperatures comparable to the stratosphere are needed by ARC for modeling the chemistry of inorganic chlorine compounds in the stratosphere. Calculations will continue to determine the oxides of nitrogen produced by the shuttle in the stratosphere. The solid motor combustion chemistry, two phase nozzle flow and the entire two phase, nonequilibrium plume flow field will be modeled using existing codes to bound the chemical and physical behavior of the rocket motor plume.

W75-70336 **506-22-10**
Goddard Space Flight Center, Greenbelt, Md.

AUXILIARY ELECTRIC PROPULSION SYSTEMS
R. A. Callens 301-982-4205

Unmanned meteorological, communication, earth observation and other application satellites require, not only long-lived, lightweight spacecraft propulsion systems, but also ones capable of providing north-south stationkeeping, precession control, east-west stationkeeping, or precise attitude control. The objective of this RTOP is to identify and develop the spacecraft 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. Spacecraft propulsion is required on virtually all application satellites for a variety of specialized functions. For example, the Applications Technology Satellite (ATS)-F, a geosynchronous spacecraft, requires a high specific impulse thruster for north-south stationkeeping. Work on a cesium bombardment ion engine, with a 2500-second specific impulse, is underway to satisfy this requirement.

W75-70337 **506-22-11**
Lewis Research Center, Cleveland, Ohio.
AUXILIARY PROPULSION ION THRUSTER TECHNOLOGY
R. C. Finke 216-433-4000

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 evaluating thruster performance. Testing of components (thruster, PCU,) as a system to optimize component performance and cyclic life testing as part of the system to verify durability will be done. The technology developed will result in hardware for flight prototype thruster subsystems of demonstrated efficiency and durability, thus assuring a firm base of technology-ready hardware for application to anticipated auxiliary electric propulsion controlled spacecraft. The major program in this area is to develop this qualified vectorable mercury electron bombardment thruster for low-powered, long-life missions (north-south stationkeeping and attitude control of 5- to 10-year geosynchronous satellites.) Endurance tests of thruster systems will be performed in a cyclic mode, duplicating the mission profile. Qualified, low-power-consumption vectoring systems will be demonstrated.

W75-70338 **506-22-12**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
PULSED PLASMA THRUSTER SYSTEM TECHNOLOGY DEVELOPMENT
A. Briglio, Jr. 213-354-6137

The objective is to demonstrate the availability of the technology of millipound-level pulsed plasma thrusters suitable for high-energy, high-total-impulses missions, such as north-south stationkeeping of long-lived satellites, and where scientific requirements impose very tight stabilization and pointing control or orbit control. Such devices could provide overall system advantages for many planetary and geosynchronous missions, particularly for spinning spacecraft, if the system mass and total efficiency could be made competitive with such devices as ion engines and colloid thrusters. Key to this is the development of reliable large, high-energy-density capacitors. Significant progress has been made to date in this area, with the life testing of mylar capacitors developed for LES-9 at three times their rated energy density, and the initiation of a life test, under USAF sponsorship, of a K-film capacitor meeting the 40-joule/lb objective. However, there continues to be a problem in obtaining reliable and reproducible capacitor characteristics. Major objectives during FY-75 are (1) to complete an evaluation of three capacitor types fabricated under rigid quality assurance procedures, to establish the relative merits of mylar and K-film capacitors divorced from extraneous influences of workmanship and fabrication techniques; and (2) to survey possible NASA and commercial applications and perform systems analysis on identified candidate spacecraft to determine the application potential of millipound-level pulsed plasma systems. The long-range objective of the joint NASA/USAF program is to qualify a high-energy pulsed plasma thruster for flight application by the end of FY-77. In FY-75, NASA support is required for the activities described above. After FY-75, it is expected that all effort will be carried out by the USAF.

W75-70339 **506-22-20**
Lewis Research Center, Cleveland, Ohio.
PRIME PROPULSION ION THRUSTER TECHNOLOGY
R. C. Finke 216-433-4000

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 evaluating thruster system performance. Testing of components (thruster, PPU,) as a system to optimize component performance and life testing as part of the system to verify durability will be done. The technology developed will result in hardware for flight prototype thruster subsystems of demonstrated efficiency and durability, thus assuring a firm base of technology-ready hardware for application to anticipated electric propulsion spacecraft. The major program will develop qualified mercury electron bombardment thruster systems for high efficiency applications; for instance, synchronous satellite raising missions and 0.3 to 3 a.u. interplanetary missions. 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. Effect of power conditioner on thruster performance and dynamics will be studied.

W75-70340 **506-22-33**
Marshall Space Flight Center, Huntsville, Ala.
SEPS ENVIRONMENTAL IMPACT
J. B. Stephens 205-453-2114
(180-17-56; 502-24-17)

The parametric qualities associated with terrestrial perturbations in the lower stratosphere and the troposphere from the release of mercury will be investigated. The study contract for RTOP 502-24-17 on the Environment Impact of Solar Electric Propulsion revealed that a detailed analysis of the effects of a mercury release from a failure mode in these regions of the atmosphere required additional definitive investigation to establish reaction rates and diffusion parameters. This work will address two separate problems: (1) the reactions and rates of mercury with ozone to determine the long-term effects of mercury on the ozone layer in the lower stratosphere; and (2) the development of mathematical methods to account for the deposition and diffusion of mercury in the troposphere.

W75-70341 **506-22-40**
Lewis Research Center, Cleveland, Ohio.
ION THRUSTER RESEARCH
R. C. Finke 216-433-4000

The broad objective 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, (2) interacting with the spacecraft or its intended mission, and (3) resulting from thruster/power conditioner/control system interactions. 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, theoretical and experi-

mental thruster diagnostics and operation of various sized thrusters using xenon as a propellant.

W75-70342 **506-23-12**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
PLANETARY SOLAR POWER RESEARCH AND TECHNOLOGY
A. Briglio, Jr. 213-354-6137
(506-22-32)

A listing of the JPL FY-75 program for planetary solar arrays and solar cell research and technology is given. The relationship between the JPL program and the specific NASA target or objective is provided after each program listing. (1) Continue the 110-W/Kg Solar Array Development Program (Ref: NASA Target-50 W/Lb Technology Ready by FY-77). (2) Continue the development of .01-cm-thick, high-efficiency solar cell (Ref: NASA Target-Pilot Production of 4-mil cells by FY-76). (3) Continue the development of silicon ribbon technology for solar cells (Ref: NASA Target-Ribbon Solar Cells by FY-76). (4) Continue the development of low-cost solar array technology (Ref: NASA Target-Low Cost $40/W Technology by FY-78). (5) Continue the program to test and evaluate solar cells for deep space applications (Ref: NASA Target-Qualify Violet Cells by FY-74). (6) Develop space solar cell standards for evaluating new solar cell designs (Ref: NASA Target-Develop New Standards by FY-75). (7) Continue the silicon research program (this effect is directed to advancing materials and device technology for purposes of increasing radiation resistance and efficiency and to improve cell design; each of these factors is related to the NASA Objectives of array cost reduction and power density improvement). (8) Continue the inversion layer solar cell program (the comments after Item 7 above apply here also). This work will be accomplished through combined in-house and contracted efforts with industry and universities. The needs of solar electric propulsion will receive special consideration.

W75-70343 **506-23-15**
Goddard Space Flight Center, Greenbelt, Md.
HIGH EFFICIENCY SOLAR CELL DEVELOPMENT AND EVALUATION
L. W. Slifer

Objectives are: (1) development of high efficiency solar cells into production line item; and (2) evaluation of production line cells for space flight use. These will be approached as follows: (1) evaluate pilot line samples of high efficiency cells; (2) transfer technology to production line; (3) evaluate production progress samples; (4) flight qualify production cells; (5) develop large area production cells; (6) develop thin production cells; (7) perform yield and cost analysis; (8) develop detailed production procedures; (9) develop quality assurance requirements; and (10) develop high efficiency solar cell specification.

W75-70344 **506-23-17**
Lewis Research Center, Cleveland, Ohio.
SOLAR CELL TECHNOLOGY
D. T. Bernatowicz 216-433-4000

In order to reduce cost and improve performance of solar cells and arrays for space applications, research and technology programs will be continued toward the following targets: (1) develop silicon solar cell with efficiency of 14 per cent (AMO) and same cost as conventional cell by end of FY-75 by integrating known technology advances in individual process steps; (2) develop an 18 per cent solar cell by FY-78 through basic research to uncover, understand, and reduce the source of losses in highly-doped cells; and (3) produce solar cell arrays at $90/watt (30 per cent of present $300/watt) by FY-79 through development of low cost single crystal silicon ribbon, automated cell fabrication and automated FEP-array production.

W75-70345 **506-23-22**
Goddard Space Flight Center, Greenbelt, Md.
BATTERY QUALITY CONTROL AND TESTS
T. J. Hennigan 301-982-5547

Objectives are: (1) to advance battery material development; (2) to increase the usable energy density of nickel-cadmium cells; (3) to improve cell and cell component characterization methods and cell fabrication process control; (4) to develop analytical methods for cell component analysis; and (5) maintain a NASA test facility to perform battery life tests and investigate methods of accelerated testing.

W75-70346 **506-23-23**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
ELECTROCHEMICAL ENERGY CONVERSION AND STORAGE
A. Briglio, Jr. 213-354-6137

The battery technology to support future planetary missions and terrestrial applications is provided. The objectives, in accord with the NASA Program Objectives, are to attain longlife (10-year), high-energy-density, and highly reliable electrochemical energy storage devices by advancing the technology of its components, operating and storage techniques, and test and evaluation procedures. Additional requirements, such as high-rate discharge and cost reduction are also addressed. A more thorough understanding of battery failure modes will be obtained, and means for eliminating these failure sources in order to permit highly reliable battery operation will be investigated. This is to be accomplished through a continuing research effort, the major activity of which is the investigation of pulse charging effects on battery performance. The specific targets of the RTOP include: (1) achieving doubling of life of Ni-Cd batteries by means of non-gassing construction and improved fabrication techniques; (2) determining the effects of zero gravity on high power outputs of Ni-Cd, Ag-Zn, Ni-H2 and other candidate systems using test vehicles such as Astrobee and the shuttle; and (3) screening and evaluating candidate electrochemical systems for selected probe applications requiring high-rate (up to 15C) performance with a life of up to five years, by the end of FY-1977. The immediate objectives of the research effort are: (1) to determine the effects of pulse charging on degradative changes in alkaline cells, and (2) to establish a better theoretical understanding of the relationship between pulsed current parameters and electrode polarization.

W75-70347 **506-23-24**
Lewis Research Center, Cleveland, Ohio.
ELECTROCHEMICAL DEVICES
Harvey J. Schwartz 216-433-6910

The object is to attain long-life, high energy densities and high reliability for electrochemical energy storage devices. In order to meet this objective, work will be performed to develop silver-zinc batteries with 4-5 times the energy density of nickel-cadmium batteries for five years life in synchronous orbit and planetary applications by FY 1977. A longer lived (10 year) higher energy silver-hydrogen synchronous orbit battery will be developed by FY 1979. A high energy potassium-sulfur cell using a glass fiber electrolyte will be demonstrated by FY 1978. Solid electrolytes suitable for operation in alkali metal batteries of the 100-150 WH/lb class will be identified by FY-76. Testing of a prototype cell for a 20 lb/KW, 10,000 hour life H2-02 fuel cell system will be completed by FY-77.

W75-70348 **506-23-34**
Marshall Space Flight Center, Huntsville, Ala.
MULTI-KW DC DISTRIBUTION SYSTEM TECHNOLOGY
J. L. Felch 205-453-4631
(113-60-21; 502-25-73)

As part of the NASA space vehicle technology development program, TRW Systems performed a comprehensive 'Space Vehicle Electrical Power Processing, Distribution and Control Study' under Contract NAS8-26270 for the Marshall Space Flight Center. This study, which was completed in late 1972, disclosed that significant reductions in weight, greater design flexibility, reliability, and lower cost can be realized for large future aerospace vehicles through use of higher dc distribution and transmission voltage (above 100 Vdc) when compared to conventional 28 Vdc or 115 Vac systems. It also showed that maximum benefit can be obtained when high voltage dc distribution is coupled with use of remotely controlled solid state switchgear and multiplexed computer controlled supervision and checkout of the electrical system. The approach which has been selected for providing technology-readiness consists of the design of a flexible

technology breadboard test facility to be installed at MSFC for test and demonstration of complete multi-kw power distribution systems using voltages up to 300 Vdc.

W75-70349 **506-23-30**
Lewis Research Center, Cleveland, Ohio.
ADVANCED LOW COST POWER PROCESSING AND DISTRIBUTION TECHNOLOGY
P. A. Thollot 216-433-4000
(506-23-31)

The objectives are to advance the state-of-the-art and establish the technology required to improve aerospace power processing and distribution systems. Terrestrial applications will also be considered in the establishment of this technology. Addressed are, improvements in electrical circuit performance, and the general optimization of power processing and distribution systems including utilization of integral solar array power requlation and conditioning. In addition to general technology, this program has as an objective directed technology for specific applications. Included in this category are: (1) power processing concepts with efficiencies in excess of 90 per cent and power densities of about 2.5 Kg/Kw for ion thrusters, and (2) single and multi-module power conditioning units meeting low cost, reusable space station/base and shuttle requirements. Also included is an effort directed toward developing engineering tools, using modeling and analysis techniques, which will enable designers to rapidly and accurately assess total system interaction and trade-off effects. Contract and in-house studies will be implemented to perform experimental investigations, and hardware fabrication as required to establish the technology of new circuits and power processing and distribution systems.

W75-70350 **506-23-31**
Lewis Research Center, Cleveland, Ohio.
HIGH PERFORMANCE POWER ELECTRONIC COMPONENTS
P. A. Thollot 216-433-4000
(506-23-30)

The objectives are to advance the state-of-the-art and establish the technology required to improve electronic power components and subsystems and to investigate interactions between the electrical systems and the environment of spacecraft. This includes the development of improved electronic power components as required for use in low weight, high efficiency power processors and distribution systems. It also includes the interaction effect of high voltage and construction materials with the space environment, including plasma, solar illumination, low temperature, and vacuum. These components are for use in space station-base and shuttle flight programs, 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 and to investigate the electrical space environmental interactions of materials used in spacecraft construction.

W75-70351 **506-23-32**
Goddard Space Flight Center, Greenbelt, Md.
POWER PROCESSING FOR EARTH ORBITAL SPACE SCIENCE AND APPLICATIONS SATELLITES
Edward R. Pasciutti 301-982-4885

Objectives are power conditioning investigative techniques and developments to improve power conversion efficiencies, reliability, performance, and develop commonality circuitry in hybrid form. Specific aims are: (1) to investigate input/output transient problem areas and solutions; (2) to establish library of computer design programs for design and analysis of power conditioning systems and subsystems; and (3) to effect improved efficiency, utilization and lower cost through standardization. Means to improve encapsulation techniques for high voltage assemblies, diffusion of gases through solids in a vacuum environment, and development of a high voltage shunt regulator circuitry in hybrid from will also be studied.

W75-70352 **506-23-37**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
LONG-LIFE, HIGH-PERFORMANCE POWER PROCESSING FOR PLANETARY APPLICATIONS
A. Briglio, Jr. 213-354-6137

The major objective is to develop and demonstrate advanced power processing and distribution and related system configuration and integration technology to meet the requirements of future planetary spacecraft. These requirements, as identified in NASA's 'Objectives' documentation, include longer life, higher performance, higher reliability and lighter weight than can be achieved with existing technology. The intent of this work is to develop designs that not only can meet the technical requirements but which can also be built and incorporated into the spacecraft power system for minimum cost. In developing the necessary capability, techniques and hardware it is required that the specialized requirements of both solar and sun-independent power sources be accommodated. Also, a significant capability for automated power systems operation is a likely requirement for many future planetary spacecraft. The basic approach being taken is to develop modular or 'building block' designs of the major power processing elements within the spacecraft power system. These designs are standardized to the maximum extent possible and feature active rather than standby redundancy. This minimizes the total number of separate modules required in the system and, hence, the cost to build and test it. High performance circuits are used throughout and the basic approach offers a large degree of flexibility for scaling the system to different input voltages and power levels, thus, providing capability for multiple applications. Additionally, standardized design and analysis methods are being developed and applied for all power processing circuits used in planetary spacecraft power system. Finally, test methodology and equipment for multi-redundant power systems are being developed, and initial investigations into providing automated power system management are being conducted.

W75-70353 **506-23-40**
Lewis Research Center, Cleveland, Ohio.
THERMO-MECHANICAL ENERGY CONVERSION
C. S. Corcoran 216-433-8346
(506-16-21)

The objective is to provide a technology base for high-efficiency, long-life thermomechanical space power conversion systems applicable to near-term NASA missions (late 70's). This program will include a demonstration of the Brayton power conversion process in the fractional-to-2 kilowatt power level. NASA missions in the late 70's and early 80's appear to require power levels in the neighborhood of 1 kilowatt. Several of these missions, especially deep space probes, cannot use solar arrays. In addition, certain DOD missions in this time period require compact power systems with long-life and in the range of 1 kilowatt power output. To fulfill these needs especially to provide confidence for mission selection, a proof-of concept Brayton conversion system will be designed, built, and run to demonstrate failure-free and unattended operation for a continuous period of at least two years.

W75-70354 **506-23-41**
Lewis Research Center, Cleveland, Ohio.
HYDROGEN-OXYGEN POWER SYSTEMS
D. L. Nored 216-433-6948

The objectives of this activity are to develop technology readiness for a hydrogen-oxygen APU to provide hydraulic and electric power for the space shuttle vehicle, and to evaluate the performance potential and applicability of hydrogen-oxygen dynamic power systems for other space and ground applications. Detail analysis, design, fabrication and test of a 400 hp test APU supplied with high-pressure liquid or gaseous propellants is being conducted under Contract NAS3-15708 by AiResearch. The primary technology area under investigation involves the system dynamic controls in the propellant feed and conditioning subsystem. This effort includes development of a system computer model to permit ready evaluation of system modifications and parametric changes as required for final application. In-house effort will be used to provide conceptual designs (weight and volume) of H2-O2 supply systems. Evaluation tests of a positive displacement liquid hydrogen pump, which would be required for a low-pressure liquid supply system, are being performed

under contract. Additional pump development and testing of the pump with the complete system may be performed.

W75-70355 **506-23-42**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
THERMOMECHANICAL POWER SYSTEMS FOR PLANETARY APPLICATIONS
A. Briglio, Jr. 213-354-6137
(502-25-90)

The purpose is to determine the applicability and usability of dynamic power systems on outer planet spacecraft. A number of dynamic conversion systems are potential candidates for utilization in outer planet spacecraft. These include the rankine, the Stirling engine, and the Brayton engine. To date only the Brayton engine has had any significant development support by NASA. Therefore, this system has been selected to perform the initial S/C integration studies. The work will be performed under the following tasks: (1) S/C integration and packaging; (2) effects of engine rotation on the attitude control system; (3) the magnitude of the magnetic field; (4) electrical transient behavior and on-pad operations, and (5) reliability and lifetime. The effort will lead to reduced cost for space nuclear power systems, which is an objective of the NASA thermomechanical energy conversion effort. In FY-75 it is planned to complete preliminary integration studies to determine the suitability of thermomechanical energy conversion systems in outer planet spacecraft, in accord with the NASA Target.

W75-70356 **506-23-50**
Lewis Research Center, Cleveland, Ohio.
SOLAR ENERGY SYSTEMS TECHNOLOGY
Robert G. Ragsdale

The objective of this program is to develop and demonstrate the component and systems technology for economical utilization of solar energy to the degree necessary that commercial implementation will begin by 1980. Solar energy represents a nonpolluting, everlasting energy source that is available in sufficient quantities to provide a large part of the nations's energy needs for electricity, for heating and cooling buildings, and for clean fuels. Tests will be carried to evaluate and to improve the operating characteristics of solar energy system components such as solar collectors, energy storage devices, and air conditioning units that can be driven by hot water. These tests will be carried out both under controlled, laboratory conditions, and outdoors in variable weather conditions. Model systems tests will be carried out to study the dynamic behavior of components connected into total systems. Design studies will be conducted to determine ways to reduce system and component costs without reducing performance. Cost/performance trade-off criteria will be established for various applications. This program will provide the technology base necessary to design and carry out major solar energy demonstration programs.

W75-70357 **506-23-51**
Lewis Research Center, Cleveland, Ohio.
LANGLEY BUILDING SOLAR SYSTEM
Robert G. Ragsdale 216-433-6943
(506-23-50)

The objective is to provide a solar test bed to demonstrate the technical and operational characteristics of a solar energy collection system being used to heat and cool an office building. This will be accomplished by designing a solar energy collection and storage system which will provide the energy to heat and to drive the absorption air conditioning system for the new Langley Systems Engineering Building. The solar system will operate in parallel with a conventional HVAC system. The conventional HVAC system will supply energy when the solar energy is not sufficient. The solar energy system, collectors, support structure and energy storage facilities will be designed in-house. The detailed design of the system and all component parts with the exception of the collectors, will be designed in-house for a construction contract. The collectors will be detail designed and procured under separate contract. The building/solar system interfaces will be defined in-house and an architectural engineering firm will design the building.

W75-70358 **506-24-11**
Langley Research Center, Langley Station, Va.
PLASMA-CORE REACTOR RESEARCH
E. S. Love 804-827-2893
(506-25-31)

The objective is to establish the scientific understanding of 235UF6 and 235U plasma-core nuclear reactors and to study their technological usefulness. Emphasis in this basic research is on the physics of fission fragments - gas interactions to understand the mechanisms of nuclear-induced electromagnetic radiation, the transport of this radiation and its conversion to useful forms of energy. In addition, a major effort of research is directed toward fluid mechanical confinement of fissioning gaseous nuclear fuel and for flow and materials studies of UF6 and uranium vapor handling systems. Fluid mechanics, UF6 handling and part of the optical radiation research will be conducted under contract under LaRC direction. Other supplementary radiation research is conducted under the LaRC 506-25-31 RTOP. Nuclear reactor experiments will be conducted at Los Alamos under a separate NASA Headquarters RTOP.

W75-70359 **506-24-13**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
NUCLEAR PUMPED LASERS
T. Vrebalovich 213-354-4530

The primary objective is to develop high pressure, visible and vacuum ultraviolet lasers where the laser pumping is provided by a pulsed nuclear reactor. A secondary objective is to conduct supporting theoretical and experimental research which will lead to an understanding of the kinetic processes responsible for lasing in high pressure plasmas produced by the products of nuclear reactions

W75-70360 **506-24-21**
Lewis Research Center, Cleveland, Ohio.
HIGH-EFFICIENCY, LOW-TEMPERATURE THERMIONIC CONVERSION
J. F. Morris 216-433-4000

The objective is to develop for land, sea, and space applications cesium diodes that produce greater current densities and higher output voltages at lower temperatures than those for established thermionic converters. The approach to high efficiency, low temperature thermionic converters combines development of improved electrodes and reduction of plasma losses. This work will utilize NASA's miniature plane guarded cesium diodes (diminiodes) and a computer system to control, collect, and correlate power-output data. Diminiode smallness allows increased coverage and economy in electrode screening while its simple, adaptable design makes possible modifications to reduce plasma maintenance voltages. Evaluations of best candidates from metals, metallides, and metal, metal-oxide solid solutions will indicate more effective emitters and collectors. Studies to minimize plasma losses will involve tiny distributed shorted diodes and pulsed discharges across the interelectrode gap. Detailed performance mapping for the better converter components will provide design data for scaling up to the thermionic conversion systems. Coordinated contract and grant efforts will also produce higher thermionic conversion efficiencies through improved electrodes and reduced interelectrode losses---

W75-70361 **506-24-22**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
LOW-TEMPERATURE THERMIONIC CONVERTER
R. R. McDonald 213-354-6186
(506-24-31)

The long range objective is to develop a low temperature converter having a conversion efficiency which is more than twice that of high temperature converters. In the high-temperature converters, reradiation heat losses from the high temperature emitter are a significant part of the total input energy required to operate the converter. This reradiation loss can be drastically reduced by lowering the emitter temperature. Resulting reduction of thermionic emission current can be readily compensated by a reduction of emitter work functions (from 3.0 eV to 2.0 eV). However, the smaller emitter work function creates a need for a collector work function as low as 1.0 eV so as not to lose

the output voltage. Thus a development of a low work function collector, which operates at a temperature as high as 800 K, becomes necessary. The short range objective is to fabricate and test a low temperature converter having a metal-oxide emitter and a low work function collector. The collector will be made of a negative electron affinity (NEA) electrode using appropriate semiconductor material, which will be determined from independent measurements of work functions in a work function test vehicle which has been built during FY-74. The goal of the low temperature converter is an efficiency better than 12 percent at an emitter temperature of 1400 K and an ultimate efficiency of better than 25 percent when means for neutralizing space charge are established. Also, a feasibility study of a thermionic power system for solar energy conversion for domestic use will be made on a limited scale during FY-75.

W75-70362 **506-24-31**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
THERMIONIC SYSTEMS TECHNOLOGY
R. R. McDonald 213-354-6186
(506-24-22)

The long-term objective is to achieve high efficiency, low-temperature thermionic power subsystem technology readiness for application to terrestrial and space power. The intermediate objective is to establish the feasibility of low cost design concepts applicable to quantity production of thermionic systems. These objectives are accomplished through system design studies and engineering applications studies, materials studies, well-defined key technology experiments at the component and subsystem levels, and a detailed evaluation of technology from other programs. A typical thermionic power subsystem consists of a heat source, thermionic converters, heat exchanger, pumps, controls, structure, and power processing. A nuclear heat source also requires nuclear shielding and containment. Power systems technology is being studied for such applications as building heating and cooling and process heating, auxiliary (decentralized) powerplants, space power, and mining. Emphasis is placed on achieving low cost, effect in fuel utilization, and maintenance-free operation. This RTOP is coordinated with the research work being conducted under RTOP 502-12-01.

W75-70363 **506-24-23**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
NUCLEAR THERMOELECTRIC SYSTEMS TECHNOLOGY FOR SPACE GENERATION
A. Briglio, Jr. 213-354-6137

Continued exploration of the outer planets will require in many cases the use of improved and advanced isotope power systems. The broad objectives of this RTOP are as follows: (1) evaluate advanced isotope systems technology developments by the AEC for NASA mission use; (2) perform technology investigations leading to improved mission effectiveness of isotope power systems; (3) develop improved methods for integrating isotope power systems with spacecraft; and (4) advance the technology of thermoelectric conversion. This work will be accomplished by analytical studies and experimental research. Planning and execution of work under this RTOP will be coordinated with the AEC and will be complementary to their programs.

W75-70364 **506-25-11**
Lewis Research Center, Cleveland, Ohio.
PLASMADYNAMICS
George R. Seikel 216-433-4000

The objective is to gain the ability to generate, confine, and manipulate plasmas of desirable characteristics in ways relevant to potential advanced power and propulsion applications of importance 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 system concepts that could lead to new NASA applications and missions. Analytical and experimental studies which include extensive diagnostics will be made. Topics to be investigated include: MHD generators for both open and closed cycle electric power systems, and high temperature plasma heating and containment in open and closed magnetic geometries. Investigations will include studies to define potential system performance, critical technology needs, and alternative applications of technology developed.

W75-70365 **506-25-21**
Lewis Research Center, Cleveland, Ohio.
MAGNETICS AND CRYOPHYSICS
Gerald V. Brown 216-433-4000

Objectives are: (1) to develop compact, lightweight magnets for propulsion and power applications; (2) to devise methods of producing higher fields; (3) to improve superconductors and to apply them in magnets; (4) to devise improved auxiliary systems (refrigerators) for magnets; and (5) to measure effects on high magnetic fields on materials. Targets include: FY-75 - demonstrate twisted, multifilament Nb3Sn ribbon superconductor in small coils; demonstrate principle of magnetic cooling by operating a 1-watt refrigerator between 4K and 20K. FY-76 - produce long lengths of twisted, multifilament Nb3Sn by a production line process; analyze room temperature potential of magnetic cooling; demonstrate small magnetic heat pump. FY-77 - demonstrate twisted, multifilament Nb3Sn superconductor in large coils. FY-78 - complete and test 30 tesla cryogenic magnets. To advance magnet technology, new structural and cooling ideas will be applied in new magnets designed for research to 30 teslas and for MHD generators. Improved superconducting materials and components will be developed and applied to make magnets more compact and reliable. Magnetic cooling cycles will be analyzed and devices constructed to try to raise the efficiency of refrigeration for superconducting systems. Existing and newly developed magnets will be used to determine effects of high fields on materials. University grants will support the superconductivity and magnetic cooling efforts.

W75-70366 **506-25-31**
Lewis Research Center, Cleveland, Ohio.
FUNDAMENTAL PHOTONICS
J. W. Blue 216-433-4000

The objectives are to utilize the newly completed cyclotron at LeRC and other sources of ionizing radiation to produce atoms and molecules at high levels of excitation. High energy photons are emitted in the subsequent de-excitation process, and an object of the work is to investigate the use of these photons in laser systems and other applications where energetic photons are advantageous. Fissioning uranium is one method of producing high power levels of excited atoms and molecules. Except for nuclear weapons, most fissioning has been in systems in which the photon energy cannot be utilized directly. The cyclotron is to be used to produce low power levels of uranium fission in which the details of the photonic processes can be determined. The radiation fields connected with fission reactors include beta, gamma, neutrons and fission fragments. These determine the environment in which a window for photons must function. The cyclotron will be used to stimulate this environment and transmission studies will be made of fused silica, alumina. The highly excited atoms and molecules produced by charged particle beams will be studied as to whether or not they can be assembled in a manner to give stimulated emission.

W75-70367 **506-25-31**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
FUNDAMENTAL PHOTONICS
R. R. McDonald 213-354-6186
(506-25-52; 506-25-62)

The objective of the laser kinetics task is to conduct the research required to develop various types of high power, efficient, short wavelength lasers. Emphasis is placed on understanding the basic physical phenomena that determine the efficiency, wavelength, size, and power output of laser devices. The objectives of the nuclear pumped laser task are to develop a laser device where the laser pumping is provided by a pulsed nuclear reactor, and to conduct supporting research which will lead to an understanding of the lasant kinetics in high pressure plasmas produced by the products of nuclear reactors. The principal objective of the electron impact spectroscopy task is to generate reliable cross sections for electron-molecule (atom) collision processes for use in understanding the behavior of high energy

lasers, plasma devices, and the energy degradation of high energy electrons. In the physics of molecular interactions, both basic and applied research programs are being conducted. In the basic research program, ion cyclotron resonance spectroscopy is being used to examine the production of excited ions in plasmas and discharges. The fundamental knowledge thus far obtained has led to a new concept for a flowing afterglow ion laser. Prototype lasers are now under construction in the applied research program. The first objective of the nuclear Zeeman maser task is to study the feasibility of constructing a nuclear Zeeman maser system and to investigate its characteristics. The second objective is to conduct preliminary line narrowing experiments in the solid state nuclear spin system to determine if this technique can be used to narrow the Mossbauer gamma-ray lines to provide adequate amplification for gamma-ray laser action to occur.

W75-70368 **506-25-31**
Langley Research Center, Langley Station, Va.
FUNDAMENTAL PHOTONICS
E. S. Love 804-827-2893

The fundamental characteristics of a fissioning uranium plasma will be investigated to determine the feasibility of direct conversion of nuclear energy into electromagnetic radiation, laser power or work. The thermodynamic properties of uranium hexafluoride will be investigated and the interaction of fission fragments with a uranium hexafluoride gas will be determined. Radiation induced plasmas will be studied to determine possible population inversion, nonequilibrium emission, and ionization and excitation cross sections. The interaction of intense CO2 laser radiation with the dense plasma focus will be investigated, specifically the efficient conversion of laser radiation to X-rays. Photocatalysts will be investigated with the aim of providing direct photodissociation of water by sunlight. The LaRC plasma-focus device will be used to produce a fissioning uranium plasma. Research on fission-fragment plasma interactions and on photo-electrochemical phenomena will be performed under grants to various universities.

W75-70369 **506-25-32**
Ames Research Center, Moffett Field, Calif.
QUANTUM ELECTRONICS
Dean R. Chapman 415-965-5065

The objectives are to conduct experiments and analysis of topics in the physics of quantum electronics that provide basic data on, and understanding of, the interaction of laser radiation with matter in support of a broad image of NASA applications in propulsion, power, lasers and space, and atmospheric physics. The specific approach will include an investigation of the following areas: The interaction of high intensity radiation with solids and plasmas, leading to linear absorption phenomena as well as to nonlinear effects, such as self focusing, will be examined by irradiation with Nd:glass or ruby lasers. Experiments will be performed to obtain inversion on ultraviolet, soft X-ray, and even X-ray transitions pumped by such high intensity sources. Special attention will be given to resonance charge exchange between highly striped ions in a laser produced plasma and ambient, neutral gas. Theoretical and experimental work will be directed toward ascertaining the relevant cross sections. A comprehensive study of a potential new CW ion-electron combination class of lasers, which will lase in the near IR and visible, will be followed by experimental verification. An examination of laser techniques for the separation of isomeric nuclei, so important to the development of a gamma-ray laser, will be made. Finally, the use of resonance two-photon pumping, to achieve lasers in the UV and SXR region, will be examined.

W75-70370 **506-25-51**
Lewis Research Center, Cleveland, Ohio.
HIGH-POWER LASER SYSTEMS TECHNOLOGY
D. L. Nored 216-433-6948
(506-21-40; 506-17-11; 506-16-21)

The objective is to evaluate by 1979 the potential of high-power lasers for NASA applications. This program will define and investigate high-power laser systems and their potential use. Both space and ground-based systems for potential NASA, commercial, and/or military applications will be included. A broad technology base will be provided, as necessary, for realistic appraisal of systems and applications, and for future design, development, and use of such systems. Efforts will concentrate on evaluation and technology investigations of flowing gas laser devices suitable for future high-power laser transmitter systems, efficient power generation systems for such devices, conversion systems for high-power laser energy receivers, optical components unique to large high-power lasers, and on (1) screening and definition of applications and in-depth evaluation of their requirements (a continuing effort); (2) performance of components and system studies (synthesis, definition, design, tradeoffs, and problem-area identification); (3) experimental investigation of component and subsystem technology needed within critical areas; (4) design and operation of high-power lasers to assist in the component technology investigation program; (5) design, fabrication and ground testing of large high-power laser transmitter systems for demonstration purposes, for evaluation of system-type problems, and for applications; and (6) design, fabrication, and operation of systems and experiments applicable to potential applications.

W75-70371 **506-25-52**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
HIGH ENERGY LASER TECHNOLOGY
R. R. McDonald 213-354-6186
(506-25-62)

The objective is to develop the necessary technology required to construct various types of high power, efficient, short wavelength lasers. Emphasis is placed on the development of scaling laws that govern the efficiency, size, and power output of specific laser devices.

W75-70372 **506-25-55**
Langley Research Center, Langley Station, Va.
HIGH RESOLUTION LASER ATMOSPHERIC TRANSMISSION RESEARCH
E. S. Love 804-827-2893
(506-21-42)

The objective is to perform high resolution atmospheric transmission spectroscopy with continuously tunable diode lasers radiating in the wavelength range of high energy lasers operating with CO, DF, and HF having potentially better transmission than CO2 lasers. High spectral resolution studies are necessary for optimizing transmission of CO and HF lasers radiating through microwindows at the edges of H2O vapor absorption bands, and for improving DF laser transmission through H2O, CO2, N2O, and other atmospheric gases. Tunable diode lasers will also be applied to high energy/pressure CO and CO2 lasers for study of pressure broadening of laser lines and amplification of low energy tunable laser radiation to high energy radiation of narrow line width and high stability. Laboratory and field transmission studies will be performed under a variety of conditions (humidity, turbulence, altitude, beam direction) and the results compared with theoretical computer studies, strengthened by inputs from high spectra resolution data. Laboratory transmission studies will be performed with chemical DF and HF laser having high frequency stability. Other studies performed under a university grant, are concerned with novel techniques for operating chemical lasers in the visible and near infrared spectral range, with the advantage of reduced laser beam divergence; also investigated will be the influence of O3 relaxation effects on non-linear transmission of high energy CO2 lasers.

W75-70373 **506-25-61**
Ames Research Center, Moffett Field, Calif.
HIGH-POWER LASERS
Dean R. Chapman 415-965-5065

The objectives are to conduct experiments and analysis of topics in the physics of quantum electronics that relate to the development of lasers and ancillary devices suitable for NASA missions and applications in solar physics, space physics, atmospheric physics and space flight technology. This work should provide the necessary research and technology base needed to evaluate the potential of the laser for these needs. The specific approach will include an investigation of the following areas: Firstly, the development of an efficient, supersonically cooled,

electric discharge carbon monoxide (COEDS) laser will be pursued. Secondly, an arc-heated GDL facility will serve as a versatile test bed to examine CW lasing at higher pressures and temperatures than previously attainable by others. Various lasant mixtures, the effect of contaminants, and supersonic injection of the lasant will also be examined. Thirdly, the study and assessment of potential laser energy converters will be pursued. After detailed examination of the pertinent physics and engineering of such candidate devices, such as metal-barrier-metal optical diodes, laser heated thermionic converters, laser engines, and laser-assisted dissociators, specific devices will be experimentally examined for conversion efficiency and suitability for space usage. Finally, the theoretical analysis and development of computer codes suitable for optimization of existing, and development of new, laser systems will be pursued. Typical of such efforts are the computer code for predicting the output power of a CO2 gas dynamic laser, and a comprehensive theory of vibrational energy transfer in anharmonic diatomic gases.

W75-70374 **506-25-62**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
LASER ENERGY CONVERSION RESEARCH
R. R. McDonald 213-354-6186
(506-25-52)

Work will be carried out to demonstrate the feasibility of efficiently converting laser energy to electrical energy with: (1) a Schottky barrier (SB) photovoltaic converter, and (2) a laser plasma dynamic (LPD) converter. Much emphasis in laser generation development is in the shorter visible and ultraviolet wavelength regions. Consequently, semiconductor materials and barrier formation techniques compatible with such wavelengths must be examined. The materials to be used will be gallium arsenide and ternary III-V compounds for the visible range, and gallium phosphide, zinc selenide, and zinc oxide for the ultraviolet range. The barrier fabrication will be the Schottky barrier technique (thin metal film-semiconductor) because of its demonstrated high collection efficiency at short wavelengths, ease and low cost of fabrication, radiation resistance, and adaptability with most any semiconductor. Multi-layer barrier devices being developed for solar energy conversion will be tested for laser conversion when and if they become available. Experimental evaluation of an existing LPD converter will be performed by irradiating it with a ruby and a Nd-YAG laser. The evaluation is to determine energy conversion capabilities rather than to understand the physics of laser-plasma interactions. These interactions including inverse-Bremsstrahlung absorption of laser energy by a pre-ionized plasma will be further investigated experimentally in a cesium-filled optical cavity. These additional investigations are to provide understanding of LPD converter physics and to open new areas for conversion of laser energy at very high energy densities.

W75-70375 **506-26-10**
Langley Research Center, Langley Station, Va.
ADVANCED EARTH ORBITAL TRANSPORTATION TECHNOLOGY
E. S. Love 804-827-2893

The objective is to identify and develop the aerothermodynamic technology required for the design and operation of advanced earth-orbital vehicle systems suitable for space operations or global transportation in the 1990's and beyond. The intent is to derive viable concepts which build upon the technology base developed under the space shuttle program, and the predicted advances within this decade in materials and structures, as well as potential gains in such areas as propulsion efficiency. Such concepts should offer significant advantages in the areas of performance, heat transfer, and flying qualities. A primary output will be the identification of technology areas requiring focused attention to permit achievement of advanced transportation goals. Programs designed to provide solutions to key technology issues will be designed and implemented using both ground based facilities and flight experiments as may be accomplished through the capabilities offered by the space shuttle. Operational limitations imposed by various constraints such as environmental considerations will be examined. Candidate concepts will be evaluated through a series of trade-off analyses and parallel experimental investigations. Analytical efforts will include the development of methods for vehicle characteristics definition, such as the methodology for flow field calculation, and the means to objectively assess the value of technology improvements. A highly efficient aerospace transportation system is a potential major thrust for the agency and the nation in the 1980's.

W75-70376 **506-26-10**
Ames Research Center, Moffett Field, Calif.
ADVANCED EARTH-ORBITAL TRANSPORTATION TECHNOLOGY
Dean R. Chapman 415-965-5065

The objective is to develop the aerothermodynamic technology required for design of advanced earth-orbital spacecraft for the late 1980s. Analytical and/or semi-empirical techniques will be developed for the prediction of the lee-side flow fields dominated by viscous effects including turbulence. Data will be obtained in the 2.5 foot hypersonic wind tunnel to ascertain the effect of flow parameters (Mach and Reynolds number, and whether or not the windward boundary layer is laminar, transitional or turbulent) and geometric parameters (planform, nose bluntness) on the leeward flow. These data will be used to verify prediction techniques, and successful techniques will be integrated into flow field codes developed for space shuttle windward surface flow field prediction. Aerodynamic data for advanced vehicles, and space tugs will be obtained experimentally in the appropriate Ames facilities.

W75-70377 **506-26-20**
Langley Research Center, Langley Station, Va.
PLANETARY ENTRY TECHNOLOGY
E. S. Love 804-827-2893

The objective is to establish the technology base necessary to assure survival and reliable performance of scientific probes during entry into the atmospheres of Mars, Venus, and the outer planets. The technology readiness target schedule, which assumes a cutoff in technology development three years prior to launch, is 1975 for Venus, 1977 for Saturn and Uranus, and 1981 for Jupiter. This target schedule is the key for the specific task milestones. 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: (1) studies to define hypervelocity earth and other planetary entry vehicle heating and aerodynamic environments and minimize radiative and convective heating and/or heat loads and optimize aerodynamic performance by choice of trajectory and vehicle shapes; and (2) development of aerothermodynamic technology required for upgrading of existing facilities or design of new facilities considered appropriate to development of planetary entry aerothermodynamic technology.

W75-70378 **506-26-21**
Ames Research Center, Moffett Field, Calif.
GAS DYNAMICS RESEARCH
Dean R. Chapman 415-965-5065
(502-27-01)

The objective is to add to the understanding of high energy fluid flow processes and the relations between such flow processes and the basic thermodynamic and transport properties of matter, including kinetic rate processes and radiative transfer in gases. Classical, semiclassical, and quantum theories will be explored to find the most efficient models for these properties in terms of the engineering needs of present and potential long-lead-time NASA mission requirements, particularly in the area of processes induced in the earth's upper atmosphere by high altitude hypersonic aircraft and space shuttle type vehicles, and also in the area of problems experienced by entry probes into the planetary atmospheres, such as those which effect thermal protection and communication. These models will be tested, where possible, with experimental results. Numerical solutions using Monte Carlo statistical modeling of fluid flow will be developed which utilize the large size, speed, and parallel processing features of modern computers to calculate transport properties of gases and other flow properties.

W75-70379 **506-26-22**
Ames Research Center, Moffett Field, Calif.

COMPUTATIONAL AND EXPERIMENTAL AEROTHERMODYNAMICS
Dean R. Chapman 415-965-5065

The objective is to develop the aerothermodynamic technology required to define the flow field around entry vehicles. Emphasis is on the development of turbulence models from numerical and physical experiments. These models will be used in computer codes that numerically simulate the flow fields. Experiments at hypersonic speeds specifically designed to verify these turbulence models and computer codes are to be performed. Additional experiments will be performed, as required, to define the aerothermodynamic environment for particular classes of entry probes such as the effect of moderate to massive ablation rates on transition to turbulent flow on blunt entry probe shapes. The first verification experiment will be that of an axisymmetric shock-wave-expansion interaction with a hypersonic turbulent boundary layer. The computer code planned is the complete solution of the Navier-Stokes equations including various models for the turbulent transport terms.

W75-70380 **506-26-23**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
PLANETARY PROBE DESIGN/OUTER PLANETS
R. R. McDonald 213-354-6186

The objectives of this plan are: (1) to calculate and measure the radiative properties of the shock heated gas found in the outer planet atmospheres to establish a method where the effect of laminar-turbulent transition and base flow on heat transfer to an entry probe can be determine; (2) to develop and provide physically sound methods and schemes for computing the flow field, energy fluxes and vaporization rates for outer planet entry probes; (3) to investigate entry probe aerodynamic stability; and, (4) to develop laboratory shock tube facilities for the purpose of studying heat transfer problems. Since the outer planets have atmospheres consisting mainly of hydrogen and helium, most of the work performed in this plan is applicable to entry to Saturn, Uranus, Jupiter or Neptune. Only the speed of entry differs for the several planets since it is proportional to the mass of the planet. In fulfilling these objectives, we will measure radiative intensity, and the radiation relaxation time behind shock waves moving at planetary entry speeds in outer planet atmospheric gases within the electric-arc shock tubes. To obtain better agreement with data, the theoretical models of the ionization scheme will be further developed. Measurements of convective heat transfer to blunt entry probe models will be made at high Reynolds number in the free-piston shock tube. These measurements of heat transfer at laminar, transition and turbulent boundary layer conditions will be used to further refine a numerical method capable of estimating entry heat transfer rates to planetary entry probes. Studies are underway to incorporate the finite-rate kinetics with simplified flow-field analysis to yield optimum shapes of Saturn and Uranus entry probes with corresponding entry angles that will minimize the heat shield weight consistent with proper aerodynamic stability. A 6-degree of freedom computer program, and low-speed testing, will be used to investigate the aerodynamic stability of outer planet entry probes during their travel thru the atmosphere.

W75-70381 **506-26-30**
Langley Research Center, Langley Station, Va.
SPACE SHUTTLE DEVELOPMENT SUPPORT
E. S. Love 804-827-2893

This RTOP focuses Langley's expertise in configuration aerothermodynamics and operational flight mechanics on those concerns having greatest impact on successful development of the shuttle. The RTOP supports the shuttle program by: (1) providing time in Langley ground-based facilities for direct OMSF/contractor-requested support, (2) continuing independent in-house shuttle technology and development studies, (3) responding to specifically requested task-study areas from the Program Office at JSC, and (4) maintaining a strong basic aerothermodynamic supporting technology program. In addition, Langley will perform independent evaluations and assessments of the configurations and operational modes and requirements as necessary. This RTOP's program is coordinated with other NASA centers and the phase C/D contractor through appropriate Program Office Engineering Coordination Panels at JSC.

W75-70382 **506-26-31**
Ames Research Center, Moffett Field, Calif.
SPACE SHUTTLE: CONFIGURATIONS AND AEROTHERMODYNAMICS
Dean R. Chapman 415-965-5065

The objective is to evaluate the aerodynamic performance, stability and control, and heating of the space shuttle orbiter and launch configuration 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 aerodynamic data will be obtained. The wind-tunnel data will be used by NASA and shuttle contractors to evaluate the space shuttle characteristics. The effects of realistic gaps, joints, and surface conditions on boundary layer transition and heat transfer will be examined. Numerical methods and computer programs will be developed for calculating the the three-dimensional chemical-nonequilibrium inviscid and viscous real gas windward flow around space shuttle orbiter configurations at angle of attack. Codes will be written for parallel and serial computers and parametric studies of shuttle entry flow fields will be performed in Illiac IV when it becomes operational.

W75-70383 **506-91-10**
Lewis Research Center, Cleveland, Ohio.
APPLICATIONS DATA SYSTEM SUPPORT
George Mandel 216-433-6285

The objectives are: (1) 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; and (2) 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. The ASRDI will use the resources and services of the Lewis Computer Services Division for access to the data bases. The ASRDI will, also, use the resources of the NASA Facility to have its information files available for retrieval at remote consoles at every NASA installation. The 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, and will continue to be, 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. The information will be analyzed, verified, correlated and qualified as required. This 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.

W75-70384 **790-40-31**
Ames Research Center, Moffett Field, Calif.
STUDY OF FUTURE PAYLOAD TECHNOLOGY REQUIREMENTS
J. M. Deerwester 415-965-5897

The objective of the RTOP is to develop the technology requirements for future space payloads and a schedule of when these technologies must be started in order to be available when needed. The approach will be to use contractors where applicable, the NASA shuttle payload Planning Working Groups, and particularly the Space Transportation System Payload Technology Panel in defining these technology requirements. The FY-74 effort includes an examination of the technology requirements across the total spectrum of payloads to a limited depth. The task for FY-75 will ba to analyze in depth certain critical technologies that emerge from the FY-74 study, as mutually agreed by RX and the study monitor. These requirements will be updated to

account for changes in the NASA Payload Model prior to the indepth analysis. The results of the FY-74 study effort to identify technologies which need further analysis, will focus on technology requirements associated with the payload/shuttle interface.

W75-70385 **790-40-41**
Ames Research Center, Moffett Field, Calif.
SPACE EXPLORATION - MISSION AND SYSTEMS ANALYSIS
B. L. Swenson 415-965-5890

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.

W75-70386 **520-71-01**
Langley Research Center, Langley Station, Va.
SOLID STATE DATA RECORDER
G. B. Graves 804-827-3745
(502-03-52; 502-33-52)

The overall objectives of this project are to provide by CY-1978, a 10 to the 8th power bit solid state data storage system suitable for replacing tape recorders in many aerospace vehicle applications. Specific intermediate objectives are: (1) to design a 10 to the 8th power bit data recorder using bubble technology; (2) develop and demonstrate a basic recorder in a breadboard configuration; and (3) Develop and fabricate a prototype 10 to the 8th power bit recorder. A two phase developmental contract will be used to provide the 10 to the 8th power bit data storage system. This contract will be supplemented by analytical studies and laboratory investigations in critical areas of the recorder magnetic and electronic systems. These studies will be directed towards providing improved operational characteristics, longer useful life, and reduced costs. Current research efforts include refinement of the materials technology to build the recorder, development of a 0.00001 bit memory element, and the building and testing of a 6 x 0.0001 bit feasibility mode. The materials technology efforts will provide increased temperature stability and decrease memory element costs. The 0.00001 bit memory element development will make available a basic building block for the flight data recorder. The feasibility model demonstrates that all components of the flight data recorder can be integrated into an operational system. This current research, therefore, provides a sound technical basis upon which a 10 to the 8th power bit flight data recorder can be developed.

W75-70387 **521-71-01**
Flight Research Center, Edwards, Calif.
ENTRY TECHNOLOGY CONFIGURATION FLIGHT EXPERIMENT
J. L. Kolf 805-258-3311

The subsonic and low supersonic characteristics of a configuration representing an advanced class of entry vehicles is being studied by means of a coordinated flight and wind-tunnel test program with the X-24B. The program will yield the detailed aerodynamic characteristics of a high hypersonic L/D entry vehicle and an indication of the ability of the wind tunnels to predict these characteristics. A flight-test approach will assess the handling qualities and piloting problems of this class of vehicle while determining performance and stability and control characteristics. Energy management and approach schemes will also be investigated during unpowered flight periods.

W75-70388 **750-01-01**
Langley Research Center, Langley Station, Va.
SYSTEMS DESIGN OF A SPACELAB COMPATIBLE ADVANCED TECHNOLOGY LABORATORY
E. S. Love 804-827-2893

Langley Research Center in-house studies have established feasibility of a Spacelab compatible Advanced Technology Laboratory (ATL). These designs included definition of LRC experiments, ATL and Spacelab concepts and operational requirements. The objective of this effort is to provide a systems design of an ATL which utilizes the NASA shuttle and European Spacelab for advanced technology investigations. The ATL will provide LRC with the capability of implementing a spaceborne research program that is truly accessible to the ground-based researcher. This primarily contracted effort will focus on major ATL program functions, experimently/payload layouts, interface hardware, display and controls, data management, mission analysis, interface GSE, etc. Design analysis will also be conducted to assess the impact of Spacelab on NASA's advanced technology program. In addition, costs, schedules, and implementation plans will be defined for phased follow-on activities. Further refinement of the ATL design will focus LRC shuttle sortie research requirements and make timely contributions to the concurrent NASA shuttle and European Spacelab design activities.

W75-70389 **750-72-01**
Langley Research Center, Langley Station, Va.
LONG DURATION EXPOSURE FACILITY PROJECT
E. S. Love 804-827-2893

The broad LDEF Project objectives are the following: to develop LDEF, a simple, low cost, free-flying facility for performing long duration technology and other experiments in the space environment using the STS; to develop a first set of experiments for the facility and, by the performance of these experiments obtain valuable technological data and demonstrate the unique Shuttle/LDEF capabilities and features; and to broaden the STS user community by providing a simple low cost approach to integrate and operate a large number of OAST and other unmanned long duration experiments via the STS. The LDEF is a reusable, unmanned, low cost, free-flying structure on which many different experiments can be mounted. The facility will be delivered to earth orbit by the shuttle. After an extended period in orbit, the facility will be retrieved on a subsequent shuttle flight and returned to earth for experiment analysis. Many of the experiments being considered for the LDEF are completely passive with the active data measurements being made in the laboratory after the experiments are returned.

W75-70390 **750-73-01**
Ames Research Center, Moffett Field, Calif.
AIRBORNE SYSTEMS SUPPORT OF SPACE TECHNOLOGY SHUTTLE PAYLOADS
Dean R. Chapman 415-965-5065

This RTOP is to provide a simulated Spacelab to be installed and flown aboard large aircraft. The aircraft containing the simulated Spacelab will be flown on a routine basis to test the operation of the entire complement of experiments by the actual teams of experiment operators as a last step in the prelaunch check-out of each Spacelab payload. The Shuttle Simulator/Airborne (SSA) facility will permit final payload and experiment operator check-out under conditions closely duplicating Spacelab operating conditions.

W75-70391 **750-74-01**
Langley Research Center, Langley Station, Va.
DEFINITION OF PHYSICS AND CHEMISTRY EXPERIMENTS IN SPACE
E. S. Love 804-827-2893

Space shuttle offers an unparalleled opportunity 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 fly in shuttle to support a wide range of original physics and chemistry experiments which make use of the unique environmental conditions in space. It is envisioned that this laboratory will be available to university and research laboratory investigators, 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 catalog of experiments considered representative of the experiments which will be performed in space in the next decade. The study covered by this RTOP will extend the work of the past by (1) defining specific experiments to be conducted in a Spacelab, (2) identifying

principal investigators for these experiments, and (3) conducting experiment definition studies for promising experiments. The definition of specific experiments involves preliminary studies by panels of discipline experts to define key experiments and the follow-on by concept and experiment definition studies.

W75-70392 **750-74-02**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
PHYSICS AND CHEMISTRY
P. J. Meeks 213-354-2546

The principal objectives of the tasks outlined in this proposal are to identify, show feasibility, and define those key experiments which will form the nucleus of the physics and chemistry in space program to be pursued as a portion of the NASA space shuttle flight program. Those areas of research which are being investigated under these tasks relate specifically to the proposed Superfluid Helium and Drop-Particle Positioning Module and to the proposed wall-less Chemistry and Molecule/Ion Beam Module. The scope of this work is threefold: first, to study the feasibility of experiments to be performed in an earth orbital laboratory, through research and tests both in the laboratory and in the weightless environment provided by rocket flights; and second to use the results of this study to provide a conceptual design for the experimental facility modules to be used in NASA's Physics and Chemistry in Space program. Pursuit of the second objective will help define the requirements to be met to accommodate these facility modules abroad the space shuttle. These objectives will be pursued with the help of the scientific community through international symposia and colloquia organized under this task, and through use by this community of the rocket-borne Physics and Chemistry in Space facilities to be developed under this task. The three types of experiments being studied are: superfluid helium and drop dynamics; gas chemistry; and molecular/ion beam reactions. The first experiment will form a nucleus for the Superfluid Helium and Drop/Particle Positioning Experiment Facility Module; the other experiments will form a nucleus for the Wall-less Chemistry and Molecular/Ion Beam Experiment Facility Module. These two facility modules have been identified by NASA Hq., as experiment facility modules to be used in carrying Physics and Chemistry in proprietary information contained in RTOP.

W75-70393 **750-75-01**
Ames Research Center, Moffett Field, Calif.
ENTRY TECHNOLOGY PAYLOADS
Dean R. Chapman 415-965-5065

The objectives of this work are to define those experiments which can be conducted utilizing the shuttle as a research facility during ascent and reentry to advance the state-of-the-art of entry technology and to assess the impact of the experiments on the shuttle systems and primary mission. The approach for the first objective is to identify those experiments that will provide design verification data relative to the shuttle's aerothermodynamic and thermal performance and to identify additional experiments which could be conducted in support of basic entry research. Experimental definition shall include definition of the experimental objective and contribution to the existing data base. For the second objective the approach will be to define for each experiment the shuttle support and interface requirements. The cummulative impact of all the experimental support on the orbiter will be assessed.

W75-70394 **750-75-02**
Langley Research Center, Langley Station, Va.
SHUTTLE ENTRY TECHNOLOGY PROGRAM
E. S. Love 804-827-2893

The planned operational flight frequency of the shuttle coupled with its large payload carrying capability will provide an unprecedented opportunity to conducting aerothermodynamics research as an adjunct to orbital operations. This research capability can be separated into two categories: (1) those research experiments which will utilize the shuttle's normal interaction with it's environment during ascent and reentry; (2) those experiments which will utilize a vehicle launched from the orbiter for earth entry. The successful application of these experiments and the effective utilization of the shuttle flights for aerothermodynamics research with minimum impact on the shuttle system and primary mission objectives depends on the early definition, development, and system integration of the experiments into the system. It will, therefore, be necessary to (1) determine in-house research requirements applicable to shuttle flight; (2) perform experiment definition studies to determine measurement location(s), number of measurements/flights required and hardware need; (3) conduct studies to identify and develop advanced measurement techniques; (4) conduct ground and flight research to verify experiment capability and applicability to flight; and (5) conduct studies to define feasibility and capabilities of various shuttle launched payloads, design launch systems, and define shuttle interfaces and mission peculiar requirements.

W75-70395 **750-76-01**
Marshall Space Flight Center, Huntsville, Ala.
DEVELOPMENT OF AN INTEGRATED REAL-TIME CONTAMINATION MONITOR
Robert J. Naumann 205-453-0940

A number of contamination monitors to measure mass deposition on surfaces and scattering of light in the vicinity of the spacecraft were developed for Skylab. During the Skylab program, the concept of a real-time contamination monitor evolved. Such a monitor consists of a set of instruments designed to measure the amount of contaminant deposited, identify species and determine the amount of optical degradation caused. During Skylab a need for additional instrumentation to provide imaging photometry, to monitor particulate concentration and to monitor deposition rates, particularly on cryogenic surfaces, was identified. The objective of the research proposed is to establish the basis for and to demonstrate feasibility of providing flight instrumentation providing the contamination monitoring capability described above. The approach will be to continue investigations of existing concepts for contamination and evaluate. Additionally, new concepts will be investigated as they are identified, and reduced to test configurations as feasible.

OFFICE OF ENERGY PROGRAMS

Energy Research and Technology Programs

W75-70396 **778-10-01**
Lewis Research Center, Cleveland, Ohio.
ENERGY CONVERSION AND CONSERVATION EVALUATION
Donald C. Guentert 216-433-6632

The objective is to provide a continuing evaluation of advanced conversion systems to determine resource requirements, environmental impact, technology requirements and time for implementation, with an initial evaluation of specified systems by the end of 1975. Both in-house studies and contract studies will be used to evaluate those systems capable of producing electric power in a more efficient and environmentally acceptable manner. Performance, economic and natural resource requirements, environmental impact and development requirements and risks will be determined and input into a national energy system model to determine benefits and impacts on a national scale.

W75-70397 **778-11-01**
Lewis Research Center, Cleveland, Ohio.
ADVANCED ENERGY CONVERSION TECHNOLOGY
M. Gutstein 216-433-4000
(770-52-01)

The objective is to apply NASA expertise and capability in advanced conversion technology to develop more efficient fossil-fueled conversion systems that are economically viable and offer reduced environmental impact. This nation is facing diminishing domestic reserves of petroleum and natural gas and must, therefore, learn to conserve these fuels and increasingly replace their use with coal in a socially and environmentally

acceptable manner. Substantial quantities of oil, natural gas and coal are presently consumed by the utility industry to generate electricity. Improving the conversion efficiency of stationary power systems and utilizing the powerplant waste heat would conserve scare fuels, encourage the substitution of coal for oil and gas, and, at the same time, reduce the impact on the environment. The approach will be to explore new technological paths toward achieving more efficient conversion systems, conduct system feasibility tests, develop the technology of key components, and evaluate materials of construction crucial to the success of many of the advanced---

W75-70398 **778-15-01**
Lewis Research Center, Cleveland, Ohio.
HIGH TEMPERATURE GAS-COOLED REACTOR-GAS TURBINE ENERGY CONVERSION
M. H. Krasner 216-433-6911

The objective is to contribute to development of a new Power Conversion Loop (PCL) to be used in commercial nuclear plants for base electric load applications. The plants will use a developed High Temperature Gas Cooled Reactor (HTGR) as a heat source, and 1500 F helium available from the reactor will be used in a Brayton cycle turbine system to generate electricity. The advantages of this system stem from its ability to use dry heat rejection economically. AEC is the funded agency for the overall program. A second objective is to validate the PCL design for the AEC and plan, manage, and execute, as appropriate, an SRT program to allow for availability by FY 1980 of a full-scale prototype. The final aim is to manage the design and construction of a facility capable of testing a full-scale prototype PCL. The facility will be operated in FY-80, 81 and 82 using a fossil-fueled heater to simulate a reactor. These tests will confirm system performance, establish transient characteristics and demonstrate maintenance techniques.

W75-70399 **778-20-01**
Marshall Space Flight Center, Huntsville, Ala.
EARTH BASED SOLAR POWER CONVERSION AND DELIVERY SYSTEMS
W. E. Whitacre 205-453-3465
(647-10-01)

The objective of this total program is the generation and provision of a broad data and technology base for the development of large scale solar thermal electric power plants. The performance capabilities, costs, and technology areas involved in solar thermal power plants will be identified through a combination of system analysis, comparison, and economic studies and by further subsystem and component testing. The component and subsystem tests will be parameterized to enhance the data applicability to other potential electrical power system concepts and to other energy source studies. Subsystem tests will provide additional data leading toward the possible construction and operation of a pilot plant. System integration considerations, concepts comparisions, economic analyses and trade-offs, projected plant operating efficiencies, and the parameters for long term operation will be the products of this phase. This phase, which will build on the results of the previous efforts covered in the FY-74 RTOP, will be composed of the following tasks: economic evaluation of competitive systems concepts, and terrestrial solar heat fluxes.

W75-70400 **778-24-01**
Lewis Research Center, Cleveland, Ohio.
WIND ENERGY SYSTEMS
Ronald L. Thomas 216-433-6844

The objective is to develop the technology for cost competitive wind-turbine generators (WTG's) and demonstrate a sufficient number of WTG's in actual applications so commercial implementation will begin by 1980. Wind energy represents a clean nondepleting energy source that is available in sufficient quantities to provide a significant portion of the nation's energy needs for electricity. Tests will be made on wind-turbine generators to determine performance, operating and engineering data. Studies and designs will be made of minimum cost WTG's from 50 KW to 3000 KW. WTG's with potential for minimum cost will be demonstrated in actual applications and the program will also develop energy storage systems. The utilities will be involved early to remove barriers to implementation. The suppliers for the WTG's will be developed early in the program to aid the transition to commercial status. This program will provide the technology base and demonstrations to lead to commercial implementation beginning by 1980.

W75-70401 **778-30-01**
Lewis Research Center, Cleveland, Ohio.
IMPROVED FUEL ECONOMY AND REDUCED POLLUTION GROUND PROPULSION SYSTEMS
D. R. Packe 216-433-4000

The objectives are to improve existing engines for the near-term and to evaluate advanced engines for the 1980's. For the near-term, several approaches to extend operating limits of Otto cycle engines will be investigated, including hydrogen injection, high energy spark, and injection ignition. For the long-term, this program will result in a comprehensive analytical and experimental capability to assess and evaluate competing alternative ground transportation propulsion systems on a consistent basis. Analytical studies, design studies, and/or experiments will be conducted to assess the merits and technology requirements of advanced engines and new engine types.

W75-70402 **778-31-01**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
CONTINUATION PHASE - HIGH-EFFICIENCY, LOW-POLLUTION ENGINE PROJECT
G. W. Meisenholder 213-354-4058

Three issues are embodied in the objective of this RTOP: (1) provide a logical continuation of the high-efficiency, low pollution engine program which considers the NASA funded Phase 1 work accomplished; (2) the partial funding by NASA of a Phase 2 effort, and tasks performed by JPL for the DOT/TSC and the EPA to date and to incorporate the solution of a critical project problem into this RTOP; and (3) to assure that project continuation beyond this RTOP is logical and orderly. The NASA Phase 1 provided a proof of concept, or a feasibility demonstration of the hydrogen injection scheme. The NASA Phase 2 effort through June 1974 permitted the following developments: (1) a high yield (90% of theoretical) hydrogen generator which requires no water addition, (2) reduced size of a generator unit, and (3) a control system for generator/engine operation.

W75-70403 **778-31-02**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
HYDROGEN GENERATOR TECHNOLOGY
G. W. Meisenholder 213-354-4058

The objective is to demonstrate improved hydrogen yields in a partial oxidation reactor under soot free conditions; to increase hydrogen content of product gas from 14 volume % (obtained in Phase 1) to 18-20 volume % and to reduce soot formation to enable operation at lower air/fuel mass ratios, close to the optimum value of 5.15. These improvements are needed to efficiently use the partial hydrogen injection concept for improving fuel economy and reducing emissions in gas turbines and internal combustion engines for aircraft. The specific emissions of all fuels from a combustor depend primarily on the air/fuel ratio in the flamefront. Lean operation at high air/fuel ratios results in low flame temperatures and low NOx emissions, as well as low CO and hydrogen levels. The efficiency increases with higher air/fuel ratios due to reduced heat losses and due to a decrease in the ratio of specific heats CP/CV of the combustion gases.

W75-70404 **778-32-01**
Lewis Research Center, Cleveland, Ohio.
EPA/NASA AUTOMOTIVE GAS TURBINE PROGRAM
J. A. Heller 216-433-6632

The objective is to transfer current and ongoing aerospace technology, particularly in the areas of turbomachinery, materials, and combustion and, by this means, to improve the fuel economy by 30% beyond the planned 100 hp EPA/Chrysler upgraded engine performance, while maintaining emissions below the 1977 standards: and to achieve this goal by FY-78. Current aerodynamic turbomachine technology will be applied to the design of EPA's

new 100 hp upgraded gas turbine, and proven new technology will be retrofitted into the new engine after delivery. Results of advanced gas turbine studies will identify new technology required and guide new and on-going advanced automotive gas turbine technology.

W75-70405 **778-33-01**
Flight Research Center, Edwards, Calif.
AERODYNAMIC DRAG OF GROUND VEHICLES
E. J. Saltzman 805-258-3311

Flight Research Center technology will be used to investigate means of reducing the aerodynamic drag of box-shaped ground vehicles, such as trucks and recreation vehicles, which have very high drag and thus are a factor with regard to the nation's energy management problems. Rectangular vehicles have high drag coefficients. This has been known for a long time, but now several factors are converging which make their high drag very important. There are several configuration changes which can substantially reduce aerodynamic drag without compromising volumetric efficiency to a significant degree. Baseline data for the drag of a real vehicle having a sharp-cornered box shape, including large tractor-trailer combinatins, will be obtained for interstate highway speed conditions (and lower). *Then the same chassis will be used to carry the same volume* in follow-on tests for modified geometry. In addition, various add-on devices to existing trucks will be evaluated as part of a cooperative effort with DOT.---

W75-70406 **778-40-02**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
ENERGY SYSTEMS STUDIES
M. E. Alper 213-354-6948

The objective is to provide broad systems study support to the Office of Energy Programs. The support will include specific technical studies, as well as requirement definition studies, program planning definition studies, and support of ongoing programmatic activities. Specific tasks will be identified as required by the Office of Energy Programs and specific plans will be developed for each task. The first task to be undertaken will be in the area of energy extraction and utilization. This study will include definition of system functional requirements of an advanced coal mining system, capable of extracting thick seam western coal at a rate commensurate with 1985 coal energy demand requirements. The second task will be to provide a participant in the NASA Management Development Program to the NASA Energy Office, Energy Systems Division, for a term of approximately one year. He will perform program management duties as specified by the Energy Systems Division Director.

W75-70407 **778-52-01**
Langley Research Center, Langley Station, Va.
ENVIRONMENTAL ENGINEERING AND ENERGY MANAGEMENT (FLYWHEEL ENERGY STORAGE SYSTEM)
G. B. Graves 804-827-3745
(909-74-35; 506-19-13)

The objective is to apply advanced space technology to the development of flywheel energy storage systems for application to ground transportation. The technical approach will include in-house studies and system simulations, and contracted efforts to fabricate the composite material flywheel energy storage system, mobile test vehicle, and test equipment. After interim testing of the vehicle with a battery set, the flywheel system will be integrated and final testing accomplished. The flywheel energy storage system for use on mobile vehicles for ground transportation will provide benefits in the areas of pollution control and more efficient utilization of energy sources. In addition, low maintenance and long life are expected from this concept.

W75-70408 **778-53-01**
Lewis Research Center, Cleveland, Ohio.
ENERGY STORAGE SYSTEMS
D. L. Nored 216-433-6366

The objective is to demonstrate efficient, low cost energy storage systems by 1980. Bulk energy storage in the form of thermal, electrochemical, chemical, mechanical, pneumatic, or hydraulic energy is attractive for many varied applications, such as: (1) uninterrupted power supply from variable sources; (2) continual operation of a power system at high efficiency during lowpower demand periods, with subsequent use of stored energy during peak demand periods; (3) recovery of waste heat or energy; or (4) operation of 'zero' pollution vehicles. Such storage systems will be evaluated relative to energy sources and applications to establish storage system criteria and requirements, to identify problem areas, and to identify required constituent technology. Design and technology efforts on attractive storage systems and their components will be conducted. Included initially, for example, will be redox flow cells (which have unique features, allowing them to be built in any size and sited anywhere), thermal (heat) storage, heat pumps (for both thermal storage charging and other special applications), and perhaps hydrogen energy storage (for peaking plants and wind power). Experimental investigations will be performed at both the component and system level. Previously defined technology requirements of the redox flow cell will be addressed by suitable electrochemical experiments, materials development, design studies, and tests.

W75-70409 **778-60-01**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
HYDROGEN ENERGY SYSTEMS STUDY
M. E. Alper 213-354-6948
(647-20-03; 778-60-02)

The objective is to provide the basis for a decision regarding the inclusion of hydrogen in the National Energy R and T Program in FY-77 and to identify NASA's role in that program. This will be accomplished through a program in FY-75 which will (1) develop an overview of the potential role of hydrogen within the national energy complex, including the advantages and implications; (2) provide a program definition and justification; and (3) identify and justify FY-76 NASA budget requirements for the accomplishment of this task. The use of hydrogen as a fuel, as an energy storage medium, as an energy transmission medium, and as an interim chemical in chemical processes will be considered, as well as hydrogen production and distribution. Working closely with NASA Headquarters, JPL will establish a NASA-wide team to conduct the study and define the FY-76 activities and the technology program for FY-77 and beyond. The team will be under the leadership of a study manager from JPL, drawing personnel and expertise from the NASA Centers and JPL. Organization of the team will include an Intercenter Working Panel and Working Groups on specific issues as required. Maximum use will be made of results of other ongoing studies of energy usage and hydrogen production, both within and outside NASA. Also, recognized experts from industry, universities and other government agencies will be asked to participate on a review and Advisory Group, and to supply information in both the technical and nontechnical areas. As appropriate, they will also be asked to participate in working groups.

W75-70410 **778-60-02**
Marshall Space Flight Center, Huntsville, Ala.
HYDROGEN PRODUCTION AND UTILIZATION
William D. Powers 205-453-2817

The objective is to carry out detailed feasibility studies of selected processes of hydrogen production, and to provide cost estimated for the development and operation of selected hydrogen production processes. Hydrogen production methods that have the best potential for commercial exploitation will be selected for in-depth technical feasibility analysis and cost projections. Some feasibility demonstrations on laboratory scale may be undertaken. Development plans, including production facility costs will be prepared for each system. An energy balance analysis showing the total energy input required per unit of hydrogen produced will be prepared for each process.

W75-70411 **790-40-45**
Ames Research Center, Moffett Field, Calif.
TECHNOLOGY REQUIREMENTS FOR OPERATIONAL EARTH OBSERVATION SYSTEMS
Jerry M. Deerwester 415-965-5897

The ultimate objective of this RTOP is to identify technology requirements needed for earth observation systems that might be operational during the 1980's. To meet this objective, it is

first necessary to further define the functional requirements of certain candidate system elements. Specifically, in FY-75 studies will be undertaken to (1) determine the desirability and technologies needed for quick look information extraction system; (2) determine the potential role and technology requirements for a relay satellite as part of the user data dissemination network; and (3) determine the potential utility and system costs for a fleet of RPV's to conduct earth observation missions. Results of these studies, together with results of prior and current in-house and contracted studies of the Systems Studies Division, other OAST organizations, and the Office of Applications will form the basis of the operational systems study to begin in FY-76. The approach will be to explore the cost-effectiveness of operational system options with respect to sensor complements; data products; coverage frequencies; synergistic combinations of sunsynchronous and geosynchronous satellites, aircraft, RPV's and in situ sensors; and spatial, spectral and temporal resolution.

OFFICE OF APPLICATIONS

Weather and Climate SR&T

W75-70412 **175-11-41**
Goddard Inst. for Space Studies, New York.
RESEARCH ON NUMERICAL MODELING OF THE GLOBAL ATMOSPHERE AND THE WORLD OCEANS
M. Halem 212-866-3619

Research will be carried out on numerical modeling of the world oceans for use in GISS long-range forecast studies with coupled ocean-atmosphere dynamics. Satellite data will be used to verify long-range predictions and to check climatology of atmosphere, and hydrosphere. A simple ocean model developed and tested at UCLA will be coupled to the advanced multi-level GISS model. In addition, improvements in the ocean modeling will be made to include salinity, bottom ocean topography and ice configurations. The intent is to develop a more realistic model for data assimilation, and forecasting studies. Since the ocean surface provides the temperature boundaries for the atmospheric model, the ocean dynamics and accompanying changes in ocean surface temperature are required as an input to all forecasting studies beyond 5 to 7 days. A new area of theoretical study involves the development of a parametrization of aerosol distribution for the GISS model. Values of global aerosols and sample methods of flux calibrations to predict global heating or cooling effects will be studied.

W75-70413 **175-11-42**
Goddard Space Flight Center, Greenbelt, Md.
RADIATIVE TRANSFER MODELS RELATING TO ATMOSPHERE AND SURFACE CHARACTERISTICS
R. Fraser 301-982-4235
(175-61-41)

The objectives are to determine the radiative characteristics of gaseous and particulate constituents of the atmosphere and of natural surfaces. This basic knowledge will be used to develop satellite methods for measuring atmospheric and surface parameters. The proposed work supports all six of the NASA Meteorology Program objectives. The radiative characteristics of gases will be obtained from laboratory measurements, theory, high altitude balloon observations, and satellite observations. Cloud radiative parameters will be derived from aircraft and balloon measurements. Radiative transfer models of clouds will be developed. The feasibility of utilizing satellite polarization observations to measure particulate properties will be determined with computer modeling studies. Models of the scattering characteristics of oceans will be developed. Atmospheric models for the inversion of ultraviolet measurements to obtain ozone profiles and infrared measurements to obtain temperature profiles will be improved.

W75-70414 **175-11-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
EFFECT OF SNOW AND ICE FIELDS ON WEATHER AND CLIMATE
D. P. Burcham 213-354-3028

An area of meteorology that has been sorely neglected, especially in the U.S., is the branch of micrometeorology dealing with atmosphere-earth interactions. While atmosphere-ocean interactions have been receiving some attention as of late, the problems of heat exchange between the atmosphere and the earth, especailly areas covered by snow and ice, have been somewhat neglected. The effect snow fields have on weather and climate has largely been attributed to the large albedo of snow, a factor which is directly linked to the earth's radiation budget. but the albedo has only a long-term effect on a climate and is generally not of major consequence for short-term forecasts. There are other aspects of snow cover, however, which can influence even short-term weather phenomena, and it is these aspects which must be intensely studied before they can be parameterized efficiently for weather prediction models. Snow influences the atmosphere by changing the nature of air masses through its latent heat capacity and poor thermal conductive properties. If warm air masses pass over extensive snow fields, their lowest layers are rapidly cooled causing a very stable layer near the surface. Treidl (1970) has shown that, despite the stability, turbulent heat exchange still takes place so that the entire air mass can be significantly changed in a matter of days. The strong radiative properties of snow intensify this process during the long winter nights. Thus, polar maritime air that passes over extensive snow fields is easily transformed to polar continental air in a short period. The mechanism of this heat interchange is still being intensely investigated, especially in Europe and the Soviet Union, but mostly for purposes of hydrology and flood control. Kuz'min (1972) gives a detailed summary of research performed recently concerning the melting of snow, but again this has been applied mainly to questions of hydrology and spring runoff rather than meteorology.

W75-70415 **175-11-71**
Marshall Space Flight Center, Huntsville, Ala.
GENERAL ATMOSPHERIC AND OCEANIC CIRCULATION EFFECTS ANALYSES
W. W. Vaughan 205-453-3106
(645-10-01)

The objectives are to increase our understanding of the general circulations of the oceans and atmospheres and the effects on these circulations of small term perturbations in heat inputs. The approach is to develop the theoretical models required to provide criteria for the development of a three-dimensional dishpan type experiment to be flown in the spacelab. These models will be used to define the equipment and procedures required to conduct the experiment as a payload in the low gravity environment of the shuttle spacelab.

W75-70416 **175-11-72**
Marshall Space Flight Center, Huntsville, Ala.
MICROPHYSICAL PROCESSES IN ATMOSPHERIC CLOUDS
W. W. Vaughan 205-453-3106
(645-10-01)

The objectives are to develop and/or establish the physical basis and quantitative techniques to be used in defining specific experiments concerning ice nucleation, ice crystal growth habits, collision induced freezing, and ice multiplication to be flown in the Zero-Gravity Atmospheric Cloud Physics Laboratory in the spacelab shuttle. These techniques will also be used in evaluating the experimental results. The approach is to develop sets of analytical expressions for the microphysical processes of the ice phase of water that can be used to establish experiment equipment and protocols necessary to conduct experiments in both ground based and orbital laboratories. These expressions will also be used to evaluate the results and provide a basis for the comparison of the one-g and zero-g results.

W75-70417 **175-21-11**
Ames Research Center, Moffett Field, Calif.
NUMERICAL MODEL AND SIMULATION OF COUPLED EARTH ENERGY AND POLLUTION TRANSFER CYCLES
Dean R. Chapman 415-965-5065

The objective is to investigate the utility of satellite and airborne observations to mesoscale meteorological and air pollution problems. The approaches are develop computer programs to model mesoscale meteorological and photochemical dispersion problems which are susceptible to numerical study; use these models to evaluate various methods of interpreting and applying satellite and airborne observations, as well as to investigate the use of such observations in development of the models themselves; evaluation to include both the current and planned satellite and airborne platforms, such as ERTS, Nimbus G, and U-2's, as well as the definition of additional capabilities desirable in future satellite developments.

W75-70418 **175-21-31**
Langley Research Center, Langley Station, Va.
NUMERICAL SIMULATION MODELS FOR SEVERE STORMS
E. S. Love 804-827-2893
(175-21-43; 175-61-43; 175-11-41)

The technical objective is to develop numerical models for the movement, growth and behavior of severe local storms. The approach is to develop analytical solutions for the movement, growth, and behavior of thunderstorms, tornadoes, and hurricanes; validate these solutions with real in-situ and satellite data; and apply the numerical solutions to study the structure of the storm.

W75-70419 **175-21-32**
Langley Research Center, Langley Station, Va.
ZONAL EARTH ENERGY MONITOR SCIENCE STUDIES
E. S. Love 804-827-2893

The principal objectives are to adopt existing methods, materials, and flight hardware to the development of an accurate, but inexpensive, satellite system for measuring the zonal earth energy budget. These measurements are important to determine the magnitude and direction of climate change (warming or cooling), and to assess the effects of pollution. 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. Studies of the various candidate measurement systems will be performed to evaluate their capability to meet the science requirements. Plans for reducing and analyzing data for the long period will be developed.

W75-70420 **175-21-41**
Goddard Space Flight Center, Greenbelt, Md.
REMOTE SENSING TECHNIQUES FOR ATMOSPHERIC STRUCTURE AND SURFACE CONDITION RELEVANT TO METEOROLOGY
Warren A. Hovis 301-982-6465
(175-91-42)

The purpose of this effort is to carry out the field experiments necessary to develop and test new remote sensing techniques for meteorological remote sensing. Included in this effort are sensing programs in atmospheric constituents, suspended particles in the atmosphere, and surface conditions of importance to meteorology such as ocean surface temperature and roughness and soil moisture content. New techniques for the multispectral detection of sea surface temperature are examined to determine the most efficient and accurate method for extracting the ocean temperatures. Extension of these methods to determine total water vapor simultaneous with the temperature measurement are considered. Results will be used to support both ongoing and upcoming spacecraft missions. The application of recent advances in detection technology to atmospheric sounding is proposed. Both laboratory and aircraft instruments are to be designed, built, and tested. Results will be used to delineate future spacecraft instruments. Soil moisture measurements utilize both microwave and infrared sensing with surface truth provided by collection and analysis of soil samples. The results of all of these measurements are used to guide specifications, production, integration and data handling and processing for future experiments on spacecraft in the applications program.

W75-70421 **175-21-42**
Goddard Space Flight Center, Greenbelt, Md.
TECHNIQUES FOR MEASUREMENT OF STRATOSPHERIC CONSTITUENTS
D. F. Heath 301-982-6421

New measurement techniques will be utilized and developed for the measurement of trace constituents in the stratosphere. The research will be directed towards those constituents which are insignificant in terms of the overall content of the stratosphere but which control the solar energy input into the stratosphere and biosphere. If altered they can produce significant long term climatic changes. The investigation will be concerned primarily with those whose natural concentration may be altered by pollution of the stratosphere. The initiation of supersonic aircraft flights in the stratosphere with the subsequent introduction of significant quantities of NO, H2O, HCl, and particulate matter has produced a continuing need for realistic assessments of their potential effects on world climatology. Some areas of special concern are a reduction of the global budget of atmospheric ozone, changes in the ultraviolet atmospheric radiance and solar irradiance and possible corresponding changes in the the erythermal band at the ground. A long term monitoring of the size and particle distribution of stratospheric aerosols from in-situ measurements would be highly desirable. New remote and in-situ sampling techniques are needed to establish a baseline of the trace constituents in the stratosphere in order to be able to assess in future years the seriousness of the introduction of pollutants into the stratosphere.

W75-70422 **175-21-43**
Goddard Space Flight Center, Greenbelt, Md.
SEVERE STORM SURVEILLANCE
W. E. Shenk 301-982-5948
(175-61-41)

The objective is to specify sensor characteristics for the detection and surveillance of severe storms primarily from geostationary satellites with special emphasis on the identification of tornado and hail producing thunderstorm cells. The establishment of this measuring capability is expected to be an important item in the design of a SEOS satellite. Among the important sensor characteristics to be determined are the spatial resolution, spectral regions, thermal resolution (for infrared measurements), and frequency of observation.

W75-70423 **175-21-44**
Goddard Space Flight Center, Greenbelt, Md.
STRATOSPHERIC MEASUREMENTS OF SOLAR SPECTRAL IRRADIANCE AND ITS VARIATIONS, RELATED TO SOLAR TERRESTRIAL RELATIONSHIPS
M. P. Thekaekara 301-982-5034
(175-44-55; 175-44-53)

The solar constant and spectrum in the range 0.27 to 4 microns and their variations with solar cycles will be measured over a sufficiently long period of time to correlate variations in input energy to the earth atmosphere system with cyclic or sporadic solar activity. A major objective is to provide bench mark standards and instrument calibrations which may be used by future investigators to accurately correlate today's data to future data. Initially, instruments and data systems already developed at GSFC for laboratory use will be adapted for the U-2 aircraft. These instrument designs will be further refined to incorporate a capability for continuous pointing at the sun during flight; thus, reducing the background noise from the earth's atmosphere. The spectral range of the instrument will be increased from 0.27 - 2.6 microns to 0.27 - 4 microns by the use of sapphire for the prism and window. The experimental package will be sufficiently light-weight and compact so that it can be flown as a piggyback on almost all possible routine U-2 missions. To provide almost continuous measurements of the solar irradiance, coordination will be maintained with current U-2 programs for earth resources survey.

W75-70424 **175-21-45**
Goddard Space Flight Center, Greenbelt, Md.
TORNADO DETECTION AND WARNING SYSTEMS
C. E. Cote 301-982-4215

A detailed study of tornadoes is planned to determine the feasibility of using satellite monitoring techniques to contribute

to improvements in tornado detection and warning systems. This work was motivated by the experiments of W. L. Taylor of NOAA/ERL who has had reasonable success at identifying an HF electromagnetic signature which is a characteristic of tornadic activity. This feasibility study will be approached as follows: (1) Previous measurements of severe storm emissions will be collected and examined for characteristics which distinguish tornadoes from other severe storm activity. (2) Additional data will be collected on those parameters, such as power spectrum and polarization, which are essential to evaluating the signal available to satellite sensors. (3) The physics of tornadoes will be studied in order to identify those mechanisms which could generate a characteristic signature and in order to identify other features potentially suitable for monitoring from space. (4) Evaluation will be made of system concepts whereby a satellite sensor might be incorporated into an improved tornado detection and early warning system.

W75-70425 **175-21-46**
Goddard Space Flight Center, Greenbelt, Md.
STUDIES OF SATELLITE SUPPORT TO WEATHER MODIFICATION
L. J. Allison 310-982-2624
(175-91-41; 175-91-43; 175-61-41)

The objective is to apply satellite observations in support of the conventional quantitative measurements of meteorological parameters during weather modification projects over the United States. Both intentional and inadvertent aspects of weather modification will be studied. Special attention will be made to determine under what cloud conditions weather modification efforts are feasible and to evaluate the effectiveness of the cloud seeding procedures using satellite sensing techniques.

W75-70426 **175-21-47**
Goddard Inst. for Space Studies, New York.
SENSITIVITY STUDIES RELATED TO ATMOSPHERIC REMOTE SENSING EXPERIMENTS
Richard W. Stewart 212-866-3603

The objective is to determine the effects of noninstrumental sources of systematic and random error on temperature and minor constituent density profiles retrieved by remote sounding instruments. The approach will be to identify those factors in remote sounding experiments which give rise to systematic or random errors; to assess the effects of systematic errors by means of simulation studies; and to describe mathematically the propagation of random error through the numerical calculations used to obtain temperature and composition profiles from observed radiances. These studies will provide an assessment of the principal sources of error involved in remote sensing experiments. In the case of systematic errors they will illuminate those factors which must be taken into account in interpreting the data obtained from sounders. In the case of the propagation of random errors through numerical calculations they will show which, among alternate computation schemes, gives the smallest error in retrieved profiles.

W75-70427 **175-21-48**
Goddard Space Flight Center, Greenbelt, Md.
CLOUD TOP SCANNING RADIOMETER DEVELOPMENT
D. S. Smith 301-982-4591
(175-21-43; 175-61-41)

The objectives are to develop a cloud top scanning (CST) radiometer, integrate it with a high altitude aircraft, and analyze the measurements. The emphasis on the utilization of measurements from future meteorological geosynchronous satellites is becoming centered on the investigation of mesocale phenomena (thunderstorm, fog, tropical cyclones, etc.). Winds (as derived from cloud motions), surface temperatures, and cloud structure are some of the key meteorological parameters that can be measured from geosynchronous satellites that are associated with these phenomena. The accurate specification of satellite sensing requirements to measure the parameters is very important. A scanning radiometer mounted on a high altitude aircraft will be able to establish these specifications and improve the interpretations of the measurements. In addition, the sensor can be used to improve multispectral techniques that have already been developed with past satellite data that can be used with future satellite systems. An example of an important investigation that can be made with the radiometer is to establish the equivalent blackbody temperature differences between overshooting cloud domes and the surrounding cirrostratus anvil. These domes are related to the type of weather activity that is associated with the thunderstorm (Heavy rain, hail, tornado, etc.). It has been assumed, but never verified, that---

W75-70428 **175-21-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
APPLICATION OF SATELLITE DATA TO ATMOSPHERIC MODELS
D. P. Burcham 213-354-3028

Theoretical and applied studies will be conducted with the following objectives: (1) application of new analytical techniques for the determination of temperature profiles in the presence of clouds, using infrared and microwave data from Nimbus F, and from Nimbus 5, NOAA 2 and NOAA 3 sounders; (2) adaptation of the resulting temperature profiles to the requirements of the general circulation model (GCM) of the Goddard Institute for Space Studies (GISS) in order to demonstrate the impact of remote sounding data on weather forecasting; (3) to improve the accuracy of computed atmospheric transmission functions needed for data interpretation; and (4) to define and propose a new all-weather satellite experiment concept for routine sounding of temperature and humidity in the earth's atmosphere.

W75-70429 **175-21-52**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
SENSING OF CLOUDS AND AEROSOLS FROM METEOROLOGICAL SATELLITES
D. P. Burcham 213-354-3028

A program of theoretical and experimental studies related to remote sensing from meteorological satellites of properties of earth's clouds and aerosols (nature, structure, dynamical evolution) will be conducted with the following objectives: (1) development of concepts of scattering and polarization theory that can form the basis of sensitive techniques for real-time sensing of cloud and aerosol characteristics (type, particle shape and size distribution, complex refractive index, total number density); (2) application of these developments to the optimized design of particle size spectrometers and refractometers appropriate for meteorological measurements; and (3) construction of prototype instrumentation for laboratory and field experiments. The studies to be conducted in FY-75 will pertain essentially to: (1) optimization of a newly developed technique utilizing the properties of the angular and spectral variations of forward scattered light, and (2) extension of this technique to the forward scattering of thermal radiation in the case of aerosols and thin clouds. Subsequent objectives will be: detailed feasibility study for a satellite experiment based on thermal formal scattering; investigation of scattering and polarization in nonforward directions; and potentialities of angular and spectral polarization.

W75-70430 **175-31-31**
Langley Research Center, Langley Station, Va.
MICROWAVE RADIOMETRY FOR REMOTE SENSING OF OCEAN-ATMOSPHERE INTERFACE
G. B. Graves 804-827-3745
(161-05-07)

The objective of this work is to investigate the application of quantitative microwave radiometer measurements to the weather and climate disciplines, and particularly to the determination of ocean-atmosphere interface. Research is focused in three major areas, namely: radiometer hardware performance, radiometer measurement techniques, and radiometer data analysis and interpretation. The approach is to develop octave bandwidth, swept frequency microwave and millimeter wave radiometers and low noise high efficiency radiometer antennas for possible use on Nimbus, EOS, and/or space shuttle. Also, multispectral microwave emissivity signatures of the atmosphere and ocean will be theoretically and experimentally evaluated to develop measurement and data inversion methods to infer physical properties from radiometric brightness temperatures.

W75-70431 **175-31-41**
Goddard Space Flight Center, Greenbelt, Md.
SENSOR SUBSYSTEM ANALYSIS AND DESIGN
J. B. Flaherty 301-982-6862

Large aperture high resolution earth observing scanning radiometers will be used in low orbit (ERS) and a synchronous altitudes (SEOS). The large radiometers will be flown when the space shuttle becomes available, either on a shuttle-launched spacecraft in low orbit (EOS) or by being brought to synchronous orbit by a space tug. The impact of such large sensors on the various spacecraft subsystems will be studied. The use of large sensor mechanical scanning mechanisms 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 landmark recognition systems will be used. Functional models of the sensor hardware will be developed where feasible. Structural requirements for supporting a large sensor scanning mechanism without causing detrimental vibrations will be determined. The accurate referencing of the motion of the large sensor mechanism relative to the spacecraft is also necessary and high quality rate and position sensors will be developed for the scanning mechanism. The angular position of the spacecraft relative to the earth between stellar and landmark references will be determined by a high quality rate gyro subsystem. Specific sensor scanning mechanisms will be investigated as well as spacecraft motion for scanning since this is integral with the spacecraft design.

W75-70432 **175-31-42**
Goddard Space Flight Center, Greenbelt, Md.
SPACECRAFT DATA PROCESSING
Marvin Maxwell 301-982-4036
(506-20-21)

Future earth observation spacecraft will generate very large quantities of data. This RTOP will investigate and develop systems that will provide the needed spacecraft and supporting systems to acquire, compact, process, and buffer this data. The first consideration is to optimize the sensor, multiplexer and ground processing elements as a total system to maximize the information to the users. Techniques are being developed to acquire and multiplex data efficiently from a variety of sensors for meteorological and earth survey applications. Magnetic tape recorder systems have been developed to provide long life and high performance spacecraft storage systems, but no further work in this area is proposed in the RTOP. On-board processing techniques and systems will be developed to optimize the information content of the data as delivered to the user. Many tasks in this RTOP are in the multidisciplinary areas of Earth Observation Satellite studies in which all of the various tasks are supporting activities primarily in weather and climate, but also in earth resources survey, and earth and ocean physics applications.

W75-70433 **175-31-43**
Goddard Space Flight Center, Greenbelt, Md.
MICROWAVE METEOROLOGY
J. L. King 301-982-5702
(175-44-51; 175-31-31; 645-25-08)

The objective is to develop microwave radiometer and radar technology for global surveillance of storms from orbit to determine precipitation rate profiles, liquid water content, cloud height, and cloud structure. Advanced spacecraft system studies will be conducted to define the microwave sensors needed to make the meteorological measurements. Both radiometer and radar systems will be studied and system comparisons made to select the optimum combination of the active and passive techniques to satisfy the meteorologist's needs within the constraints of reasonable shuttle era spacecraft technology. Antenna systems, receiver systems, transmitter systems, and APT microwave image transmission systems will be studied and hardware development undertaken where system deficiencies are identified. Three areas of deficiencies presently identified are (1) the two meter and larger scanning microwave radiometer antenna which will be studied under this RTOP's FY-75 funding, (2) a 37 GHz spacecraft parametric amplifier, and (3) an APT microwave image transmission system study.

W75-70434 **175-41-75**
Marshall Space Flight Center, Huntsville, Ala.
CLOUD PHYSICS OPTICAL AND IMAGING MEASUREMENTS RESEARCH
W. W. Vaughan 205-453-3106
(645-10-01)

The main objective of this RTOP is to assure the planning and executing of a coherent and coordinated measurements techniques evaluation and assessment research program for selection and definition of the optimum zero-g atmospheric cloud physics laboratory optical and imaging instruments. This will be accomplished by developing and/or improving techniques for making remote measurements of surface temperatures of liquid droplets and ice crystals, cloud droplet size distributions, condensation nuclei size distribution, and liquid water content. These techniques should be capable of detecting continuing incremental changes in the parameters being measured. The main techniques requiring assessment and research to develop new and/or improve existing optical detection and imaging devices for use in accomplishing cloud microphysical experiments in the low-gravity environment of the shuttle/spacelab are such as IR imaging, Raman spectroscopy, holography, X-ray diffraction, laser Doppler, light scattering, etc. The planning of this program will begin with the results of the measurements techniques supporting research and technology assessment as reported in NASA CR-129013. A group of advanced techniques have been initially selected for detailed study and advanced infrared imaging, Raman spectroscopy, ultraviolet water vapor profile determination, and X-ray diffraction. In addition, other advanced technology techniques will be studied. The entire evaluation program will be executed by an in-house MSFC research and test team.

W75-70435 **175-51-45**
Goddard Space Flight Center, Greenbelt, Md.
SEVERE STORM ANALYSIS USING GEOSYNCHRONOUS SATELLITE MEASUREMENTS
W. E. Shenk 301-982-5948
(171-61-41; 175-21-43)

The main purpose of this program is the development of methods to improve the detection and prediction of severe storms using geosynchronous satellite measurements. These storms include severe local storms (including those that produce tornadoes), tropical cyclones, and extratropical cyclones. Flood situations (which can be produced by any of the above storm types) will also be studied. In addition, at a lower level of effort, the geosynchronous satellite capability to detect and improve the prediction of fog, frost and freeze situations, and dust storms will be determined. The specific geosynchronous satellite measurements that will be used are from the Visible and Infrared Spin Scan Radiometer (VISSR) on the Synchronous Meteorological Satellite (SMS) and the Geosynchronous Very High Resolution Radiometer (GVHRR) on the sixth Applications Technology Satellite (ATS-6). Both sensors are working satisfactorily in orbit. The objectives of this RTOP are essentially the same as those of the proposal entitled A Proposal for the Acquisition, Processing, and Analysis of ATS-F GVHRR and SMS/GOES VISSR Visible and Infrared Measurements submitted to NASA Headquarters by GSFC on Sept. 5, 1973.

W75-70436 **175-61-11**
Ames Research Center, Moffett Field, Calif.
EFFECT OF ATMOSPHERIC CONSTITUENTS ON CLIMATE VARIATION
Dean R. Chapman 415-965-5065
(176-61-11; 175-21-11)

Long range goals are to assess the sign and magnitudes of climatic variations induced by changes in the amount of various atmospheric aerosols and trace gases. The effects of both natural and man-made perturbations will be considered, and attention will be given both to global effects and to effects in regions such as basins or valleys where local climates can be defined. A combination of laboratory measurements, theoretical modeling, and comparison with records of past climatic variations will be

utilized to assess the possible climatic effects of contaminant emissions into the atmosphere. Laboratory measurements will be made of the radiative properties of candidate contaminants. These include the specification of the optical properties of aerosols of interest. The theoretical modeling includes the development of radiation and dynamical models, that will be applied on local, regional, and global scales. Studies of past records of climatic change, as illustrated by the investigation of polar ice cores, will supply clues on the past causes of climatic change, as well as permitting an assessment of the models. The use of remotely sensed parameters in the climatic models will be stressed. The sensitivity of the models to variations in the parameters they utilize will be assessed, and the question of the utility of mesoscale models (which can be run only for short time periods) to the assessment of climatic effects will be investigated.

W75-70437 **175-61-41**
Goddard Space Flight Center, Greenbelt, Md.
TECHNIQUES FOR UTILIZING SATELLITE OBSERVATIONS IN METEOROLOGICAL APPLICATIONS
J. Theon 301-982-5249
(175-11-42; 175-21-43; 175-21-46)

The objective is to apply satellite observations to the quantitative measurements of meteorological phenomena. Specifically the satellite data are applied to determine the location and intensity of rainfall, the vertical distribution atmospheric temperature, humidity, and ozone, and cloud motions (winds) 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 the remote sensing of the global meteorological observing system required for large-scale, long term weather forecasts (viz. the Global Atmospheric Research Program-GARP), and, similarly, 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.

W75-70438 **175-61-42**
Goddard Space Flight Center, Greenbelt, Md.
ANALYSIS OF THE ENERGY INTERACTIONS BETWEEN ATMOSPHERIC LEVELS AND OF SOLAR TERRESTRIAL RELATIONSHIPS
D. F. Heath 301-982-6421

The interactions of mechanical, radiation, and chemical energies between the lower and upper regions of the atmosphere and its interactions with the sun and distributions of minor constituents are investigated. This encompases absorption, scattering and emission of solar and atmospheric radiation by constituents of the stratosphere and meososphere. The photochemical and chemical reaction in the upper atmosphere, horizontal and vertical transport processes, gravity waves, turbulence, and tides originating in the lower atmosphere are investigated. Satellite data on global ozone distributions and ultraviolet solar radiation and their variability with time in conjunction with standard meteorological parameters will be investigated in terms of possible relationships between solar activity and meteorological phenomena. Prior to the flights on Nimbus of experiments for monitoring and measurement of ultraviolet solar spectral irradiance and the determination of global distributions of atmospheric ozone, there existed too little data to investigate stratospheric transport and dynamical processes on a global basis. Furthermore, recent studies have indicated a persistent correlation between solar activity and meteorological phenomena which need to be explored in terms of the new satellite data. New absolute spectroradiometric calibration techniques need to be developed and used in the calibration of instruments being flown on satellites, rockets, and aircraft if measurements of the solar constant, solar spectral irradiance and spectral radiance of the terrestrial atmosphere are to be used in long term climatological studies.

W75-70439 **175-61-44**
Goddard Space Flight Center, Greenbelt, Md.
STRATOSPHERIC OZONE - DISTRIBUTION AND DYNAMICS FROM SATELLITE OBSERVATION
D. F. Heath 301-982-6421
(175-61-42; 175-21-42)

Advanced analysis techniques will be developed and utilized for the reduction of the nearly four-year data base on stratospheric ozone which has been acquired from observations with the Nimbus 4, backscatter ultraviolet (BUV) experiment. The data will be made available in a format which best reflects the needs of the scientific community for the investigation of basic stratospheric processes and dynamics. The data will be formulated so that it may be used as a benchmark for global ozone distribution near the period of solar maximum of the eleven year sunspot cycle. The initiation of supersonic aircraft flights in the stratosphere and the eventual use of the space shuttle on an operational basis will lead to the introduction of significant quantities of NO, H2O, HCl and particulate matter into the stratosphere with the possibility of causing significant changes in the global distribution of atmospheric ozone. This subsequently alters the isolation of ultraviolet solar energy at the ground. For these reasons it is imperative that a benchmark global atmospheric ozone climatology be developed over the eleven year solar sunspot cycle. The ozone data derived from the BUV experiment on Nimbus 4 will provide the baseline for the period of solar maximum and it is anticipated that the Solar, Backscatter Ultraviolet/Total Ozone Mapping System (SBUV/TOMS) experiment will provide the required global ozone data about the period of solar minimum. The stratospheric ozone distributions will be used as a tracer in the investigation of stratospheric dynamics which are clearly shown in the global ozone distribution being derived from the BUV.

W75-70440 **175-61-61**
Wallops Station, Wallops Island, Va.
OZONE MEASUREMENTS
J. F. Spurling 804-824-3411
(176-11-61; 176-11-62)

The objective is the improvement of techniques for the measurement of ozone. The approach is to: (1) improve the methods of evaluation of remote optical measurement of ozone and other atmospheric trace constituents 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; and (4) utilize the ground-based and balloon-borne ozone measurement systems to provide truth data for the calibration and validation of rocket and satellite-borne ozone sensors, for example, limb radiance inversion radiometer (LRI), scheduled to fly on Nimbus F in 1974 and measure ozone profiles in the region from 15 to 50 kilometers.

W75-70441 **175-61-71**
Marshall Space Flight Center, Huntsville, Ala.
INTERRELATIONS BETWEEN ATMOSPHERIC MOTIONS OF DIFFERENT SCALES
W. W. Vaughan 205-453-3106
(175-61-72)

Past research has demonstrated the existence of significant relationships between small size systems which are detectable in synoptic data and sub-synoptic 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 relationships that exist between mesoscale atmospheric phenomena and larger-scale averages of the same or related phenomena. In addition, the atmospheric structure derived from polar orbiting and geostationary satellite remote sensing measurements will be assessed relative to applicability of mesoscale structure definition. This wll be revealed by selected

atmospheric variability experiments involving radiosonde, rocketsonde, and satellite soundings data sets.

W75-70442 **175-91-11**
Ames Research Center, Moffett Field, Calif.
AIRCRAFT SUPPORT OF THE METEOROLOGY PROGRAM
Dean R. Chapman 415-965-5065

This RTOP is to provide an airborne platform, carrying instrumentation for meteorological measurements. Experiments will be mounted and flown aboard the Convair 990 (NASA 712) to conduct basic meteorological studies and to support satellite instrumentation development and data analysis. A necessary first step in the development of satellite instrumentation for remote sensing of the earth and atmosphere is to obtain information basic to the understanding of factors influencing the spectral signals to be observed from space. This information must be obtained aboard aircraft because measurements must be made from the ground to the stratosphere with speed and flexibility in geographical location to obtain data under the many desired meteorological conditions. Scales ranging from local to global are amenable to study by an aircraft such as the CV-990.

W75-70443 **175-91-41**
Goddard Space Flight Center, Greenbelt, Md.
SYSTEMS AND MISSION ANALYSIS OF METEOROLOGY PROGRAM ELEMENTS, METEOROLOGY PROGRAM OFFICE
E. A. Neil 301-982-6291

The objective is to provide financial support to the NASA Meteorology Program Office (MPO) in the conduct of its business in support of the Office of Applications and the various program offices represented. Results of efforts under this RTOP will be used in performing evaluations, providing recommendations, and developing future plans for NASA's Weather and Climate mission and programs. Funding will be utilized through in-house and available support services contractors for selected efforts in fulfilling the objectives of the MPO as defined in the proposal dated 10 July 1972, covering the formation of the MPO at GSFC. Emphasis will be placed on solicited areas of particular importance to future programs. Studies will be focused on new technology already emerging so as to expedite applications of these developments and on future requirements so as to identify areas requiring initiation of new technology development. Functional expertise available at GSFC and other centers involved in Weather and Climate activities will be drawn upon to the maximum extent possible. Quick-reaction task order contractors will be used for support for technical writing/editing, preparation of visual aid materials and other resources not otherwise available. Support also will be provided for meetings and/or symposia having a programmatic input and as sponsored by Headquarters.

W75-70444 **175-91-42**
Goddard Space Flight Center, Greenbelt, Md.
EARTH OBSERVATIONS LABORATORY FIELD EXPERIMENTS, AND CALIBRATION OF RADIATION SENSORS
Warren A. Hovis 301-982-6465

The objective is to provide laboratory calibration facilities, sensor technique research, sensor component evaluation and test and to conduct field programs where new concepts in meteorological remote sensing and new sensors are tested prior to flight on spacecraft. Anin-house calibration facility is maintained and continually updated to provide calibration support to both field projects and spacecraft sensor projects. The present capability extends to sensors with up to 46 cm diameter aperture and will be increased to meet the demand for larger aperture sensors. Calibration sources and consultation are supplied to projects such as SMS VISSR, HIRS, ITOS VHRR, TIROS N, AVHRR, and the Nimbus G Sensors. The new and rapidly developing microwave sensing effort is supported with laboratory measurements of the basic properties of natural materials in the microwave spectral region utilizing in-house measurements in various frequencies. The laboratory measurements are utilized to guide development of aircraft and eventually spacecraft borne techniques and to provide data handling experience before spacecraft flights. The field experiments on aircraft are supported with equipment such as data processing equipment, digitizers, tape recorders, auxiliary sensors and aircraft housekeeping recorders that are common to any aircraft field program.

W75-70445 **175-91-44**
Goddard Space Flight Center, Greenbelt, Md.
ANALYSIS OF THE ECONOMIC BENEFITS OF METEOROLOGICAL SATELLITE DATA
E. A. Neil 301-982-6291
(683-74-16)

The objective is to demonstrate that meteorological satellite data, based on space technology that has been, or is planned to be developed, can be utilized for applications having a definable economic and social benefit. The Meteorology Program Office (MPO) will complete a review of existing studies that relate to social and economic benefits. The MPO will also define the multiplicity of interests to be served by improved forecasting and delineate the benefits to be gained by selected, special interest groups. The MPO intends to formulate a baseline for future study to complete this indepth understanding of the economic benefits. The data will be used by the MPO as a basis to recommend future research and operational requirements based on needs of the ultimate user. The study will provide for a continuing update, evaluation, and set of recommendations based on a defined need as reflected by accurate data obtained from the user community. This will assist in guiding future plans in the field of meteorology with regard to sensor development, improved analysis, and information dissemination.

Pollution Monitoring SR&T

W75-70446 **176-24-31**
Langley Research Center, Langley Station, Va.
NUMERICAL MODELING OF POLLUTANT TRANSPORT AND DISPERSION
E. S. Love 804-827-2893

Analytical models will be developed and studies carried out to determine the nature of significant changes in the stratospheric temperature or constituents that occur as a result of stratospheric emissions due to natural causes or due to aircraft operations. Interactions between radiative energy transfer, diffusive mass transfer, and chemical transformations occurring in the stratosphere will be considered. Studies will also be made to determine the impact light-scattering particulates or aerosols have on the atmospheric energy flux, heat balance, and photochemistry. The stratospheric effects problem is being attacked using single and multidimensional diffusion and radiation models which incorporate stratospheric chemistry and photochemistry. The radiation transport submodel is based on a recently developed solution to the radiative transfer equation and accounts for emission and absorption of nongray radiation. An analysis of the effect of particulates and aerosols on the atmospheric energy balance will use a time relaxation technique and the method of moments, a more approximate solution. The temperature in the atmosphere will be determined under the assumption of radiative equilibrium with a convective correction for the troposphere. Parametric studies will be made to determine the importance of particulate and aerosol vertical distributions, concentrations, size distributions, and optical properties. The effects of scattering, due to aerosol layers in the stratosphere, on stratospheric photochemical processes (particularly those related to the O3 concentrations) will be---

W75-70447 **176-11-41**
Goddard Space Flight Center, Greenbelt, Md.
DISPERSION MODELING OF ATMOSPHERIC CONTAMINANTS
Richard W. Stewart 212-866-3603

The objective is to develop a capability for calculating the distribution of gaseous and particulate contaminants in the earth's atmosphere on local, regional, and global scales. The approach is to develop techniques for obtaining simple and reliable solutions to the equations describing the convective and diffusive transport

removal mechanisms and chemical interactions of the contaminants. Two methods for predicting dispersion of inert pollutants in urban areas were developed. One method consists of obtaining an approximate analytical solution of the transport equation using integral methods, and the other is a numerical method based on the multicell concept. These methods will be extended so that they can be applied to large regions and to the global atmosphere. Further generalization is necessary to include the effects of temperature stratification of the atmosphere, linear and nonlinear removal effects, chemical interactions between different pollutants, and other pertinent phenomena.

W75-70448 **176-11-42**
Goddard Space Flight Center, Greenbelt, Md.
STUDY OF THE PHOTOCHEMISTRY OF THE NATURAL AND PERTURBED STRATOSPHERE WITH GLOBAL ATMOSPHERIC MODELS
Richard W. Stewart 212-866-3603

The objective is the theoretical determination of self-consistent temperatures, radiation fields, and minor constituent distributions in the stratosphere and the calculation of the chemical and thermal response of the stratosphere to the injection of contaminants at prescribed rates. Changes in stratospheric ozone levels resulting from hydrochloric acid or nitric oxide injection are of special interest. The constituent distributions as functions of latitude and altitude will be computed by simultaneously solving the energy balance equation for the temperature field and the coupled continuity equations for the species of interest in the stratosphere. These equations will include descriptions of the advective and turbulent transport, as well as the photochemistry of all species of interest. Primary inputs to the model are zonally averaged winds and diffusivities, and absorption cross sections, quantum yields, and chemical reaction rate coefficients. The results of these calculations will comprise a self-consistent description of the temperature and composition of the stratosphere and of the response of the stratosphere to chemical perturbations. This study will provide an assessment of the impact of space shuttle and high-altitude aircraft operations on stratospheric ozone levels.

W75-70449 **176-11-11**
Ames Research Center, Moffett Field, Calif.
LABORATORY INVESTIGATION OF MINOR ATMOSPHERIC CONSTITUENTS
D. R. Chapman 415-965-5065

The objectives are to provide the spectroscopic data for detection and quantitative abundance determination of minor constitutents in the earth's atmosphere and to develop new techniques for remotely sensing minor atmospheric constituents and pollutants. The gases to be studied will include pollutants such as NO2, SO2, CO HCl, and O3. High resolution grating spectrometers and interferometer spectrometers will be used in conjunction with a variety of existing absorption cells to measure the absorption spectra of the minor constituents. Data obtained in the Laboratory will be used (1) to interpret the spectra of gas samples obtained via horizontal and vertical aircraft flights and (2) to define the spectral region(s) most useful for remote sensing techniques. Emphasis will be given to stratospheric pollutants.

W75-70450 **176-11-31**
Langley Research Center, Langley Station, Va.
DETECTION AND CHARACTERIZATION OF ATMOSPHERIC AEROSOLS
G. B. Graves 804-827-3745

Techniques are to be developed which apply to future space missions for determining the origin and role of aerosols in the atmosphere and their impact on atmospheric pollution and changes in the earth' albedo. Specific tasks include: (1) analysis of remote measurements data taken from helicopter, balloon, and shipboard measurements, to establish inversion techniques for the visible radiation polarization measurement and solar extenction techniques; new sensing methods are also to be investigated; (2) development of and constituent analysis of aerosols; and (3) theoretical investigation of light scattering from nonspherical particles.

W75-70451 **176-11-61**
Wallops Station, Wallops Island, Va.
LABORATORY INVESTIGATIONS OF MINOR ATMOSPHERIC CONSTITUENTS
Shardanand 804-824-3411

The objective is to carry out an integrated laboratory study in order to provide the spectroscopic data that are required to assess the effects, and to detect and quantitatively determine the amounts of minor constituents in the earth's atmosphere. In the later part of the program the development of new techniques of measuring the minor species may be undertaken. The basic technique used in measuring these species is to monitor the transmitted or scattered radiation (Raman, resonance-fluorescence) through the atmosphere assuming that the species are in equilibrium. For this, reliable spectroscopic data, such as absorption and scattering (Rayleigh, Raman, resonance-fluorescence) coefficients are required. Although the bulk of absorption coefficient data for most of the individual gases do exist, a careful consideration is required in their use when more than one gas are simultaneously present and subject to photochemical changes. However, knowledge of photon scattering (Rayleigh, Raman, resonance-fluorescence) is very meager. Therefore, the absorption data will be obtained in simulated conditions of photchemical equilibrium (dynamic and/or static) for chemically active constituents (NOx,SO2,O3,O2...). For this purpose the multiple gas cells in series which can be connected to each other for reactions to occur will be utilized. The study of photon scattering will also be an integral part of this program to obtain the spectroscopic data of electromagnetic radiation interaction with atmospheric constituents.

W75-70452 **176-11-62**
Wallops Station, Wallops Island, Va.
DETECTION, CHARACTERIZATION AND ANALYSIS OF ATMOSPHERIC AEROSOLS
A. C. Holland 804-824-3411
(185-47-94; 177-61-61)

Objectives are to develop the analytic techniques necessary to interpret remotely sensed data on the atmospheric aerosol and to develop the models necessary to evaluate the impact of atmospheric aerosols on the earth's albedo. Models of radiative transfer through the earth's atmosphere for both plane wave and finite beam illumination will be developed and tested. The model atmospheres used will be: (1) plane-parallel, stratified and (2) spherically symmetric, stratified models. These simulations will be used to determine the best strategies for the remote detection of atmospheric aerosols using both passive and active techniques. The models will further be used to calculate the effect of varying amount of atmospheric aerosols on the earth's radiation budget.

W75-70453 **176-13-11**
Ames Research Center, Moffett Field, Calif.
WATER QUALITY AND POLLUTION SENSING
D. R. Chapman 415-965-5065

Objectives are to measure and study those characteristics of water pollutants and water quality indicators which are accessible by remote sensing in order to provide techniques for the identification, quantification and mapping of water pollution by remote sensors. Field studies of water bodies containing predominantly one type of water pollutant will be conducted to develop basic data on various pollutants regarding spectral signatures, thermal effects and, possible, active or passive fluorescence. Laboratory and analytic investigations will be conducted when necessary to separate competing processes and when sufficiently real situations can be simulated in the Laboratory. Candidate water bodies will be selected for study by preliminary multispectral aerial photography. Field investigations of spectral signatures will be conducted on the surface and from aircraft using a fast 500-channel radiometer of the vidicon type and both laboratory and surface field investigations will use a conventional spectroradiometer. Thermal effects will be studied using an airborne RS-25 calibrated thermal IR line scanner in conjunction with simultaneous in situ temperature measurement in the water body. Multispectral photography will be conducted simultaneously on all aerial missions, sometimes with narrow

band filters to pick out special effects for future sensor definition work. Possibilities for real-time multispectral imagery will be investigated using a field-sequential color television camera system.

W75-70454 **176-13-33**
Langley Research Center, Langley Station, Va.
WATER QUALITY AND POLLUTION SENSING
G. B. Graves 804-827-3745

The objective is to determine remotely observable characteristics of water pollution and water quality indicators and develop remote sensing techniques for the identification, quantification, and mapping of water pollution. Initial effort will concentrate upon the use of AAFE developed instrumentation to identify remotely observable water quality parameters. The multichannel ocean color sensor will be flown over a variety of water masses to measure visual spectral characteristics of water pollutants including algae, sediment, oil, sewage, and industrial waste. Simultaneous water temperature and thermal infrared spectral measurements will be made with the Hadamard transform spectrometer. Algorithms which treat collected data to maximize sensitivity to specific pollutants will be developed and used for plotting color coded contour maps of pollutants. Also, techniques will be developed for providing a real time operational indication of pollutant level for use of editing data and for in-flight operation control. The results of the above efforts will be used to define optimized design parameters for spacecraft and/or aircraft pollution monitoring systems.

W75-70455 **176-14-31**
Langley Research Center, Langley Station, Va.
STATISTICAL INTERPRETATION OF REMOTELY SENSED POLLUTION DATA
E. S. Love 804-827-2893
(176-24-31)

The objective is to develop statistical techniques for deriving the maximum possible information on the spatial and temporal distribution of pollution from satellite, aircraft and in situ measurements. The techniques will be developed for both air and water pollution. Maximizing the use of data includes, for example, the statistical interpretation of measurements of air pollution from Nimbus-g and the Aircraft Regional Monitoring System (ARMS). Other information (such as meteorological data, pollution dispersal models, and a pollution source inventory) must be coupled with the remote and in situ measurements to achieve the end objectives of the program-pollution monitoring and source location. The equivalent techniques will be developed for water pollution using data from Seasat, ERTS, and the second pollution monitoring satellite as well as aircraft and in situ (buoy) measurements.

W75-70456 **176-21-31**
Langley Research Center, Langley Station, Va.
ATMOSPHERIC POLLUTION SENSING
G. B. Graves 804-827-3745
(176-21-33; 176-91-32; 638-00-00)

The objective is to develop techniques and sensors to measure atmospheric trace constituents, primarily gaseous. The primary emphasis is on development of remote sensors for measuring pollutant distributions over regional and/or global areas from aircraft and space platforms. Spectral signatures of important trace constituents and interferants will be determined accurately for temperature and pressure conditions in the earth's atmosphere, and current work includes O3, HNO3, NO2, and stratospheric particles. Multigas radiative transfer models describing EM signals as functions of realistic atmospheric parameters are being developed, using line-by-line absorption characteristics, for inverting data from Nadir sensors; and inversion algorithms for limb-scanning sensors are being optimized. The development of a brass-board gas-filter radiometric sensor (GFRS) for CO was completed and aircraft flight tested during FY-73-74, and data reduction techniques developed. A companion GFRS for SO2 will be assembled, and tested during FY-75. An active technique for measuring tropospheric pollutants will be studied during FY-75. The differential absorption lidar is a concept using a UV laser and atmospheric aerosols as scattering centers to obtain range resolved measurements of SO2, and NO2 and O3.

W75-70457 **176-21-32**
Langley Research Center, Langley Station, Va.
LANGLEY RESEARCH CENTER–GEORGE WASHINGTON UNIVERSITY ENVIRONMENTAL MODELING PROGRAM
E. S. Love 804-827-2893

The objectives of this educational and research program conducted in cooperation with George Washington University (GWU) are: (1) to expand the environmental modeling activities at Langley in a manner which directly supports the Office of Applications' remote sensing activities, Langley Research Center's involvement in the Nimbus G satellite experiments in the stratosphere, and other environmental modeling activities at Langley; (2) to strengthen and expand the research and educational opportunities within the Joint Institute for Acoustics and Flight Sciences (JIAFS) at Langley; (3) to increase the quality and number of trained research scientists in the area of atmospheric environmental modeling; and (4) to promote cooperation between NASA, GWU, and other organizations and agencies involved in this work area (EPA, NOAA, etc.). The approach taken to accomplish these objectives will be to establish within JIAFS, a research and education program in environmental modeling in conjunction with GWU. Senior faculty members and qualified graduate research assistant scholars will be recruited by GWU. The faculty and research assistants will conduct research in conjunction with Center professionals which is supportive of the needs of Langley and the Office of Applications. The research and educational efforts of the research assistants will lead to a Master of Science degree from GWU upon completion of the basic requirements, normally 2 years. The program will be managed by a coordination committee composed of NASA and GWU personnel.

W75-70458 **176-21-33**
Langley Research Center, Langley Station, Va.
REMOTE SENSING CONCEPTS FOR TROPOSPHERIC POLLUTANTS
G. B. Graves 804-827-3745
(176-21-31; 176-91-32; 638-00-00)

The objective is the analysis and development of remote sensing techniques to measure pollutant concentrations in the troposphere from aircraft and satellites. Special emphasis will be given to measurements of near surface pollutant concentrations and of the vertical distribution within the troposphere. Remote sensors for tropospheric pollutants now under development are limited to measurements of total burden beneath the observation platform. The radiative transfer pertinent to the use of a side or upward viewing spectral radiometer from aircraft will be studied to evaluate the usefulness of the concept for measuring vertical pollutant distributions within the troposphere. Nadir-viewing remote sensors are subject to errors introduced by temporal and spatial variations of the observed earth background. An analytical and experimental study to evaluate the magntiude of background induced errors as a function of sensor footprint, spectral interval, modulation transfer function, and pointing stability will be initiated in FY-75.

W75-70459 **176-21-41**
Goddard Space Flight Center, Greenbelt, Md.
REMOTE SENSING CONCEPTS FOR TROPOSPHERIC POLLUTANTS
C. L. Korb 301-982-4347

The purpose is to identify and assess the feasibility of using different concepts for measuring near surface concentrations and the total vertical path content of trace gases and pollutants which are primarily concentrated in the troposphere. The atmospheric transmission spectrum of trace gases and interfering species will be modeled in conjunction with various instrumental methods of detecting the scene energy. Particular attention will be given to high spectral resolution techniques using the reflected infrared portion of the spectrum which are thus, sensitive to the effects of gases near the earth's surface. Preliminary studies indicate that instrumental techniques and methods of data processing can be devised so that the experimental measurements

yield the total pollutant content in a vertical atmospheric path and so that the measurements are relatively insensitive to sensor calibration, and scene reflectivity and temperature variations. Instrumentation will be developed based on the results of the modeling and field experiments will be carried out to develop and test new remote sensing techniques. The determinations of total gas content are to be supported with surface truth measurements in order to assess the experiment accuracy. Laboratory measurements of the transmission spectrum of trace gases will be made with high spectral resolution in support of the pollution measurements.

W75-70460 **176-22-21**
Lewis Research Center, Cleveland, Ohio.
LAND POLLUTION MONITORING FEASIBILITY STUDIES
H. Mark 216-433-4000

The objective is to detect, identify and monitor by remote sensing techniques, land pollution due to stripmining of coal, and to determine the degradation of streams due to runoff from this polluted land (toxic spoilbanks). Eventually, optimum techniques for stripmining and related pollution monitoring will be transferred to data obtainable from ERTS-1 and for other earth observation satellites.

W75-70461 **176-31-51**
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 instruments which utilize infrared laser and heterodyne receiver technology for the remote monitoring of atmospheric pollutants from aircraft and spacecraft altitudes. The instruments under investigation and development are of both active and passive types. The active system, based on differential absorption, is presently being emphasized. Both systems provide certain capabilities which are not available using existing passive radiometers or solar absorption spectrometers. At present the task covers both analytical and experimental work. In the first realm, published spectra of several important atmospheric constituents (O3, H2O, NO, NO2) are being studied in order to determine how well the airborne, downward-looking active system would be able to produce concentration versus altitude profiles for each constituent. Experimental work involves several related activities which generally point toward the goal of operating the active system in an aircraft. A ground-based active instrument is set up for monitoring ozone and nitric oxide. Experimental water vapor transmission measurements are being conducted to provide high resolution spectral data for calibrating the laser instrument in atmospheric monitoring. Albedo measurements and aerosol scattering studies are planned with the ground-based system in order to better understand flight operation capabilities. More compact lasers are also under construction. Concurrent analysis will continue on the potential of other remote sensing systems which make use of laser technology and appear to offer advantage over present instruments.

W75-70462 **176-31-52**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
AIRBORNE INTERFEROMETRIC MEASUREMENTS OF ATMOSPHERIC TRACE CONSTITUENTS
D. P. Burcham 213-354-3028
(645-20-02; 501-24-20)

The composition of the atmosphere over a large portion of the Northern Hemisphere will be investigated by means of remote infrared sensing techniques in a series of aircraft flights extending over a period of three years. The objective of the observational program is to obtain a complete inventory of atmospheric trace constituents and pollutants with a sensitivity extending down to the 10 to the minus tenth power range, and to study their three-dimensional and temporal variation in the troposphere and stratosphere. The experimental approach involves the use of a very high resolution fast Fourier interferometer spectrometer to obtain absorption spectra in the 1 to 9 micron region in short time intervals (approximately 200 sec). The instrument will be mounted in aircraft flying at altitudes ranging from 1 km to 20 km. Observations will be made by viewing the earth's surface in the Nadir mode to study tropospheric composition, and by observing the sun through long atmospheric paths traversing the stratosphere in the horizontal-looking mode. The work to be accomplished includes fabrication of an improved version of the existing Fourier spectrometer which is presently being used in programs making preliminary compositional measurements, installation of the new instrumentation in the various aircraft, conduct of the observational program, data analysis and interpretation of the results.

W75-70463 **176-52-41**
Goddard Space Flight Center, Greenbelt, Md.
DEMONSTRATION OF THEMATIC DATA BASE USE FOR POLLUTION MONITORING IN THE MID-ATLANTIC STATES.
Phillip Cressy 301-982-5483

The objectives are to integrate remotely sensed and other data pertinent to environmental problems in a limited test area; to identify, in that area the disparate users on the operational level and to define technical data products which can most readily and advantageously be applied by operational level users having similar needs in other regions. At the center of this effort is a task for a land use-environmental study which has, as its purpose, (1) the integration of the data produced in the several tasks of the study; (2) the development of a base (in map and computerized form) of regional land use information; (3) the identification and stimulation of a local user community; (4) the dissemination of data in a form in which it can readily be applied by the users; (5) the assessment of the efficacy of the regional survey, especially in comparison with alternative methods; and (6) the consideration of system modifications required for greater utility and efficiency. The objectives of the tasks are to explore the important environmental problems of silt-, chemical- radionuclear and land pollution and their sources in this geographic area, and how remote sensing can contribute to their alleviation.

W75-70464 **176-53-11**
Ames Research Center, Moffett Field, Calif.
REMOTE SENSING OF EUTROPHICATION AND OTHER LAKE PROCESSES
D. R. Chapman 415-965-5065
(176-13-11; 177-54-13)

The objectives are to study lake eutrophication and associated processes in California in cooperation with federal, state and local agencies by means of remote sensing (satellite and aircraft) in conjunction with water property measurements to provide the synoptic and sequential coverage necessary to understand whole lake processes to the extent required for monitoring and control. Processes in Lake Tahoe and Clear Lake will be studied using earth resources technology satellites (ERTS) I and B and aircraft remote sensing techniques (multispectral images, color images, chlorophyll detection, thermal images, multispectral and polarized video images) coordinated with water property studies. Studies at Lake Tahoe will continue to concentrate on biostimulation by sediment plumes and other nutrient inputs during snowmelt periods and after rainstorms. Studies at Clear Lake are directed toward: (1) documentation of the time and spacial sequence of noxious (blue-green) algal blooms in this naturally eutrophic lake; (2) relating these blooms to nutrient sources and/or physical conditions; and (3) to test aeration control measures designed to inhibit development of floating noxious algal mats.

W75-70465 **176-53-21**
Lewis Research Center, Cleveland, Ohio.
MARINE POLLUTION MONITORING AND ASSESSMENT
H. Mark 216-433-4000

Remote sensing systems are developed for monitoring water quality and for limnological measurements in the Great Lakes. The systems to be developed are to be applied to entire Great Lake water bodies to fully utilize the synoptic advantages of remote sensing. Observations by aircraft and by the Earth Resources Technological Satellite (ERTS) of the spectral response (visible and IR) of the lakes with special emphasis on Lake Erie will be correlated with water sample measurements made at the surface and at several depths including the lake bottom. Correlation of the remote sensing data with biological, chemical,

and water current models will be made to demonstrate the utility of the remote sensing systems. The main objective of the systems is to provide data which can aid in the management of the Great Lakes water resources including the specification of pollution restrictions. Because of this objective the systems will be developed in cooperation with the Environmental Protection Agency, NOAA, and the Canada Centre for Inland Waters, and once developed will be turned over to them for their own use.

W75-70466 **176-53-32**
Langley Research Center, Langley Station, Va.
MARINE POLLUTION MONITORING AND ASSESSMENT
Eugene S. Love 804-827-2893

This RTOP covers cooperative work with user institutions to quantitatively measure the ecological consequences of specific man-made and natural pollutants in the Chesapeake Bay, in adjacent coastal zones, and in nearby rivers. Work includes evaluation of remote sensing and remote readout instrumentation for applicability to marine pollution measurement, study of oil spill effects, study of trace organic compounds in the air, water, and biota of the marine environment, and studies of spectral reflectance signatures of water pollutants. Satellite and aircraft data will be employed to correlate remote data with sediment transport and chlorophyll concentration of selected areas in the Chesapeake Bay, and its estuaries. Spectral reflectance signatures of various pollutants in water will be obtained in the laboratory as well as in the field, and comparisons made with remotely sensed data. Data analysis techniques appropriate to use with multispectral scanner sensing of water pollutants will be developed. 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.

W75-70467 **176-53-71**
Marshall Space Flight Center, Huntsville, Ala.
REMOTE SENSING: FRESH WATER AND LAND POLLUTION; BIOTIC AND ABIOTIC DEGRADATION, ENERGY BUDGET AND CULTURAL PRESSURES
H. G. Hamby 205-453-0889
(177-32-71; 176-54-71)

Objectives are: (1) to establish in controlled laboratory remote sensing tests basic capabilities of state of the art sensing systems to measure water quality parameters in polluted turbid waters typical of the Tennessee River; (2) to establish a definition of the optimum role of in situ instrumentation used in support of remote sensing and to conceptualize a prototype system of instrumentation; (3) to establish with industrial and regulatory agency users, among others, a system for utilizing remotely- and in situ sensed water quality parameters in controlling the release of effluents into streams, rivers and estuaries in Alabama; (4) to examine the potential of remote sensing for detecting acquifers in limestone cavities which are potential contamination sources as a results of established waste control techniques in Alabama. Activities under associated RTOPs and Earth Resources Technology Satellite (ERTS-1) and EREP experiments will be utilized; these will be augmented by laboratory work to answer certain questions raised in examination of ERTS-1 and other remotely sensed data. Through established user/partner relationships with local, state and federal agencies working on water quality problems in Alabama, the techniques of remote sensing and in situ monitoring will be combined, supplemented by an information system, and put to use in a real-life situation.

W75-70468 **176-53-73**
Marshall Space Flight Center, Huntsville, Ala.
REGIONAL WATER POLLUTION SENSING SYSTEMS
H. G. Hamby 205-453-0889
(177-54-71)

Consultation with state planning agencies and user groups relative to water pollution problems and control has identified two major research needs. These are: (1) the development of planning procedures and systems analysis techniques whereby water characteristics can be forecast without the necessity of long historical records, particularly for regions where history means very little due to the rapid change within the region; and (2) the development of a systems approach toward the needs and requirements of an integrated pollution sensing system. The Environmental Applications Office (S and E-EA) has made some preliminary reviews of the needs in these areas. There has been one new study started to develop a hydrological planning model which will be designed to provide adequate accuracies when applied to ungauged watersheds and to measure those shifts in regions undergoing very rapid development. This research study has as its first phase requirement the (1) critial investigation of 'driver' phenomena, (2) construction of generalized planning models, and (3) the sizing of the role of remote sensing in the construction of watershed planning models. In the area of specific sensor requirements, and analysis of the DCP's for the Earth Resources Technology Satellite (ERTS-1) of the Alabama region was made and some preliminary recommendations for further improvements have been made. For this phase of work, it is proposed---

W75-70469 **176-61-11**
Ames Research Center, Moffett Field, Calif.
GLOBAL STUDY OF STRATOSPHERIC CONSTITUENTS
D. R. Chapman 415-965-5065
(185-47-67)

Long range goals are to reach as complete and understanding as possible of stratospheric chemistry and physics by developing computer models of the chemical, transport and radiative processes in the stratosphere and by making physical measurements in those regions. Specifically, global models will be developed as well as a global 'bench mark' as a background against which to compare future measurements and evaluate the effect on stratospheric structure of artificial perturbations (space shuttle, SST). Models are being developed for two purposes: (1) chemical and transport studies of minor atmospheric constituents in order to determine their spatial distributions and understand their respective roles in stratospheric processes; and (2) radiative balance studies to evaluate the long term effects of gaseous and particulate contaminants on global climate. 1-D models which compute transport as well as chemistry have been developed, 2-D models are under development; development of a 3-D model has been initiated. The 2- and 3-D models are being developed and programmed to utilize the power of the Illiac 4 system. Airborne measurements of stratospheric minor constituents including particles in the 0.1 to 1 micrometer range are being made over large geographic areas using aircraft capable of flying in the stratosphere. The measurement of most of the materials of interest is within the state-of-the-art, but instruments are available only for a very few. An instrument package has been assembled, and flight tests have been made in the CV-990 and the U-2 aircraft. A sampling program using the U-2 to measure O3, NO and aerosols is now underway. Data on atmospheric constituents are thus being collected for use with operating 1-D---

W75-70470 **176-62-41**
Goddard Space Flight Center, Greenbelt, Md.
ENVIRONMENTAL INFORMATION SYSTEM
Jane Schubert 301-982-4860

The objectives are to develop an information system which will permit evaluation of the effects of resource management decisions on physical and biological environmental factors. A near real-time description of environmental parameters obtained through information extraction and integration of data from several spacecraft systems will serve as a data base for decision processes at the operational level. The principal tasks are: (1) developing a computer system for integrating data obtained from earth observing satellites, including the Earth Resources Technology Satellites, the Nimbus and NOAA satellites, Skylab, HCMM, and other proposed systems; and (2) the development of models. This will include the development of models to determine the effects of land use decisions on environmental quality, the relation of climatic parameters to potential land use, the effects of land use on macro and micro-climatic parameters, and, finally, develop within the system a forecast model for analyzing the effects on the environment of various management decisions, and (3) the application of information obtained from the system data base

for operational decisions in developing areas that are under environmental stress. The entire Sahelian Zone of Africa is such a region - one in which current land use practices are leading to rapid deterioration of the resource base and environmental quality. The Sahelian zone will be one test site to evaluate the effectiveness of the---

W75-70471 **176-91-21**
Lewis Research Center, Cleveland, Ohio.
JOINT NASA/EPA PROGRAMS IN ENVIRONMENTAL QUALITY
J. Stuart Fordyce 216-433-4000

A joint agreement between Environmental Protection Agency (EPA) Region 5 and NASA Lewis is being developed which will respond to needs which EPA has defined in connection with its responsibility for the Great Lakes area of the country. The specific objective is for NASA to use its technology and capability to develop environmental monitoring systems for the Great Lakes. The approach to be followed is a phased effort in close coordination with EPA Region 5 covering the development, test, feasibility demonstration and technology transfer to the following monitoring systems: for water (1) shipboard, (2) in situ automated, and (3) remote sensing; for air (1) baseline/trend, and (2) ground based regulatory; and for land a remote system for non-point source runoff. In support to the above, a comprehensive effort on the development of data management and display systems and transport and dispersal models for Great Lakes application together with network strategy and communications will be undertaken.

W75-70472 **176-91-32**
Langley Research Center, Langley Station, Va.
APPLICATION DEMONSTRATION FOR REMOTE MONITORING OF ENVIRONMENTAL QUALITY
E. S. Love 804-827-2893
(176-21-31; 176-21-33)

Technical objectives are to define, plan, and begin implementation of an aircraft regional monitoring system to demonstrate the capability of remote monitoring techniques for local and regional environmental quality measurements. Support of other program tasks, such as remote sensor performance verification and collecting corroborative data for Nimbus G experiments is also planned. The initial approach is to build-up a system using available remote sensors from AAFE and related programs. Flight measurement programs will be developed in conjunction with user agencies to demonstrate the usefulness of an integrated remote sensing system for pollution monitoring, environmental modeling validation, and local and regional planning. Support of Nimbus G tropospheric measurements is included. This work represents an expansion of tasks carried as 176-91-31-03 in FY-74.

W75-70473 **176-91-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
MEASUREMENT OF POLLUTANTS IN AN URBAN ENVIRONMENT
D. P. Burcham 213-354-3028

The primary objective is to perform experimental studies addressing a specific current problem with respect to establishment of air quality standards, which are germane to NASA's role in supporting the government's effort in obtaining environmental air quality. In addition to meeting this more immediate objective, the work will also lead toward a better understanding of experimental techniques required for the remote sensing from satellite platforms of atmospheric constituents of importance to air quality. The objectives will be met by conducting a program of survey flights from an aircraft with a remote sensing infrared interferometer spectrometer developed by JPL under the AAFE program. This high throughput and high efficiency instrument - the High Speed Interferometer (HSI) - has been designed for aircraft operation, and has performed local surveys of stratospheric trace constituents during flights on board and Air Force NC 135 in February/March 1973 and aboard both the French and British Concorde SST in May/June and October/November 1973, respectively. While those observations were made by observing the sun near the horizon, the measurements to be made for this research will result from analysis of spectra obtained in the same wavelength region (1.2 to 5.3 microns) but using solar radiation diffusely reflected from the ground and energy emitted by the surface. This measurement technique was successfully demonstrated in the concluding phase of the AAFE program, when the HSI was flown aboard the Goodyear airship Columbia over downtown Los Angeles. Concentrations of pollutants in the lower troposphere, such as NOx, N2O, CO, CO2, and low level hydrocarbons as well as the more common molecules like H2O and O3 will be determined to accuracies in the 10 to the minus eight through 10 to the minus 10 range.

Earth Resources Survey - SR&T

W75-70474 **177-11-41**
Goddard Space Flight Center, Greenbelt, Md.
SYSTEM REQUIREMENTS DEFINITION STUDY
C. C. Schnetzler 301-982-2282

The study has two objectives: (1) the definition of a facility through which Earth Resources Satellite system requirements are derived from user needs; and (2) pilot demonstration of the operation of this facility in two selected disciplines: water resources and mineral/oil exploration. The requirements which will be considered concern three aspects of the total earth resources system: (1) spacecraft/sensor characteristics (including spectral band definitions, sensitivity, signal/noise ratios, coverage frequencies and time of day of coverage,); (2) data interpretation and data products (including the degree of interpretation required by operational and experimental users, map formats, data transmission alternatives,); and (3) conceptual and mathematical models and ancillary data needed to derive useful information from earth resources data.

W75-70475 **177-54-72**
Marshall Space Flight Center, Huntsville, Ala.
INTEGRATED LAND USE AND WATER MANAGEMENT APPLICATIONS
G. F. McDonough 205-453-2880
(176-56-71; 177-52-71; 177-54-71)

The basic capabilities to determine land use and the associated environmental parameters and to monitor water resources and the processes that affect these resources have been or are being established at MSFC under related RTOP's. In many cases the most significant parameter affecting land use change, particularly in the southeast and other regions for which water resources are important, is the development of a water resource. The Tennessee Valley development is a prime example in which development of the water resource, the Tennessee River, had led to widespread urbanization and industrialization of the Valley with obvious far reaching impacts on the land use patterns within the Valley. The Tennessee-Tombigbee Waterway development will produce impacts of the same magnitude as it progresses and the experience with the Tennessee Valley will be extremely useful in planning to minimize adverse effects. Similarly, experience gained in studying the impacts of land use on water quality, gained in part from ERTS and other studies of strip mining effects, can be extended to establish the overall interaction of land and water quality. This interaction has been recognized by regional development planners as one of the central points on which decisions regarding development are based. This has become even more important since the requirements for environmental impact statements have been increased.

W75-70476 **177-22-41**
Goddard Space Flight Center, Greenbelt, Md.
VISIBLE AND IR SENSOR SUBSYSTEMS
Harvey Ostrow 301-982-4107

High performance visible and infrared IR sensor systems are required for future earth survey missions, such as EOS and SEOS. Increased spatial and spectral resolution, improved signal to noise ratio, response into the emissive air and inherent registration between spectral channel are required. The tasks included in this RTOP will be used to achieve this improved sensor performance. Improved visible and IR detector will be

developed and evaluated with special emphasis placed on self-scanned linear arrays. Included will be photodiode arrays, CCD arrays and hybrid structures in which HgCdTe elements are coupled to a silicon CCD in order to provide performance in the 10 micrometer spectral region. New computer programs will be developed to permit the design and analysis of advanced optical systems, such as those using non-rotationally symmetric aspheric correcting elements, among others. Optics of this type are required in wide field, high spatial resolution, broad spectral bandwidth sensor systems. The development of a laboratory to permit in-orbit evaluation of sensor performance will be continued in order to identify those elements of the sensor systems that need to be modified or improved. Another objective of this laboratory will be to introduce commonality in the calibration and testing of new sensors and allow a feedback path into instrument design and test programs based on data obtained from actual orbital operation.

W75-70477 **177-22-42**
Goddard Space Flight Center, Greenbelt, Md.
EARTH OBSERVATION SENSOR SUBSYSTEMS
Harvey Ostrow 301-982-4107

The basic objective is to develop advanced high resolution sensor subsystems to meet the anticipated requirements of future earth observation missions. Effort will be concentrated on developing new scanning techniques, including systems for providing constant resolution as a function of scan angle, high scan efficiency systems and methods for providing commandable pointing of the optical field-of-view. Low noise preamplifiers will also be designed and combined with photodiode detectors to eliminate the need to use photomultiplier tubes in many applications, since such tubes have demonstrated a number of disadvantages in earth observation sensors. A second objective is to develop analytical or semi-analytical techniques for optimally selecting and characterizing the spectral channels required in multispectral sensors. The data developed in this area will be used to guide further sensor subsystem development as well as to assist in sensor selection for future multispectral imaging missions.

W75-70478 **177-22-81**
Lyndon B. Johnson Space Center, Houston, Tex.
VISIBLE INFRARED SENSOR SYSTEM TECHNOLOGY DEVELOPMENT
S. Gaudiano 713-483-2497

An activity will be undertaken to upgrade several technical areas critical to the performance evaluation or improvement of remote sensing technology used in the Earth Resources Aircraft Program in the ultraviolet, visible, and infrared spectra. (1) A study will be conducted to determine which solid-state technology best satisfies both the spatial and spectral requirements of the scanning imaging spectroradiometer (SIS) developed for the Earth Resources Program. The results will be applied to a development which demonstrates the feasibility of solid-state imagers in this application. (2) Sensors will be developed which provide multiple spectral response at a single focal point. Layered or sandwich techniques will be evaluated wherein the upper detector is transparent to the responsive wavelengths of the lower detector. (3) New materials will be used for the fabrication of detectors in the ultraviolet and near infrared (NIR) spectrum which provide characteristics superior to those in current use.

W75-70479 **177-22-91**
John F. Kennedy Space Center, Cocoa Beach, Fla.
REMOTE SENSING OF SEA TEMPERATURE AND TURBIDITY
Roy A. Bland 305-867-4541
(177-56-91)

A study to determine whether or not it is feasible to measure the shifted and unshifted return radiation of the Raman and Brillouin effects that results when a laser beam is directed through water is proposed. The study will conclude whether or not these measurements can furnish the needed data to derive the vertical temperatures and turbidity of the water. The study approach will include laboratory experiments which will augment literature research and theoretical analyses. The study will thoroughly discuss the feasibility or non-feasibility of using a laser device as a remote sensor for vertical temperature and turbidity.

W75-70480 **177-23-91**
John F. Kennedy Space Center, Cocoa Beach, Fla.
THE USE OF AIRBORNE IMAGING RADARS (L AND X-BAND) FOR SOLUTIONS TO EARTH RESOURCES PROBLEMS
E. J. Hecker 305-867-7705

The purpose is to further develop the usefulness of airborne imaging radars for water resources management, rural land use and urban land use. By further analysis and interpretation of existing radar imagery, thermal scanner data and photography of the Brevard Country, Florida, test sites, extract the maximum of user oriented data available by manuel techniques. The relationship of detectable features to radar imaging parameters frequency, polarization, look angle, depression angle is defined. Alternate optical processing techniques by which a substantially larger portion of the radar's dynamic range can be presented for interpretation is investigated. Concurrently, means by which radar data may be formatted for automated or semi-automated data reduction are studied.

W75-70481 **177-25-41**
Goddard Space Flight Center, Greenbelt, Md.
DEVELOPMENT AND EVALUATION OF ON-BOARD DATA COMPRESSION TECHNIQUES
T. J. Lynch 301-982-6969

Because of the growing volume of digitized data in the earth observations programs, the total cost of the missions involved will be increased. However, much of the data involved contains redundancy which may be removed or reduced by presently-known techniques. The purpose of this RTOP is to assess the feasibility of applying these redundancy-reduction techniques in the spacecraft for the purpose of achieving a cost reduction in the total data handling system. This RTOP has the following three objectives: optimum choice of a redundancy reduction technique, on-board redundancy reduction systems, and error protection for redundancy-reduced data. These objectives will be met through the following three tasks: redundancy-reduction algorithm selection study, on-board redundancy reduction study, and error control study for redundancy-reduced data.

W75-70482 **177-26-41**
Goddard Space Flight Center, Greenbelt, Md.
SENSOR CALIBRATION, TEST AND SIMULATION
Warren A. Hovis 301-982-6465

The objective is to provide calibration support for earth observation sensors in the applications program, to devise and produce new calibration devices for new, advanced sensors of large aperture and to extend the spectral range of calibration to accommodate new areas of interest, such as ocean color sensing. New sensor techniques are developed and tested and speacraft sensor performance simulated to guide development of spacecraft sensors. The radiance standards of the National Bureau of Standards are utilized to calibrate sources compatible with large aperture scanners made to view extended sources. These sources are then provided to applications satellite programs such as Nimbus G, ERTS, and EOS to assure commality of calibration and intercomparability of results. Calibration sources for spacecraft sensors are evolved from the laboratory experience and new problems in sensor technology, such as elimination of polarization sensitivity, are studied using breadboard sensors before flight sensor construction is begun.

W75-70483 **177-42-42**
Goddard Space Flight Center, Greenbelt, Md.
ADVANCED IMAGE PROCESSING TECHNIQUES
W. L. Alford 301-982-5515
(177-42-41)

The trend in the development of image sensors is to obtain more spatial samples. However, analysis results indicate that similar effects can be gained by better definition of sensor parameter and analysis techniques. Analyses within the last few years have and optimization shown that more information than had been expected is available within a 'resolution cell'. The

objective of this RTOP is to refine and test these results over a diverse set of data and user requirements. The outcome of this effort can be used to define spatial parameters in future sensor developments and to improve analysis techniques. The benefits of optimization will be: (1) to transmit more information over a limited communication channel, (2) to minimize the data volume to be stored and disseminated to users, and (3) to reduce the computational requirements for transformating this data to useful information.

W75-70484 **177-42-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
EARTH RESOURCES GEOLOGY/MINERAL EXPLORATION
D. P. Burcham 213-354-3028

Computer image enhancement of digital ERTS images has proved necessary to extract specific sub-sets of information useful for geologic mapping and mineral identification. Application of the techniques, developed by the JPL Image Processing Laboratory (IPL), to problems brought by outside investigators has been very fruitful. The objective primarily is to make better geologic maps through identification and separation of different lithologic units. Spacecraft and aircraft multispectral images provide the data base. Ground truth spectroradiometry using the previously developed backpack field spectrometer will be correlated with the spacecraft and aircraft images. Specific objectives will include the detection of uranium sands in cooperation with the University of Wyoming, study of the Baghdad, Arizona porphyry copper deposits in cooperation with Goddard Institute of Space Science and a concentrated effort, in cooperation with Continental Oil Co. to study the use of ERTS in the search for porphyry copper deposits. An investigation of some surface effects correlated with oil bearing structures detectable on ERTS will be undertaken in cooperation with the USGS and perhaps the Union Oil Co. which has expressed interest. Assistance will be provided to other outside investigators on the basis of the potential application of the investigation and the suitability of the application of IPL techniques.

W75-70485 **177-32-71**
Marshall Space Flight Center, Huntsville, Ala.
DATA MANAGEMENT AND INTERPRETATION TECHNIQUES FOR EARTH RESOURCES SURVEY
Robert E. Cummings 205-453-2144

This effort is directed to the development of more refined and cost effective techniques and conceptual/mathematical models for the processing, display, and management of large amounts of earth resources data. Results will provide essential support to those discipline-oriented projects involving land use, hydrology, geology, and vegetation resources that ultimately depend on automated information extraction and data management techniques for timely earth resources planning and decision making. In general, this work will include the investigation and evolution of earth resources data analysis techniques, the development and demonstration of automated data analysis systems, the research and analysis of user needs to determine information and format requirements, the development of prototype earth resources data management techniques and systems, the distribution of information to users for specific application demonstrations, and the documentation and transfer of the technology to user agencies for their pilot and/or operational applications.

W75-70486 **177-32-81**
Lyndon B. Johnson Space Center, Houston, Tex.
OPTICAL/DIGITAL PROCESSING OF MULTISPECTRAL DATA
J. Dragg 713-483-4761

The objective is to test and evaluate a multispectral classification procedure which is based upon performing a correlation between a transformed measurement vector and vectors which describe the transformed measurements of known target classes. This procedure is attractive because it offers extremely high classification rates, even when using many data channels, within a variety of computational technologies, including digital electronic and analog optical. It is particularly attractive when classifying data sets with large numbers of channels, both because of the increased accuracy afforded, and because, even in a general purpose computer, it can run faster with 24 channels than Gaussian maximum likelihood classifiers (LARSYS) can run with 4. The optical implementation of this scheme is considered particularly attractive because it offers substantial advantages in data storage density and, potentially, in computation speed.

W75-70487 **177-32-82**
Lyndon B. Johnson Space Center, Houston, Tex.
TRANSFER OF REMOTE SENSING ANALYSIS TECHNOLOGY VIA COMPUTER TIME-SHARING ORGANIZATIONS
J. D. Sargent 713-483-6478
(177-42-83)

Transferring of NASA developed or supported technology to other federal, state and local governments, the university community, and to the private sector is a major agency objective. This task is proposed for the purpose of establishing structured means of expediting the transfer of remote sensing analysis techniques and capabilities to these other organizations. During the course of implementation of this task, selected remote sensing analysis algorithms will be identified for dissemination to a wide community of users. The goal for dissemination of this information will be the implementation of the algorithms on selected commercial time-sharing systems. Such an approach will provide the capability to support a diverse community of users in widely separated geographical areas. This approach provides a comprehensive facility encompassing the most current techniques available to the user with limited resources and secondly provides the training, background and sets the stage for organizations to expand to an in-house capability if desired.

W75-70488 **177-40-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
OPTICAL TEXTURE ANALYSIS OF ERS DATA
D. P. Burcham 213-354-3028

In order to display digital images effectively, optical techniques are required. In addition, it is economically reasonable to supplant certain digital techniques for processing images with optical techniques. This is attractive especially where digital processing is inconvenient; for instance, at the stage of data acquisition. The objective is to study development of optical techniques for texture analysis techniques at a single pixel level to guide the specification of new sensor requirements.

W75-70489 **177-42-21**
Lewis Research Center, Cleveland, Ohio.
REMOTE SENSING DATA MANAGEMENT AND INTERPRETATION TECHNIQUES FOR EARTH RESOURCES SURVEY
H. Mark 216-433-4000

The objectives are to develop 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 automated recognition and inventory of surface mining operations as well as general soil and surface feature recognition, also 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 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. In the surface feature recognition studies, additional efforts will be made to extend recognition capabilities to include other soil features needed in land capability determinations that must be inferred (an additional step) from remotely sensed data.

W75-70490 **177-42-41**
Goddard Space Flight Center, Greenbelt, Md.
INFORMATION EXTRACTION TECHNIQUE DEVELOPMENT
W. L. Alford 301-982-5515
(177-31-41)

Existing systems contain many features useful for experimen-

ters such as interactive, user-oriented fast execution. However, none of these systems incorporate all of the major features required in a general purpose system. The broad objectives of this RTOP are (1) to develop techniques, systems, and interfaces for discipline-oriented users to perform multispectral image analysis and manipulation, (2) to transfer existing technology to local users and assess the utility of this technology, and (3) to provide analysis capability for local users. Near term objectives include the continued operation and assessment of the Purdue/LARS remote terminal. Other systems will be investigated also. Based on these investigations and a close working relationship with users, a general purpose interactive image processing system will be developed and implemented. This system development will concentrate on the user interface including a flexible interactive terminal, a user language and system executive, and output result presentation.

W75-70491 **177-42-81**
Lyndon B. Johnson Space Center, Houston, Tex.
DEVELOPMENT OF MATHEMATICAL TECHNIQUES FOR THE ANALYSIS OF REMOTE SENSING DATA
Kenneth Baker 713-483-2362

The primary objective is to develop the mathematical techniques that are needed to perform the data analysis for specific applications of remote sensing, such as a large area crop inventory. Research will be conducted in areas of applied mathematics such as statistics, matrix theory, and numerical analysis with the aim of improving data analysis algorithms and procedures until they meet the performance levels and cost constraints that are necessary for a major application of remote sensing. The research will be conducted by local universities on a task by task basis as problem areas in the analysis of remote sensing data are identified. The second objective is the development of a source of continuing education for JSC personnel in the areas of mathematics that are basic to the analysis of remote sensing data. This will be accomplished through seminars, and personal consultation.

W75-70492 **177-42-82**
Lyndon B. Johnson Space Center, Houston, Tex.
TECHNIQUES DEVELOPMENT FOR MULTISPECTRAL SCANNER IMAGERY
A. E. Potter 713-483-2071

The objectives are assessment of existing techniques for computer-aided imagery analysis and the development and test of new techniques as required by applications projects. The assessment of existing crop inventory techniques was a large part of the effort during FY74. With the exception of work on proportions of unresolved objects, it is expected that these analyses will be concluded during FY74, and that final reports will be issued early in FY75. The new work proposed for FY75 is focused on the solution of technical problems related to the applications of crop inventory over large areas. These problems have been defined by JSC/University crop inventory design teams during early CY74. About 85% of the total effort will be spent in this area. Tasks dealing with advanced remote sensing research are the remainder of the effort. The work related to crop inventory over large areas must be completed according to schedules provided by JSC, and will use either the CITARS baseline data set or a crop inventory data set as defined by the Joint JSC/University crop inventory design team.

W75-70493 **177-42-83**
Lyndon B. Johnson Space Center, Houston, Tex.
APPLICATIONS RESEARCH AND TECHNIQUES DEVELOPMENT FOR REMOTE SENSING
A. E. Potter 713-483-2071

The objectives are: (1) assessment of existing techniques for computer-aided imagery analysis, (2) development of new techniques to satisfy major applications requirements, and (3) demonstrating feasibility for new applications of computer-aided imagery analysis. The assessment of crop inventory techniques was a large part of the effort during FY74. It is expected that the analysis will be concluded during FY74, and that the final reports will be issued early in FY75. The major new direction for LARS is a realignment of LARS projects in direct support of JSC applications projects. The needs of these projects have been surveyed, and new technology development tasks have been defined as required by the applications projects. These tasks comprise about 70% of the total effect. It is recognized that a portion of the LARS effort should be research on new techniques development and applications demonstrations without a current applications project in mind. Current plans call for about 30% of LARS effort to be spent in such research.

W75-70494 **177-44-41**
Goddard Space Flight Center, Greenbelt, Md.
HCMM APPLICATIONS: SURFACE CHARACTER MAPPING
Warren A. Hovis 301-982-6465
(177-51-41)

The HCMM will fly in 1977 on the AEM Satellite. Prior to that flight it is essential to develop the techniques to process the data into thermal inertial maps and gain experience in the use of thermal inertia measurements in areas such as rock type mapping, soil moisture mapping, coastal zone studies, and plant canopy studies. In order to accomplish this effort, a simulator of the Heat Capacity Mapping Radiometer has been constructed for flights on aircraft in the NASA Applications Aircraft Program. Aircraft flights will be conducted over selected areas at times corresponding to the expected times of HCMM overpasses. The data will be processed, utilizing the temperature and albedo measurements from the simulator, to thermal inertia maps. Thermal inertia maps will be analyzed to determine their utility in the areas under consideration and the results will be compared with surface truth measurements accomplished by competent investigation in each area.

W75-70495 **177-44-42**
Goddard Space Flight Center, Greenbelt, Md.
REMOTE SENSING OF OCEAN COLOR, TEMPERATURE
Warren A. Hovis 301-982-6465

The object is to conduct laboratory and field experiments, in advance of the launch of Nimbus G, to develop data analysis and processing techniques and interpretation skills for use with data from the Coastal Zone Color Scanner. Aircraft investigations will be carried out with a Coastal Zone Color Scanner Simulator (CZCSS) aboard a NASA U2 over a variety of areas with differing quantities of chlorophyll containing plankton and sediment. These overflights will be coordinated with surface truth measurements to be carried out by government agencies and university scientists. The scanner data will be processed in a manner similar to that planned for the Nimbus G data and analyzed, in cooperation with the surface truth investigators, to determine how best to carry out the same procedure with the spacecraft data.

W75-70496 **177-44-82**
Lyndon B. Johnson Space Center, Houston, Tex.
RADAR STUDIES FOR EARTH OBSERVATIONS
A. E. Potter 713-483-2071

Radar may be an important sensor in future earth observations projects. While there have been some applications demonstrated with photointerpretation of radar imagery, further progress requires a more quantitative approach. Of particular interest is the capability of radar for crop inventory. For this, it is necessary to determine the optimum conditions for crop discrimination with radar by means of ground-based measurements using a radar spectrometer, and to assess the performance of modern image analysis techniques when applied to radar imagery. The specific objectives of this work are to: (1) relate quantitatively to vegetation type, moisture content, and plant morphology to radar cross sections; and (2) to determine the capability for discrimination of agricultural scenes by application of pattern recognition techniques to radar imagery. (a) A ground-based radar spectrometer will be used to measure the radar backscatter from various crops as a function of radar frequency, polarization and incidence angle. Results will be statistically analyzed to determine the inherent capability of radar for discrimination between agricultural scenes. (b) Four-band radar imagery (X-, L-band at H and V polarization) of agricultural regions in Huntington County, Indiana, will be analyzed by pattern recognition techniques developed for analysis of multis-

pectral scanner data. The capability for crop type discrimination with this imagery will be evaluated.

W75-70497 **177-51-41**
Goddard Space Flight Center, Greenbelt, Md.
THE APPLICATION OF MICROWAVE TECHNIQUES FOR THE REMOTE SENSING OF PARAMETERS OF HYDROLOGICAL INTEREST
T. J. Schmugge 301-982-6360

The objective of this effort is to study the use of active and passive microwave techniques for use in the remote sensing of water resource parameters. These include the observation of changes in the emissivity or reflectivity for soil as a function of moisture content and similar changes for a snow pack as a function of depth and liquid water content. The feasibility of using microwave radiometers for the remote sensing of soil moisture has been demonstrated using data obtained from aircraft. The remaining problem is to quantify the relationship between soil moisture and emissivity in presence of perturbing surface conditions such as surface roughness and vegetative cover. The primary approach will continue to be the use of data obtained from aircraft platforms flown over suitably selected ground truth sites. A natural extension of this technique is to consider the use of active microwave systems which with the use of synthetic aperture techniques can yield much higher spatial resolution. The dependence of the backscatter coefficient on soil moisture has been demonstrated in field measurements and needs to be followed up with aircraft experiments. The capabilities of microwave techniques for snow measurements are less well defined. It has been observed that dry snow of sufficient depth has a low emissivity at certain wavelengths and that the presence of liquid water in the snow produced a dramatic rise in the emissivity. The objective of this study will be to determine how well parameters such as snow depth and liquid water content can be extracted from these phenomena by observations at several wavelengths.

W75-70498 **177-32-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
IPL EQUIPMENT UPGRADING
D. P. Burcham 213-354-3028
(177-31-51; 177-52-51; 177-53-51)

The first objective is to continue the development of digital interpretive techniques relative to earth resources image applications. Widespread use and processing of the ERTS MSS data over the last several years have demonstrated the advantages of digitally processing this data. Although numerous techniques for extracting information from the data were derived, there is a continual need to develop new or improved techniques to increase the efficiency and/or accuracy of those techniques which are now becoming classical and to develop new techniques for which digital processing is uniquely suited. A second objective is to meet the needs of the increasing number of outside users and their increasingly complex processing by augmenting the IPL to allow its use as an Earth Resources Interpretation Assistance Center, to be used by selected investigators for image enhancement, registration, thematic classification, and other general purpose image processing in the solution of their problems. The third objective is the provision of a geocoded data conversion and field system for land use and resource inventories that will provide both rapid up-to-date information access for a user's model or the construction of a thematic map, as well as an inexpensive and flexible mode of primary data input. Such a geographic information system will collate primary data into a raster image which will then be converted by the geocoded data base management system to a data base file.

W75-70499 **177-51-11**
Ames Research Center, Moffett Field, Calif.
ON-LINE PEST MANAGEMENT SYSTEM
J. M. Deerwester 415-965-5897

The objectives of this RTOP are: (1) to evaluate the utility of a regional on-line past management system that includes a network of remote data collection platforms; (2) to study the application of this technology to nationwide control of a wider variety of economically important pests and to other agricultural services; and (3) in so doing, to illustrate and document, credible means for arriving at functional system requirements from a basic understanding of the control function to be performed. Our basic approach to satisfying these objectives is to have two faculty members of Michigan State University work with us at ARC during the summer of CY-1974 and to monitor research grants to MSU beginning in FY-1975. For the past several years MSU has been developing, primarily via funds from the U.S. Department of Agriculture and the NSF/RANN, a system for real time monitoring and control of the cereal leaf beetle. This system is nearing the pre-operational demonstration phase. It is the intent of this RTOP to consider the attendant networks between the remote platforms and the central processor; between the classification sites and the processor; and between the processor and the farmer and make comparisons with rational alternatives such as in-situ measurements and pest state predictions.

W75-70500 **177-51-81**
Lyndon B. Johnson Space Center, Houston, Tex.
FORESTRY APPLICATIONS PROJECT STUDY (FORMERLY SAM HOUSTON NATIONAL FOREST STUDY)
Bryan R. Erb 713-483-4623

The JSC Earth Observations Division's Applications Office and Southern Region, U.S. Forest Service began a cooperative effort in July 1971, to investigate the applications of remote sensing to Forestry. Two Forest Service employees were assigned to the Applications Office. Since then the Forestry Applications Project Team has determined that the following tasks should be developed into applications procedures - forest resource inventory, timber volume measurement, and extensive soil survey - using computer processing of multispectral data. The overall objective is to assess the utility of remote sensors and their related processing as a tool for assisting in making forest inventories and monitoring of management activities and to develop procedures for implementing suitable techniques in the southern region. The approach will be to meet this objective through a thorough investigation and implementation of the following tasks: (1) Determine which requirements can be accomplished by remote sensing techniques. (2) Establish task objectives and procedures for remote sensing studies involving those requirements. (3) Perform the above tasks utilizing present state-of-the-art remote sensing techniques, define areas of needed technological research and direct that research toward satisfying project objectives. (4) Evaluate the results of the investigations and assess their economic feasibility. (5) Verify techniques in a different forest ecosystem to determine breadth of application. (6) Transfer to the user agency the acceptable techniques and assist them in the implementation of the applications.

W75-70501 **177-51-84**
Lyndon B. Johnson Space Center, Houston, Tex.
JOINT EXPERIMENT ON REMOTE SENSING OF SOIL MOISTURE
A. E. Potter 713-438-2071

Because soil moisture greatly affects the radar cross section and thermal emissivity in the microwave frequency range, microwave remote sensing techniques can be exploited to detect soil moisture. Other surface features such as roughness and vegetal cover also influence cross sections and emissivities. Ground based observations show that these effects can be minimized if one chooses: (1) a multispectral approach, and (2) to make observation at a high depression angle. The problem is complex, requiring simultaneous attack by hardware groups, soil experts, etc. The objective of this task is to organize and execute an attack on the problem in a joint effort, including all the required elements drawn from several different organizations. Sites will be chosen that have irrigated fields (to get a wide variety in soil moisture). It will be desirable to have some fields bare and some covered with wheat. This would have the added benefit of assisting those who are analyzing data from the Large Area Crop Inventory Project (LACIP). Preliminary ground based measurements should be made close to the time of the flight experiment. Analysis of data from the flight is expected to yield an estimate of the feasibility of remote sensing of soil moisture beneath vegetal covering. Groups from ERIM, Texas A and M,

the University of Kansas and the University of Arkansas will be actively involved. Consultants from USDA (Chickasha, OK) will also be involved.

W75-70502 **177-51-91**
John F. Kennedy Space Center, Cocoa Beach, Fla.
THE APPLICATION OF REMOTE SENSING TO EVALUATING SURFACE TEMPERATURE DURING FREEZING CONDITIONS
Paul D. Toft 305-867-4541

The primary objective of this investigation 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 citrus areas for accurate freeze exposure forecasting. The approach selected utilizes airborne thermal scanning data to measure the earth-air interface temperatures over selected agricultural areas during freeze conditions. These data are then used for comparison with actual freeze conditions and inputted into computer models. These models would then be improved as indicated by the comparison of the predicted vs. measured temperatures.

W75-70503 **177-52-41**
Goddard Space Flight Center, Greenbelt, Md.
APPLICATION OF INTEGRATED THEMATIC DATA BASE AND DEMONSTRATION OF ITS USE IN REGIONAL ENVIRONMENT/LAND USE MANAGEMENT
J. Schubert 301-982-4860

The objectives of this program are to integrate remotely-sensed and other data pertinent to environmental/land use problems in a limited test area; to identify, in that area, the disparate users on the operational level and to define technical data products which can most readily and advantageously be applied by operational level users having similar needs in other regions. At the center of this effort is a task for a land use - environmental study which will have, as its purpose, (1) the integration of the data produced in the several tasks of the study; (2) the development of a base (in map and computerized form) of regional land use information; (3) the identification and stimulation of a local user community; (4) the dissemination of data in a form in which it can readily be applied by the users; (5) the assessment of the efficacy of the regional survey, especially in comparison with alternative methods; (6) the consideration of system modifications required for greater utility and efficiency.

W75-70504 **177-52-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
LOS ANGELES COUNTY LAND USE ANALYSIS
M. E. Alper 213-354-6948
(177-52-52)

The objectives of this project include a short-range task of developing a land use information system for the Los Angeles Santa Monica Mountains and the initialization of a longer range plan for a Los Angeles city geographically based urban information system. Both systems would be based on the New York State Land Use and Natural Resources (LUNR) system. The Santa Monica Mountains land use system would consist essentially of LUNR with major modifications to analyze present land use policy effects and open space planning on the natural resources and scenic beauty of the roughly 1000 square kilometer mountain range. It is anticipated that the background study and research associated with this phase of Los Angeles land use planning would be completed under this RTOP. In addition, a natural resources inventory in the more northern Santa Suzanna Mountains and Verdugo Mountains would be initiated under this RTOP with funds to complete the work coming from other sources. The city-wide information system would incorporate the modified LUNR system as an information provider for the urban environmental and transportation models presently used for planning functions in the metropolitan area of Los Angeles. In this respect LUNR would be used as an aggregative base for assessor file and census tract data as well as functional land use (as opposed to strictly vegetative cover). The desired product under this phase of the program is to provide the city's planning models with reliable, up-to-date, easily accessible information of both socio-economic and physical resource types. This RTOP would include a significant beginning into this phase of the program; it is envisioned that this urban information system would be developed simultaneously with the Santa Monica Mountains system.

W75-70505 **177-52-52**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
ECONOMIC ASSESSMENT OF INCORPORATING LAND USE/NATURAL RESOURCE DATA INTO CITY PLANNING
M. E. Alper 213-354-6948
(177-52-51)

A methodology is to be developed whereby a city planning department can readily identify those subsets of their general comprehensive plans where remote sensing land use data might provide one or more of the following benefits: (1) a reduction in litigation costs to the city, costs due to individual or public challenges of proposed plans or environmental impact reports (EIR); (2) an improvement in the rather nebulous 'quality of life' indices due to the better understanding of present land uses and potential conflicts among proposed land uses; and (3) an increased capability of the planning department to achieve significant gains in their general plans by freeing manpower presently required to inefficiently gather environmental data which tends to be inadequate, subjective, and poorly organized to be accepted as credible. Methods of quantifying these benefits will be investigated under this RTOP by economically assessing results of the Santa Monica Mountains land use system being developed simultaneously under approved RTOP 177-52-51-01-00, entitled 'Los Angeles County Land Use Analyses'. It is envisioned that as this land use/natural resources system is expanded into the environmental data system to be appended to Los Angeles' Block Level Reporting System, the economic assessment studies will be continued in order that an effectiveness criteria can at any time be applied to the urban management systems being developed.

W75-70506 **177-52-71**
Marshall Space Flight Center, Huntsville, Ala.
LAND-USE MAPPING FOR RESOURCE MANAGEMENT
C. T. Paludan 205-453-2142
(177-32-71; 177-52-72; 177-52-73; 177-52-75)

The objective is to develop and demonstrate a useful system for land-use information derivation and retrieval. Accomplishment of this depends upon three areas of research: (1) determination of user requirements, (2) development and demonstration of an automated information retrieval system, and (3) refinement of the technology for classification and retrieval, both software and hardware. Determination of user requirements will be accomplished by continued joint activities with state agency personnel in several Southeastern states. These activities will be accompanied by demonstration projects which are designed to maximize the user's feedback of adequacy and utility. An area of emphasis for these demonstrations will be use of interactive terminals and mini-computers in conjunction with a computerized data bank utilizing information from EREP, ERTS, and aircraft derived through automatic processing techniques developed at MSFC.

W75-70507 **177-52-73**
Marshall Space Flight Center, Huntsville, Ala.
MULTIPLE RESOURCE SURVEYS IN THE TENNESSEE VALLEY AREA
C. T. Paludan 205-453-2142
(177-32-71; 177-52-71; 177-52-75; 177-54-71)

The objective is to develop and apply methods of using remote sensing and automatic data handling for delineation and description of resources, with emphasis on cooperative activities with regional planning and development organizations. Because they are basic to comprehensive understanding and management of multiple resources, emphasis is on land-use and water resources. Operations of the Tennessee Valley Authority (TVA) and Tennessee-Tombigbee Waterway Development Authority (TTWDA) provide the key emphasis of this research. Studies of selected test sites are conducted to establish guidelines for

management and planning of lands and waters under their jurisdictions Application of remote sensing, automated classification, automated retrieval, decision-modeling and predictive modeling are among techniques refined and demonstrated in this multi-agency research activity.

W75-70508 **177-52-81**
Lyndon B. Johnson Space Center, Houston, Tex.
LAND USE AND RESOURCE INVENTORY
R. O. Piland 601-688-2034

This RTOP will: (1) conduct research investigations in the Mississippi/Louisiana/Gulf areas in land use classification applications 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; and (4) conduct continuing studies of user requirements of the potential land use classifications in order to guide future research efforts. Land Use/Resource Inventory tasks fall into three major categories, with subdivisions as follows: State wide land use system applications (small scale photographic application, ERTS MSS imagery application, ERTS MSS digital application); Technique development agricultural, forestry---

W75-70509 **177-52-82**
Lyndon B. Johnson Space Center, Houston, Tex.
REGIONAL APPLICATIONS PROJECT
G. E. McKain 713-483-4623

Regional Councils of Government have been established throughout the State of Texas each having specific need for regional planning and management information. The Governor has formed an Interagency Council on Natural Resources and the Environment (ICNPE) to ensure a well coordinated focus on all aspects of land resource planning. ICNRE has established a Remote Sensing Task Force to determine the utility of remotely sensed data as a source of land resources information. NASA has been contacted by the Governor's office to explore a cooperative program to transfer remote sensing and information systems technology to the state. Working jointly with the ICNRE, the remote sensing task force and various state agencies, several significant accomplishments have been made: a procedure for the utilization of ERTS-1 MSS data to detect and locate surface water was developed, tested and transferred to the state; a Purdue Terminal has been installed in Austin and is currently being used to train state personnel in the utilization of pattern recognition techniques; the state has submitted a proposal for an ERTS-1 follow-on investigation; and a joint state/NASA remote sensing project is currently being planned, with the objective being to design, develop and demonstrate a pilot regional land resources inventory and monitoring system.

W75-70510 **177-53-11**
Ames Research Center, Moffett Field, Calif.
GEOTHERMAL RESOURCE INVESTIGATIONS
D. R. Chapman 415-965-5065
(177-53-13)

The objective is to determine if increased mercury vapor concentrations can be combined with remotely sensed thermal anomalies to identify potential geothermal sites. The approach was to measure field concentrations of mercury vapor at sites where anomalies are recognized with thermal infrared images. This will be a cooperative project with the AEC/Lawrence Berkeley Laboratory (LBL) to help evaluate four sites in Nevada for construction of a geothermal power plant.

W75-70511 **177-53-13**
Ames Research Center, Moffett Field, Calif.
EVALUATION OF REMOTE SENSING APPLIED TO CIVIL WORKS PROJECTS
D. R. Chapman 415-965-5065

The objective is to determine the feasibility of assessing civil works sites by measuring soil moisture using remote sensing in the 0.4 to 14 microns wavelength region. The approach was to perform investigations to determine the conditions underwhich soil moisture can be correlated with remotely sensed reflected energy (0.4 to 2.5 microns) and emitted energy (8 to 14 microns). Apply these results to civil works sites to evaluate their usefulness to field conditions. Applications to be studied include: landslides, levees, highways, ground water localities and dams. Application studies will be cooperative efforts with USACE and California State agencies.

W75-70512 **177-53-41**
Goddard Space Flight Center, Greenbelt, Md.
GEOLOGIC INVESTIGATIONS USING ERTS AND RELATED DATA
N. M. Short 301-982-6603

The purpose of this RTOP is to fill major gaps in the continuing program support for the use of Earth Resources Technology Satellite data in geologic studies and applications. Recent program reviews indicate these gaps to be (in order of priority): (1) preparation of geoenvironmental maps from ERTS, (2) use of ERTS data in petroleum exploration, (3) development of a working model for metals exploration using space imagery, (4) analysis of linears as geologic features. Research and field projects designed to develop and assess specific contributions of ERTS data towards geoenvironmental mapping, petroleum and metals exploration, and linears identification will be carried out through this RTOP. In addition, a relevant study of the use of thermal and reflected IR data in solving certain geologic problems will be included in the proposed tasks. The approach is twofold: first, certain aspects of each task, including special data processing and representative site studies, will be conducted inhouse at Goddard Space Flight Center; second, most of the remainder of these tasks will be performed under contract outside GSFC, especially where extensive field work requires proximity to individual test sites.

W75-70513 **177-53-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
THERMAL INERTIA AND GEOTHERMAL MAPPING
D. P. Burcham 213-354-3028

Thermal inertia (TI) is a body property rather than a surface property of earth materials. Therefore TI can be used as another parameter, along with surface reflectivity, in tele-geologic mapping. Initial steps in this direction have been taken by Watson and Pohn of the USGS, Denver, using Nimbus data. The heat capacity mapping mission (HCMM) will be flown by GSFC in 1977. This mission will supply the bulk of the high resolution data needed to produce thermal inertia maps. The inventory of existing geothermal anomalies, and discovery of new ones by satellite mapping, is an order of magnitude more difficult task than TI mapping. TI itself is a noise source. Mapping of accurate temperature differences of 1 C or less is necessary. It is not clear whether it will ever be possible to map accurately such small differences from satellite altitudes. Much of the work required to reduce, analyze, and interpret thermal data for geothermal applications is identical to the HCMM work. Problems such as elevation, slope, albedo, vegetation, etc. are common to the two methods. Work toward evaluation of a geothermal satellite must include TI work first. It is proposed to begin reducing data from NIMBUS NOAA DAPP and Skylab to make thermal inertia maps in anticipation of HCMM. Work in thermal modeling will be done experimentally with use of tethered balloons as well as with aircraft data. Modeling work will be done in cooperation with the USGS Denver.

W75-70514 **177-53-71**
Marshall Space Flight Center, Huntsville, Ala.
REMOTE SENSING FOR GEOLOGICAL RESOURCE SURVEY
J. Bensko 205-453-0187
(177-51-71; 177-52-71)

The objective is to investigate the applicability of remote sensing and other space technology to the problems of federal and state agencies with planning or other direct responsibilities for producing decision-base information necessary for effective resources management in the areas of environmental geology, engineering geology, mineralogy, geobotany, and geothermal technology. The approach of selected state and federal user-partner agencies together with MSFC technical personnel will define

basic problems and will develop a project plan for alternate solutions. The plans will include (1) acquisition of remote sensing data, processing testing automated techniques and systems engineering by MSFC; (2) discipline experties, data analysis, information interpretation and application by the user agencies.

W75-70515 **177-54-11**
Ames Research Center, Moffett Field, Calif.
REMOTE SENSING FOR SNOW AND ICE MAPPING AND MONITORING
D. R. Chapman 415-965-5065

Snowpack measurements by use of remote sensor technology, to obtain hydrological cycle data input, so as to achieve better utilization of water resources, flood forecasting, and related activities. Remote sensing techniques will be applied for the measurement of the extent, depth, density, and percent moisture of snowpack, to assist in water resource management. Specific techniques include surface, airborne, and satellite-based instrumentation. Surface systems are needed for ground truth data: depth and density by standard snow sampling; percent moisture by our new method to obtain the change in dielectric constant and loss tangent of snow sample before and after freezing. Time-progressive ground truth information will also be obtained by completely automatic, remote installations using a profiling system to measure moisture in the snow by attenuation of microwaves between source and receivers that move vertically within a dielectric tube. Data would be relayed via ERTS satellite. This is a joint project with the U.S. Forest Service. Airborne systems will be investigated using passive and active electromagnetic measurements, the latter being based on multifrequency sounding to obtain snowpack depth, density, and moisture. Calculations will be made for representative models of air, snow, ice, water, and earth, including dry or wet conditions of the snow. Actual field site measurements will be employed in the models.

W75-70516 **177-54-14**
Ames Research Center, Moffett Field, Calif.
HYDROLOGIC MODELING
D. R. Chapman 415-965-5065

The objectives are to develop a management-oriented hydrologic model, taking into account supply, demand and impact, that makes optimal use of modern remote sensing capabilities. To study the cost-effectiveness of such a model as compared to the utility of conventional, presently used models. Large water basins and regional water distribution systems, e.g., the California Water Project, will be the focus of study. Three aspects of such a system, i.e. supply, demand and impact, will be initially studied separately as benefitting from the application of remote sensing techniques in their effective consideration as components of a water delivery system. Results will then be integrated into a simple comprehensive model which will be tested in its usefulness to resource managers.

W75-70517 **177-54-21**
Lewis Research Center, Cleveland, Ohio.
REMOTE SENSING FOR SNOW AND ICE MAPPING AND MONITORING
H. Mark 216-433-4000

The primary objective is to develop a rapid all-weather ice information system for determining ice type, coverage, and thickness on the Great Lakes for navigation purposes. A certerion for the system is that it provides the necessary information in a form that can be used in the wheelhouse for transiting the ice with minimum difficulty. This effort is being performed as part of the Winter Navigation Season Extension Program authorized by Congress in 1970. An array of instrumentation is flown over the Great Lakes to develop an all-weather ice information system. The instrumentation includes a side-looking airborne radar (SLAR), microwave ice thickness sensors, cameras and a multispectral scanner. A combined sensor package capable of meeting the ice information requirements of the U.S. Coast Guard, the National Weather Service, and the commercial shippers will be determined from the results of these flights. Demonstrations of the instrumentation are conducted to ensure that the user's operational needs are satisfied.

W75-70518 **177-54-41**
Goddard Space Flight Center, Greenbelt, Md.
INVESTIGATIONS OF THE HYDROLOGICAL CYCLE AND LARGE HYDROLOGICAL SYSTEMS
V. V. Salomonson 301-982-6481
(177-54-42)

The thrust of this effort is to (1) seek means of incorporating remotely-sensed data from spacecraft and high altitude aircraft into deterministic watershed models in such a way as to improve their accuracy and timeliness, and (2) develop means of analyzing and processing these same remotely sensed data so as to repetitively monitor and measure hydrologic parameters over large regions in such a way as to improve our understanding and ability to manage dynamic, large scale water resources systems. The current efforts will involve modelling of hydrologic processes on the Monocacy and Patuxent Rivers using updated versions of the Stanford Watershed Model. Data processing and interpretation efforts involving land use, flooding, and physiographic features will be continued on the above rivers and the Anacostia Basin in Md., several watersheds in Colorado, Wyoming, Wisconsin, Pennsylvania, and along the Mississippi River. In particular, efforts will be extended to better map flood plains, snowcover, impervious area, and drainage density in these areas using photo-interpretation and digital-multispectral classification methods. Meteorological satellite, ERTS, Skylab, and aircraft data will be examined. Means of interpreting and applying data from future spacecraft missions such as EOS, SEOS, and HCMM will also be investigated.

W75-70519 **177-54-71**
Marshall Space Flight Center, Huntsville, Ala.
INVESTIGATIONS OF THE HYDROLOGIC CYCLE AND LARGE SCALE HYDROLOGIC SYSTEMS
H. G. Hamby 205-453-0889
(176-53-71)

The objectives are: (1) to extend or adapt existing hydrologic models to incorporate remote sensing data for parameter determination. To reduce requirements for historical rainfall/runoff/streamflow data by improved predictive capabilities using remote sensing. (2) To apply advanced modeling concepts, such as finite element techniques to make existing models more amenable to remote sensing parameter determination. (3) To improve and extend existing river and estuary mathematical models to full three-dimensional descriptions so that surface or near surface remotely sensed parameters can be utilized most efficiently to monitor streamflow, temperature profiles and other significance parameters. (4) To develop a predictive model of river dynamics such that user agencies might determine real-time characteristics using remote sensing, thus deleting dependence on long historical records and fully gaged watersheds. Existing models for watersheds, streams and rivers, deep lakes, and bays and estuaries will be augmented, modified and improved to incorporate remotely sensed data from aircraft and satellites as well as in-situ measurements. Advanced three-dimensional modeling techniques developed for rocket exhaust plume analysis and finite element analytical techniques will be adapted to watershed and water-body analysis. Existing user expertise, in particular the Tennessee Valley Authority,---

W75-70520 **177-55-31**
Langley Research Center, Langley Station, Va.
COASTAL PROCESSES
E. S. Love 804-827-2893

This RTOP includes the preparation of a Coastal Zone Applications Plan, which will be in part an expansion of the recommendation of the Environmental Quality Enhancement Program Study prepared for the Office of Applications by the Langley Research Center. Work on Task 1 (wave measurement and analysis on the continental shelf) and Task 2 (current circulation studies on the continental shelf) will be accomplished. Included also is the development of remote monitoring techniques for wetlands and organic vegetation, work previously carried under 177-55-33. Objective of work on the continental shelf is to develop a predictive capability for the wave and current environment for application to problems in these waters. Problem areas of interest include pollution distribution and circulation on the shelf, sedimentation, thermal properties of shelf

waters, wave climate, and shoreline alteration. For vegetation studies, the objective is to develop remote signatures for specific species. The approach to be used includes the development of analytical wave and current models and the measurement of conditions in the coastal zone by various means to provide data for preliminary model verification, and to develop input measurement techniques for eventual use with monitoring systems. Measurement methods to be used include remotely sensed data from satellites (such as NOAA II), aircraft, in situ measurements and surface observations from drifting or fixed stations with location information and measured data relayed in some cases by satellite (such as EOLE) and aircraft.

W75-70521 **177-55-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
EARTH/COASTAL ZONE STUDIES, RADAR
D. P. Burcham 213-354-3028

The purpose of this task is to apply radar techniques to the investigation of ocean wave/coastal topography interaction. The major objective is to develop an operation airborne/spaceborne system for earth/coastal region observation which would help in the conservation of coastal regions, mapping of bottom topography and the determination of safe locations for deep harbors, power plants, and off-shore nuclear plants. A second objective is to conduct some observations of the Colorado plateau for geological studies and development of future ground water supply. Another major objective of this work is to complete a breadboard of a spacecraft digital system (DDS) which is required for future spacecraft radar imaging systems. The approach is: to use the existing MPL multispectral (3 cm, 25 cm, 200 cm) imaging radar in conjunction with the NASA CV-990 or other airplane provided by NASA to make flights over specific coastal regions to acquire the necessary ocean wave patterns, and sea state of ocean profile data. The areas overflown will be selected during a users/scientists meeting in April 74. Most probably we will emphasize the East Coast (New York, New Jersey, ...) because of the critical need of energy plants in that region. Preference will be given to regions where coastal topography and wave diffraction models are available. During one of the flights multispectral radar data will be collected over the Colorado Plateau. The radar imagery will be correlated with the ERTS imagery, high-altitude conventional photography and extensive ground truth mapping which is presently being studied in detail as part of the ERTS program at JPL. The digital data system will be mated to the L-band radar, and output imagery of both the optical and digital systems will be compared to evaluate the DDS performance.

W75-70522 **177-55-52**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
MICROWAVE RADIOMETRIC MEASUREMENT OF ICE THICKNESS
D. P. Burcham 213-354-3028

The objective of this task is to perform ground based experiments with microwave radiometers operating at 1.42, 10.69, and 31.4 GHz. These experiments were made to: (1) demonstrate the feasibility of remotely measuring the thickness of lake ice with a microwave radiometric system, (2) determine the microwave properties of newly formed sea ice and, if feasible, multi-year ice, (3) determine the feasibility of remotely measuring the thickness of sea ice with a microwave radiometric system, and (4) support the 1975-1976 AIDJEX mission by measuring the microwave signatures of various ice types and thicknesses. This is a three-year program based on a logical progression of experimentation with definitive reportable objectives for each year of experimentation (see attached schedule). During FY-74, dual-polarized microwave radiometers operating at 1.42 GHz, 10.69 GHz, and 31.4 GHz were used to perform experiments on both controlled and natural samples of fresh water ice. These experiments were conducted from a van in the Great Lakes area and demonstrated a correlation of radiometer data with thickness of fresh water ice. Accuracies will be required to prove usefulness. Test techniques are being defined to extend the application to sea ice.

W75-70523 **177-55-81**
Lyndon B. Johnson Space Center, Houston, Tex.
MARSHLAND ECOLOGICAL SURVEY
R. O. Piland 601-688-2034

The Earth Resources Laboratory is conducting research investigations in Marshland Ecological Survey under the guideline of its charter as follows: (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, and (4) conduct continuing studies of user requirements of potential applications in order to guide future research efforts. The Marshland Ecological Survey has as its objective the development of remote sensing techniques and procedures necessary to produce information needed for monitoring the marshland ecology and management of coastal zone resources.

W75-70524 **177-55-82**
Lyndon B. Johnson Space Center, Houston, Tex.
COASTAL PROCESSES/LIVING MARINE RESOURCES
R. O. Piland 601-688-2034

The basic mission of the Earth Resources Laboratory is as follows: (1) to conduct research investigations in the Mississippi/Louisiana/Gulf areas in the application of remote sensing, stressing the interest and needs of agencies in the area, (2) to extend these research investigations into experimental demonstration projects in cooperation with the 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, and (4) to conduct continuing studies of user requirements of potential applications in order to guide future research efforts. In the ERL program area of sea remote sensing for FY-75, emphasis will be continued on the development of techniques and applications on coastal processes and living marine resources. Remote measurement technique developments will concentrate primarily on water surface temperature, salinity and water color. Water surface remote temperature measurement is the most advanced of these techniques and efforts there will be primarily in the advancement of atmospheric correction methods for both aircraft and satellite systems. Several projects are already underway or are being initiated for the demonstration of the application of these techniques to assessment and management of living marine resources, characterization of estuarine and near shore waters and the monitoring of natural and man made impacts on the coastal environments. Results of these projects will demonstrate cost effectiveness of remote techniques and lead to the development of remote sensing system specification for transfer of the technology to user organizations.

W75-70525 **177-56-81**
Lyndon B. Johnson Space Center, Houston, Tex.
ENVIRONMENTAL INFORMATION SYSTEM (ASVT)
Dr. Gary C. Thomann 601-688-4254
(177-52-81; 177-55-81)

The objective of this project is to test and demonstrate an automated environmental information system based on remotely sensed data for the updating of basic environmental data in a predominantly wetlands area. The Corps of Engineers have a continuing need for basic environmental information for planning projects and assessing the resulting impact. An Atlas Inventory of Basic Environmental Data, South Louisiana had been produced from existing data. The Corps of Engineers requested NASA to assess the atlas to determine which sets of data could be updated using remote sensing. Data dealing with land use and vegetation classification were identified as candidates for automated classification utilizing remote sensing data. A number of ERL SR and T projects in South Louisiana and Mississippi and associated software and hardware projects have provided the basis for developing an automated system to meet---

W75-70526 **177-56-91**
John F. Kennedy Space Center, Cocoa Beach, Fla.
APPLICATION OF REMOTE SENSING TO DETECTING

THERMAL POLLUTION
Roy A. Bland 305-867-4541

The effects of hot discharges from nuclear power plants can have detrimental effects on the ecological systems. Proper management of thermal pollution will be based on our ability to choose the most advantageous sites for future power plants. The approach is to develop a generalized, predictive, analytical model involving remote sensing and in situ measurements. Output of the model will include the motion and diffusion of thermal discharges and the extent of the region affected.

W75-70527 **177-57-81**
Lyndon B. Johnson Space Center, Houston, Tex.
EARTH SURVEYS IN SUPPORT OF THE LIFE SCIENCES
C. M. Barnes 713-483-5406

This research program is designed to explore the possibilities for the use of remote sensing systems technology for the life sciences. During the past year, the NASA and support contractors have investigated the aircraft and spacecraft imagery and ground truth data of the Earth Resources Program. The Health Applications Office has directed the acquisition of additional data pertinent to the health related remote assessments of the environs. Responsible scientists in the health field have emphasized that remote sensing is not only a highly desirable way of collecting data in field situations but may indeed be the only means of acquiring such information. While the use of remote sensing technology has not yet been forcefully applied in field situations by the responsible public health authorities, preliminary data collected by the Johnson Space Center has generated considerably enthusiasm in the health community. In addition to continuing investigation into feasibility of the use of remote sensors for health purposes, it is proposed that a close liaison be developed with general life science users and regulatory agencies and that pilot-type eradication and control programs be initiated during the coming year.

W75-70528 **177-60-41**
Goddard Space Flight Center, Greenbelt, Md.
APPLICATIONS SYSTEMS VERIFICATION TESTS (ASVT) - OPERATIONAL APPLICATIONS OF SATELLITE SNOW COVER OBSERVATIONS
A. Rango 301-982-6481
(177-54-41; 177-54-52)

The objectives are: (1) in the initial ASVT phase - to map snowlines and areal snow cover and associated changes in snow cover using satellite data for 1972-73 and 1973-74, (2) to continue study through FY-78 and extend the mapping in objective 1 to a total of six years, (3) to compare satellite snow mapping products to products from conventional information sources, and (4) to develop or modify methods in an operational framework that would allow incorporation of satellite derived snowpack observations for prediction of snowmelt derived runoff. The rationale for such a study is that snowmelt is the source for greater than 50% of streamflow in most areas of the Western United States.

W75-70529 **177-60-72**
Marshall Space Flight Center, Huntsville, Ala.
DEMONSTRATION OF APPLICABILITY OF NASA DATA ACQUISITION AND MANAGEMENT PROCESSES TO RESOURCE MANAGEMENT PROBLEMS IN THE ATCHAFALAYA RIVER BASIN
J. M. Balch 601-688-2121

The objective of this plan is to demonstrate to selected user agencies, federal and state, the beneficial application of NASA-developed technologies in acquiring, processing and managing data to meet selected resource management information needs in the management of natural resources of the La. Atchafalaya River Basin and to provide a basis for those agencies' expanded adoption of such technologies to meet operational requirements. The plan is to engage in a joint effort with the DOI, Bureau of Sport Fisheries and Wildlife, U.S. Geological Survey, EROS; U.S. Army CoE; EPA; La. Fish and Wildlife Commission; and the La. Dept. of Public Works. The joint effort will provide for this collection on a near real-time basis, by the use of data collection platforms and the ERTS Data Collection System, measurements including water stage, turbidity, DO, temperature and Ph from selected remote sites in the Atchafalaya Basin to provide input data for verification and operation of predictive eco-system models being prepared by participating agencies from existing broad-scale data. Also NASA/MTF will provide data management techniques to establish an archive of information over a selected small-scale grid in the Basin and will exercise mathematical predictive models on existing ADP equipment to correlate hydrological data with biological data, collected by others. The resultant information will be the basis for the formulation of a resource management plan by Bureau of Sport Fisheries and Wildlife with special emphasis on fish and wildlife management as related to flooding and flood control structures, for one or more Atchafalaya Basin management areas. Cooperating agencies will make various contributions ranging from the purchase of DCPs and sensors by the Corps of Engineers to calibration and maintenance of sensors by the USGS (funded by La. Dept. of Public works).

W75-70530 **177-61-81**
Lyndon B. Johnson Space Center, Houston, Tex.
GLOBAL WHEAT ASVT (LACIP)
John Overton 713-483-4776

The objective of the large area crop inventory project (LACIP) is to demonstrate the capability to perform a Global agricultural production assessment of a selected crop through the use of remote sensing in a quasi-operational mode. In order to demonstrate the capability to conduct a large area crop production assessment through the use of remotely sensed data, the crop of interest must be identified, the areal extent of the crop must be estimated and the yield per unit of area must be estimated. The approach is to sample the area of interest, classify the crops and statistically estimate the production of crop grown in selected regions. Three major elements are required to support this approach -- a data system, a statistical sampling scheme, and an analysis procedure. The system is to be designed, developed and operated in cooperation with the U. S. Department of Agriculture and the National Oceanic and Atmospheric Administration. The project will be a phased effort beginning in 1974 and running through 1977 consisting of a planning phase, two one year quasi-operational phases and resulting documentation. During the first two phases, directed in-house and university R and D activities will be conducted to support and improve the quasi-operational phases. These activities will include procedures for acreage determination from ERTS data, development of yield determination from meteorological data, improvement of sampling---

W75-70531 **177-61-82**
Lyndon B. Johnson Space Center, Houston, Tex.
NATURAL RESOURCES INVENTORY SYSTEM (ASVT)
Dr. Armond T. Joyce 601-688-4254
(177-52-81)

The objective of this project is to test and demonstrate an automated natural resources inventory system based on remotely sensed data oriented to state or regional use and directed at specific applications. States and other governing bodies have a need for accurate up to date natural resource inventory information for managing resources, optimizing growth and development and minizing environmental impact. The large geographical areas involved make surface inventory difficult and encourage the use of remote sensing. The resulting large quantities of data imply the desirability of automatic processing, access, and correlative capability. The ERL SR and T effort for the past three years has been oriented to the development of software, hardware and disciplinary techniques suitable for incorporation into such an automated system. The state of Mississippi is proposed as an initial test area for reasons of logistics.---

W75-70532 **177-71-01**
National Aeronautics and Space Administration, Washington, D.C.
EARTH RESOURCES SURVEY, GENERAL STUDIES
Richard T. Hibbard 202-755-8623

The objectives of this RTOP are to conduct studies and various activities that are of a general nature which are applicable

to earth observations and earth resources survey in particular. These studies may be in such areas as land, water, air environments, and the pollution of the environments. The studies may be in the form of theoretical, paper, or demonstrated types, and fundamental and basic research.

W75-70533 **176-91-31**
Langley Research Center, Langley Station, Va.
COORDINATION AND PLANNING ACTIVITIES FOR THE ENVIRONMENTAL QUALITY PROGRAM
E. S. Love 804-827-2893

The purpose is (1) to continue the planning and coordinating activities necessary to implement the Environmental Quality Enhancement Program; (2) to coordinate with user agencies, and to explore with these user agencies cooperative programs that will take advantage of NASA's expertise in the area of environmental quality monitoring; (3) to continue studies of economic parameters relating to environmental monitoring with emphasis to be placed on regional and global problems; (4) to extend the agreement between NASA Langley and the Region 6, Virginia State Air Pollution Control Board which provides for assistance in the area of sampling techniques, analysis and dispersion modeling; and (5) to provide Headquarters-OA with technical assistance involving preparation of material for programmatic recommendations, congressional briefings, budgetary submissions, preparation of material for new program emphasis and cooperative programs with user organizations. This RTOP is also intended to cover the extensive coordination activities required between other lead centers and assignments to committees in support of the lead center role.

Energy Applications

W75-70534 **647-10-01**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
SPACE BASED SOLAR POWER CONVERSION AND DELIVERY SYSTEMS
M. E. Alper 213-354-6948
(647-30-01)

This is a continuation of an RTOP initiated April 1974 which seeks to establish the most effective means of utilizing solar energy in the large scale production of power in the 1990's and beyond and to compare this option with other means of generating power, such as nuclear. The study will perform system type economic comparisons between orbital power generation/transmission concepts and ground based power generation and distribution. The work is being closely coordinated with a parallel effort being conducted by the Marshall Space Flight Center. The study will build upon the results of previous technical and economic investigations of orbital and terrestrial power systems including satellite solar power systems, microwave power relay systems, nuclear power plants in earth orbit, terrestrial hydrogen energy transport, and other known new concepts for power generation and transmission. During FY-74 a thorough literature review was initiated, identifying the work that has been done to date and the technologies which have been developed or which are required. In addition during FY-74, a detailed program plan coordinated with the MSFC effort was developed. The plan included milestone schedules and cost. During FY-75 this program plan will be implemented. The overall study will focus on an economic comparison of terrestrial and space based solar and nuclear power system concepts and will establish the unique advantages of each, the technology required and the cost and schedule associated with a fully developed system.

W75-70535 **647-10-01**
Marshall Space Flight Center, Huntsville, Ala.
SPACE BASED SOLAR POWER CONVERSION AND DELIVERY SYSTEMS
W. E. Whitacre 205-453-3465
(647-10-02)

The objective of this continuing effort is the performance of economic and technology assessment comparisons between space based power generation/transmission concepts and other ground-based conventional modes of production and distribution of electrical energy to be used in the 1990's and beyond and to define the near-term activities on which to proceed, if warranted. This 10-month study will build on the results of the previous conceptual feasibility studies, the MSFC in-house investigations, and the FY-74 contracted effort. It will consider in greater depth the various facets of the many proposed new concepts for both power generation and distribution. This study will focus on the economic comparison of these new proposed approaches with the evolutionary trends of the more conventional power generation and transmission concepts. Special emphasis will be placed on the development of trends for the items that affect the establishment of new energy sources to a major extent and on the areas of major concern identified as a result of the FY-74 funded effort.

OFFICE OF SPACE SCIENCE

Launch Vehicle Development SR&T

W75-70536 **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 underway for several years aimed at evaluating and analyzing the capability of existing and proposed propulsion systems for accomplishing planned or proposed automated mission. The theory, analytic approaches and computer implementation necessary to conduct this work have been pursued at the Aerospace Systems Lab of Princeton University, Analytical Mechanics Associates, Inc. and by the MIT Charles Stark Draper Laboratory. Current efforts are directed at extending the capabilities of these computer programs, as well as the use of the programs 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 thrust propulsion systems show a distinct advantage in either payload or trip time.---

W75-70537 **180-06-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
ELECTRIC PROPULSION RELIABILITY
P. J. Meeks 213-354-2546
(506-22-31)

An electric propulsion system/stage reliability computer code is under development. When completed, the code will allow propulsion system design optimization based upon failure mode analysis and mission reliability requirements. The assessed reliability of the various subsystems of an autonomous stage must meet the mission requirements. Use of the system code will provide sensitivity analysis and will provide information such as (1) where to put redundancy for highest payoff and (2) where the emphasis for increased reliability is needed. The development of the computer code will be accomplished with close coordination with the JPL Office of Quality Assurance and Reliability. This work will be fully documented for export to other NASA Centers.

W75-70538 **180-06-51**
Goddard Space Flight Center, Greenbelt, Md.

GENERALIZED ACOUSTICAL STUDY FOR PAYLOAD ENCLOSURES
D. J. Knighton 301-982-4258

Increasing sensitivity of space-vehicle payloads to increased launch vehicle engine generated and in flight acoustic fields has focused more attention on the noise reducing properties of payload enclosures. In some cases the optimization of structural enclosures for aerodynamic, weight and structural constraints have lowered the acoustic insulation characteristics of the enclosure and thereby increased the acoustic levels incident on the payloads. To further complicate the problem the analytical prediction methods used today do not correlate well with actual acoustical test and flight measurements. The purpose of this study is to develop a generalized acoustical prediction technique which would result in design guidelines and monographs; thus, providing designers the analytical tools to more accurately determine payload acoustical environments. In formulating the analytical techniques the prodigious quantity of acoustical test and flight data acquired under the Delta, Saturn, and Titan Programs on payload shrouds will be utilized. The structures tested included aluminum integral machined skin, aluminum semi-monocoque skin-frame and stringer and fiberglas fabrication methods. Available acoustical test data on aluminum honeycomb panels will also be used. In addition, the effects of a gaseous---

W75-70539 **180-06-52**
Langley Research Center, Langley Station, Va.
LAUNCH VEHICLE CONCEPTS AND ANALYSIS
E. S. Love 804-827-2893

The following programs will be accomplished: (1) to determine the feasibility of using launch vehicles of the Scout class to perform earth escape missions. These missions shall include probes, solar and planetary (both in the ecliptic and out-of-ecliptic planes), and planetary transfer orbits. Further, a simple means will be identified, to the extent possible, to enhance the capability of the launch vehicle to perform these missions. (2) 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 configurations, changes in terms of performance, cost, and scheduled phase-in with the present systems. (3) 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. (4) To compare measured bending moments of the Scout vehicle during flight with moments calculated based on measured inflight input parameters.

W75-70540 **180-06-60**
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 studies and analyses required for OSS Launch Vehicle and Propulsion Programs planning and OSS level space program planning. Individual tasks are formulated and assigned by the Office of Space Science or by launch vehicle and propulsion programs. The contractor conducts studies and analyses (OSS planning studies, economic analyses, trade-off studies, investigations in areas of launch vehicle technology; etc.) that provide a base of technical information that can be drawn upon in the formulation of program recommendations.

W75-70541 **180-17-50**
Marshall Space Flight Center, Huntsville, Ala.
SYSTEM PERFORMANCE AND TECHNOLOGY ASSESSMENT FOR UNMANNED MISSIONS
G. Wittenstein 205-453-0359

Methods and computer programs, developed under NAS12-550 and updated and tested under NAS8-26491, allow the definition of systems parameters for planned OSS missions. These parameters include data needed to identify astrionics/avionics subsystems and hardware requirements. The sensitivites 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 a comparison of requirements for specific OSS 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.

W75-70542 **180-17-50**
Langley Research Center, Langley Station, Va.
ASTRIONICS SYSTEMS EVALUATION
E. S. Love 804-827-2893

A feasibility study will be conducted to define a guidance and control system concept for application to a spin-stabilized final stage of a launch vehicle, based on tradeoff studies, stability and control analyses, guidance and trajectory error evaluations, and a preliminary design utilizing the concept selected. Tradeoff 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 state-of-the-art guidance packages (miniaturized gimbal or strapdown, conventional gyros or laser gyros) which could be utilized in launch vehicles. Evaluation points will be weight, volume, cost, ease of maintenance, reliability, and accuracy. A detailed systems analysis shall be performed using the results of the above feasibility study. Detailed system specifications and requirements shall be prepared.

W75-70543 **180-17-53**
Marshall Space Flight Center, Huntsville, Ala.
DYNAMIC TESTS OF INERTIAL SENSORS
B. J. Gaines 205-453-0795

The objective is to determine the performance quality of inertial sensors designed for astrionics' application. The approach followed was: (1) to determine the suitability of existing methods and equipment for dynamic tests of inertial sensors developed as experimental prototypes for astrionics' applications, (2) to 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, (4) conduct performance tests with the inertial sensors combined into an astrionics sensor package, and (5) analytical studies will be performed as required to develop specifications for inertial measuring units.

W75-70544 **180-17-54**
Marshall Space Flight Center, Huntsville, Ala.
GUIDANCE COMPUTER TECHNOLOGY
J. B. White 205-453-4129

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 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 being emphasized. Digital logic, circuits, packaging techniques, and configuration are being developed to meet the reliability and environmental constraints of these advanced missions. Emphasis is being given to continuation of research in modular computer configurations. Existing software is being 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 which demonstrates and verifies the objectives, approach, and architecture of a long life fault tolerant computational systems.

W75-70545 **180-17-55**
Marshall Space Flight Center, Huntsville, Ala.
CONTAMINATION CONTROL IN HYBRID MICROELECTRONIC MODULES
Salvadore V. Caruso 205-453-1505
(502-23-51)

The objective of this effort is to develop, test, and evaluate coating materials, processes, and process controls for protection of hybrid microelectronic circuit modules from contamination. The materials and processes selected and tested shall be for the purpose of passivation and particule immobilization in hybrid packages. Investigations will be performed to select and test passivation coating materials and processes for applications in particulate contamination control. The materials shall be selected from the general chemical categories such as high purity silicon resins, polyimide, etc. The materials selected by the current investigations will be thoroughly tested and screened on operating microcircuits. Processes will be developed for coating microcircuits and additional programs performed to determine long-life reliability, compatibility and chemical and thermal stability of the materials. Investigations will be performed to determine the relationship of these process controls and materials on such key assembly techniques as package sealing, wire bonding, rework, testing, long-life reliability, etc. This activity would continue the investigations in order to provide a means of preventing particulate contamination in hybrid microcircuit package.

W75-70546 **180-17-56**
Marshall Space Flight Center, Huntsville, Ala.
SOLAR ELECTRIC PROPULSION STAGE (SEPS) TECHNOLOGY
J. P. Hethcoat 205-453-5584

This RTOP represents the total FY-75 SEP Stage SRT effort excluding the solar array which is being pursued under a related RTOP (180-17-57). Technology research to be performed under this project will support advanced SEP stage definition activities and the detail design and development of a SEP stage or an evolutionary design that is to evolve into a multiuse SEP stage. Advanced study and ongoing in-house activities have identified areas where technology research is deemed important. These areas were selected following consideration of technical, operational, and program requirements. Under this project detailed technology requirements for critical SEPS subsystems will be defined and analysis tools (software) will be developed for use in SEPS definition activities and to support the subsystems requirements definitions. In pursuit of these objectives our FY-75 program will continue investigation of critical subsystems and subsystem interactions and will continue software development, systems simulations, and high energy radiation effects analyses. Systems simulations will proceed toward the development of a simulator for detailed definition of control subsystem requirements. Tasks are to be initiated that will investigate interactions between the SEPS solar array and power conditioning, determine the impact of potential surface coatings on the SEPS vehicle, and develop a mockup of the SEP stage.

W75-70547 **180-17-57**
Marshall Space Flight Center, Huntsville, Ala.
SOLAR ARRAY TECHNOLOGY FOR SOLAR ELECTRIC PROPULSION STAGE
L. E. Young 205-453-4566
(502-24-17)

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 perform a preliminary design in order to identify the solar array technology required by the solar electric propulsion stage (SEPS). This technology will be compared with the state-of-the-art to identify areas where demonstration or further development of technology is needed. These areas will be worked as specific problems with results being fed back into the design effort. The availability of overall array technology will be demonstrated by fabricating and testing a full-scale wing.

W75-70548 **180-24-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
ENGINEERING INSTRUMENTATION
P. J. Meeks 213-354-2546

It is the objective of this applied research program to (1) develop and demonstrate comprehensive nondestructive test (NDT) techniques for electroexplosive devices (EED's), (2) develop designs and techniques to reduce or eliminate the electrostatic hazards to EED's, and (3) to develop an EED simulator which can be used repetitively to measure pyrotechnic system susceptibility to an RF environment. First, with regard to (1), it is planned to characterize the primary failure modes of EED's, such as incorrect explosive loading by building devices with known fault types and then testing them with use of the thermal coupling technique. Each fault type or failure mode will have its own unique signature or profile. This effort will result in a complete characterization of EED faults, previously undetectable by any NDT method, versus signal output obtained by the thermal coupling technique. It is planned also to design and fabricate a prototype set of instrumentation to automate the transient pulse test technique. This system will include data measurement, storage, calculation, and recording capabilities. Second, with regard to (2), the application of miniature nonlinear shunts to EED's appears to be an excellent means to reduce the hazard of premature actuation caused by electrostatic discharge. It is presently planned to conduct a two-pronged approach namely; to design the shunt as a component within the electrode portion of the device apart from the pyrotechnic, and secondly, to include the shunt materials within the---

W75-70549 **180-31-51**
Lewis Research Center, Cleveland, Ohio.
THERMAL SYSTEMS MANAGEMENT
C. A. Aukerman 216-433-4000
(502-24-24; 502-24-31)

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, and (3) optimize multilayer insulation by selectively varying thickness and shield emissivity.

W75-70550 **180-31-52**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
LIQUID PROPULSION TECHNOLOGY
P. J. Meeks 213-354-2546
(506-21-20)

The overall objective of this effort is to evolve and demonstrate the technologies of critical components for a 1000 lbf thrust bimode propulsion system. Once these technologies have been demonstrated, they can be easily adapted to flight application by the ultimate user. Specific components, such as propellant control valves and their actuators and the engine, will be developed and demonstrated to indicate the capability of meeting the requirements of a liquid propulsion system using nitrogen tetroxide and hydrazine. The engine development effort, which constitutes a major portion of this RTOP, has as its objective the demonstration and evaluation of a preflight configuration bimodal rocket engine for unmanned planetary spacecraft applications. It will employ the above mentioned propellants, earth-storable propellants, and will produce a bipropellant vacuum thrust of approximately 4500 N (1000 lbf) at a 40:1 expansion area ratio. The preflight model will be designed based on criteria and information generated during prior years' efforts. This engine then will be subjected to performance, maring-limit, and life testing in a vacuum environment. An engine propellant valve and actuator for the 1000 lbf bimodal engine will be developed. A similar device, but at a smaller line size, is being developed for the space storable propulsion system. The results of the two efforts will be coordinated to ensure maximum technology interchange.

W75-70551 **180-32-51**
Langley Research Center, Langley Station, Va.
SOLID ROCKET PROPULSION SYSTEMS
E. S. Love 804-827-2893

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 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 identify the critical design parameters that affect the reliability of pyrotechnic systems so that low cost, simple, and reliable systems can be used. An investigation shall determine what materials and designs are best for solid rocket motor nozzles including those used in new high energy propellant programs. Studies and demonstrations of high energy propellants in existing solid rocket motor hardware shall be initiated.

W75-70552 **180-32-52**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
SOLID PROPULSION TECHNOLOGY
P. J. Meeks 213-354-2546
(506-21-32)

The first objective is to study future mission applications of solid propellant rocket motors, and to investigate technical problem areas arising from on-going project applications of such motors. A principal activity will be to provide solid propulsion technical support to the Scout Project Office. The support will include: (1) consulting services, (2) critiques of contractor supplied documents, (3) aid in solving solid rocket motor problems, (4) in-house analytical and experimental work to either supplement or verify contractor efforts, and (5) assistance in the definition and technical management of programs relative to providing thrust termination capability to the Scout system. The second objective is to develop an analytical technique that can be employed effectively in the prediction of the limit to which a solid rocket motor can be tested without experiencing failure. Through contractor and in-house efforts an analytical method will be developed to predict the failure modes, and the limits at which failures will occur when a motor is subjected, singly and in combination, to: (1) temperature cycling, (2) vibration, (3) acceleration, and (4) shock. Several surplus motors will be acquired, analyzed by the failure prediction technique, and tested to verify the adequacy of the prediction technique.

W75-70553 **180-59-01**
Goddard Space Flight Center, Greenbelt, Md.
INTEGRAL VARIABLE THRUSTING SEPARATION JOINT
D. J. Knighton 301-982-4258

The present thrusting joint designs are limited to a maximum of 160 F environment. This qualification test limitation is based on a thermally insulated joint temperature reaching a maximum of 140 F during the Delta launch vehicle flight. Available data, however, indicates that the separation system may be able to operate efficiently up to approximately 200 F. To prove this several tests are planned utilizing the test fixture already developed under this RTOP during Fiscal Year 1974. Successful test results would permit the variable thrusting separation system (currently being developed under this RTOP) to require less external insulation and/or to be incorporated in future higher thermal input launch vehicle missions. Data obtained from these temperature tests has potential application to Delta, shuttle and/or space tug and Titan launch vehicle Programs.

W75-70554 **180-72-50**
Langley Research Center, Langley Station, Va.
ATMOSPHERIC EFFECTS RESULTING FROM EFFLUENTS PRODUCED DURING NASA UNMANNED ROCKET LAUNCHES
E. S. Love 804-827-2893
(502-24-88)

The objectives of this research are to examine the effluent from NASA unmanned launch operations which may alter the environment and to conduct a program to assess the possible impact of these operations on the environment. The type and amount of effluents from launch operations will be determined from studies of the launch systems. Analytical models are being developed and applied by the Marshall Space Flight Center to describe increases in concentration and dispersion of launch vehicle effluents. Measurements of the concentration and dispersion of effluents from selected launches will be made by the Langley Research Center. The analytical predictions and the experimental measurements will be used jointly to assess the effects of NASA unmanned launch operations on the environment. The primary environmental effects that will be determined are: (1) the spatial and temporal distribution of toxic materials in the vicinity of the launch site resulting from NASA unmanned launch operations; (2) possible adverse effects of exhaust effluents on vegetation and man in the vicinity of the launch sites, by studying the environmental fate of the effluents; and (3) the type and amount of material deposited in the troposphere during launch operations. This study is being coordinated with other related studies on the environmental impact of exhaust effluents through the NASA Panel on Shuttle Exhaust, OAST Shuttle Technologies Office. This work is also being coordinated with related DOD studies. Previously developed measuring techniques and hardware will be used whenever practical.

Planetary Exploration SR&T - Science

W75-70555 **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 refine laboratory techniques and construct test facilities for testing and calibration of instruments to measure the neutral particle composition and temperature of the planetary atmospheres. 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. A pressure calibration system has been constructed for mass spectrometer calibration with non-reactive gases, i.e., N2, O2, CO2, H2, He, Ar, etc., in the pressure range from 10 to the minus 3rd power to 10 to the minus 10th power torr. Liquid helium cryogenic pumps and sputter ion pumps are used to provide efficient pumping to low pressures without hydrocarbon contamination. High speed computer compatible data recording is planned to improve measurement accuracy and data handling efficiency. Particle beam systems of chemically active species, i.e., O,N,H, are developed for mass spectrometer calibration and gas surface interaction studies. Atomic oxygen and hydrogen are produced by thermal dissociation on heated tungsten surfaces with kinetic beam energies of approximately 0.2 eV. To simulate satellite energies, a sputter beam system is developed with the intent to produce atomic beams of nitrogen and oxygen with average kinetic energies of 10 eV. Static high pressure and temperature test facilities will be designed to test mass spectrometer components and sample inlet systems. Conditions expected to be found in the lower atomospheres of Venus and the outer planets will be simulated.

W75-70556 **185-47-52**
Goddard Space Flight Center, Greenbelt, Md.
EXPERIMENT DEVELOPMENT FOR NEUTRAL GAS COMPOSITION MEASUREMENT IN PLANETARY ATMOSPHERES
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 planets and comets. 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 (1) the improvement of ambient gas sampling techniques for high velocity probes into high density atmospheres (e. g., Saturn or Uranus entry probes), (2) the design of more efficient ion sources of both the open type which provides side-energy focussing, and the closed type which increases the thermalization of the gas being measured, and (3) 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 planetary and cometary flight opportunities. This work will concentrate on (1) development of smaller, lighter, higher resolution, less expensive mass analyzers, (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 processsing system under true flight conditions.

W75-70557 **185-47-53**
Goddard Space Flight Center, Greenbelt, Md.
ADVANCED ION MASS SPECTROMETER TECHNIQUES FOR PLANETARY AND COMETARY EXPERIMENTS
H. A. Taylor, Jr. 301-982-6610

The purpose of this RTOP is to support instrument development for optimizing the direct measurement techniques used in the detection of ambient thermal ion composition and concentration from planetary probes, orbiters, and cometary probes. The desirability for optimizing the Bennett RF ion mass spectrometer measurement technique is brought about by the mission constraints anticipated for flight opportunities such as the Pioneer-Venus Probe and cometary wake exploration, both of which demand a maximum degree of automatic inflight adaptability in response to limitations such as low telemetry rate, power, and weight. Realization of these objectives in the midst of a constantly evolving technological development in turn requires a continuing evolution of instrument concepts. To realize this objective, improvements in the Bennett spectrometer instrument aer planned in the areas of (1) step-dwell ion peak detection, replacing a continually scanning spectral sweep and (2) implementation of a servo system for automatically adapting the accelerating voltage and retarding potential to optimized values for the detection of resonant ions in the spectrometer sensor. These tasks involve electrical design enhancements, emphasizing a controlled and reliable extension of present technology. It is planned that these improvements will be evaluated as part of an earth flight test program involving cooperative participation as a piggyback instrument on a forthcoming Javelin rocket payload.

W75-70558 **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.

W75-70559 **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. Measurements on phodissociative excitation of CO2 have been extended to include cross sections for producing CO(a3pi),CO2(+)(A2pi), and CO2(+)(B2 Sigma u) and a function of incident photon energy. Excitation cross section for electron impact on CH4, NH3, and H2O have been measured for those spectral feature which lie between 1100 and 2000A. The electron excitation apparatus was modified and results have been obtained for electron impact on N2 and O2 to produce emission in the EUV (Lambda < 1050A). A series of sounding rocket observations of the aurora in the EUV are planned which will complement the laboratory measurements in the EUV. An experiment has been set up at the University of Maryland, in collaboration with Dr. M.A. Coplan, which has measured cross sections for producing ions in excited electronic states via charge exchange of He+ with CO2 and CO. The flash photolysis-resonance fluorescence apparatus is now equipped with a---

W75-70560 **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 on 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 applicationto 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 can be utilized as tracers to determine factors involved in large scale circulation and interaction between different atmospheric regions. Development of an instrument suitable for a Viking type Mars mission is a prime objective.

W75-70561 **185-47-61**
Lyndon B. Johnson Space Center, Houston, Tex.
SPECTROSCOPY OF PLANETARY ATMOSPHERES
R. D. Hudson 713-483-5891

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< 0.04 A), (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.

W75-70562 **185-47-66**
Ames Research Center, Moffett Field, Calif.
ATMOSPHERIC CHEMICAL PHYSICS - RESEARCH STUDIES OF PROCESSES IN PLANETARY ATMOSPHERES, COMETS AND INTERSTELLAR SPACE
D. R. Chapman 415-965-5065

The objectives are: to determine products, rates, and yields of energy transfer reactions in planetary atmospheres, comets, and interstellar space, to determine how 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, and to provide insight into how the nature of planetary atmospheres, comets, and interstellar matter can be obtained from studies of these processes

under controlled laboratory conditions. The recombination of CO and O to produce CO2 will be investigated under conditions simulating the CO2-rich atmospheres of Mars and Venus. Similar studies for the reaction CO + OH will be undertaken. The recombination process in the presence of Cl or S will be considered to assess the effectiveness of these species in catalyzing the reaction. This study is relevant to the CO2 photochemistry on Venus. 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 reduced atmospheres (e.g. Jupiter) and will provide scientific support for future Jupiter missions.

W75-70563 **185-47-67**
Ames Research Center, Moffett Field, Calif.
STRUCTURE OF PLANETARY ATMOSPHERES
Dean R. Chapman 415-965-5065
(185-47-66; 384-47-66)

The basic goal is to connect atmospheric observations with theory. Immediate objectives are to determine: (1) structure of the ionospheres of Venus, Mars, Jupiter and the moons of Jupiter and Saturn, (2) interactions of planetary ionospheres with the solar wind; (3) dynamics of the Venus atmosphere; (4) atmospheric structure of Jovian planets and Titan, and (5) mean particle sizes and optical depth of Saturn's rings. The abundances and distribution of ions and electrons and minor constituents on Mars and Venus are being studied theoretically, using data from observations and laboratory measurements. In each case this work involves numerical solution of appropriate conservation equations; for example, we solve the complete set of coupled mass, momentum and energy conservation equations in the case of the upper ionosphere of Venus. Thermal structure models have been constructed to understand the operation of the greenhouse effect on Titan. In order to understand the dynamics of Venus' atmosphere, calculations are being carried out to examine the effects of rotation, apparent solar motion, and the energy deposition profile on the circulation of the atmosphere. Estimates of the particle size in the rings of Saturn are obtained from analysis of observed near IR and microwave spectra measurements.

W75-70564 **185-47-68**
Ames Research Center, Moffett Field, Calif.
PLANETARY ATMOSPHERES - STRUCTURE AND COMPOSITION
Alvin Seiff 415-965-5685
(185-47-67)

The ongoing OSS program to explore the planets includes two missions, Viking and Pioneer Venus, on which properties of the planetary atmospheres will be measured during entry and descent to the surface by instruments carried by the probes. These experiments have grown out of research supported by this RTOP. The continuing studies will optimize the approach and maximize the return related to atmosphere structure from the Viking Entry Science experiment, and will further develop the capabilities of the Pioneer Venus experiment. A major thrust of this work recently has been the relationship of measured parameters to the winds at the entry sites and the overall circulation of the planets' atmospheres (not an area of emphasis in the early work). The further development of wind observational techniques will require continuing effort. (It is the writer's opinion that the Russian failures to put a surviving probe onto the surface of Mars is quite possibly associated with wind-connected phenomena). In addition, work will be devoted to study of atmosphere structure and composition experiments for future missions to Saturn, Uranus, and Jupiter.

W75-70565 **185-47-69**
Ames Research Center, Moffett Field, Calif.
PLANETARY ATMOSPHERES EXPERIMENT DEVELOPMENT
Dean R. Chapman 415-965-5065

The objective of this program is to establish the feasibility of experimentally identifying the composition of planetary atmospheres by utilizing the spectral signature of atmospheric components as measured with attenuated total reflection techniques (ATR) on atmospheric probes. The ATR techniques should be especially effective for monitoring the proposed organic and inorganic constituents of the atmospheres of Jupiter and Venus without the necessity of sample ingestion or erection of experimental components external to an atmospheric probe. The ATR technique will be applied to the measurement of the spectral characteristics of thin films of typical proposed constituents condensed onto the outside of simulated windows of an atmospheric probe. Commercially available apparatus will be employed to obtain the pertinent signatures, applying minor hardware modifications necessary for the particular requirements of the pertinent atmospheric constituents. The possibility of identifying several constituents from a layer of one constituent deposited on a sub-layer of another constituent, as well as single layers of mixtures of two or more constituents, will be investigated. Based on the results of the measurements, consideration will be given to the feasibility of incorporating a typical ATR apparatus into space experiment by considering component development requirements.

W75-70566 **185-47-71**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
ATMOSPHERIC EXPERIMENT DEVELOPMENT
D. P. Burcham 213-354-3028
(185-47-72)

This work defines, develops and evaluates new or improved remote sensing experiments for the exploration and study of the atmospheres of solar system bodies from spacecraft. The approach is through research in four broad categories: (1) the practical application of developments in radiative transfer theory to the problems of remote sensing of atmospheric structure, (2) methods for the inversion and interpretation of radiometric and spectroscopic measurements of atmospheric radiation, (3) experimental and theoretical studies of the spectral properties of atmospheric gases and possible cloud constituents at wavelengths of importance for remote sensing experiments, and (4) feasibility of attaining specific scientific goals, with state of the art instrumentation and within a framework of spacecraft and mission constraints. Instruments and techniques are developed via detailed numerical studies and error analyses, and laboratory, ground based or airborne experiments as appropriate. The development of realistic atmospheric models as focal points for studies is an important subactivity. Major efforts for FY-75 are centered on: (1) exploratory remote sensing experiments for Uranus, (2) measurement of parent molecule distributions in cometary comas from spacecraft, (3) experimental evaluations of the dual frequency-dual field of view and zenith scanning approached to remote sensing of cloudy atmospheres, and (4) development of further improved model atmospheres for Venus and Jupiter by analysis of new earth-based spectra (including our anticipated high-resolution mid-infrared C141 observations) and Mariner 10/Pioneer 10 data.

W75-70567 **185-47-72**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
THEORETICAL STUDIES - PLANETARY ATMOSPHERES
D. P. Burcham 213-354-3028

A broad program of applied and theoretical studies related to planetary atmospheres will be conducted, with the following primary objectives: (1) understanding the properties and determination of the parameters of planetary atmospheres, (2) application of laboratory experimental data to the understanding and interpretation of spectral features and photochemical processes and mechanisms for complex planetary atmospheres, (3) applying these findings toward design of ground based and spacecraft experiments, and (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-75 pertain to planetary atmospheric modelling, photochemistry of planetary atmospheres, radiative transport theory, spectroscopic theory development and microwave spectral studies of planetary atmospheres.

W75-70568 **185-47-74**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
IONIZATION AND RATE PROCESSES IN PLANETARY ATMOSPHERES
D. P. Burcham 213-354-3028

Differential and integral cross sections for electron-molecule (atom) collision processes which occur in planetary atmospheres are measured. The methods of electron-impact spectroscopy are also used to locate and identify (as to symmetry) the low-lying optically-forbidden electronic transitions in molecules and atoms (He, H2, O2, CO2, H2O, NH3, CH4). Elastic, inelastic, and superelastic scattering from radical, atomic species, and metastable molecular states which are of importance in planetary atmospheres are also studied (O, O2(a1 Delta g). The ion-cyclotron resonance spectrometer (ICR), High-pressure mass spectrometer (HPMS), and photoionization mass spectrometer (PIMS) facilities in the JPL Laboratory for the study of ionization processes will be used to examine the ion chemistry of the outer planets and their satellites. The objective of this work is to apply unique and complementary laboratory instrumentation towards the dedicated study of ionic processes and chemical synthesis in atmospheres with reducing and near-solar compositions. The addition of the PIMS and HPMS instruments to the ICR Laboratory considerably widens the scope of these studies and allows for a more general and comprehensive attack on chemical reactions in planetary atmospheres. Specific objectives for the coming year include: (1) completion of the study of second stage ionic chemical reactions in mixtures of H2, He, CH4, NH3, H2O and H2S, (2) completion of the HPMS and begin the study of three-body ion-molecule reactions in H2-H2-CH4 mixtures, (3) attempt to study the very slow bimolecular reaction He + H2, using both the ICR and HPMS, and (4) begin studies of the reaction of ions with H atoms. These latter two studies are extremely important for modeling of the Jovian ionosphere.

W75-70569 **185-47-80**
National Aeronautics and Space Administration, Washington, D.C.
EXPERIMENT DEVELOPMENT
R. F. Fellows 202-755-3660

The objective of tasks supported under this RTOP is to develop the instrumentation capability required for spacecraft exploration and study of planetary atmospheres and cometary gases. New concepts will be sought and evaluated, and known techniques and instruments will be modified and developed for specialized application. Studies essential to understanding the response and behavior characteristics of sensors and instruments will be conducted. Emphasis is being placed on three areas of development: (1) specialized sensors and instruments required for investigation of the lower atmosphere and cloud phenomena of Venus and Jupiter by entry probes, (2) instrumentation and experiments required for investigations of the atmospheres of the outer planets from flyby and orbiter spacecraft, and (3) design of experiments and instruments for the in situ investigation of comets. Entry probes enter the atmosphere at high speed creating problems in sampling for mass spectrometer usage. In addition, it is necessary to provide the ability to determine the composition of atmospheres of planets such as Venus and Jupiter at low altitudes where pressures are much higher than the regime in which flight mass spectrometers have been used to date. Investigation of new concepts and improvements in existing techniques of sample acquisition and handling are required to solve the problems imposed by the high speed and high pressure environment.

W75-70570 **185-47-81**
National Aeronautics and Space Administration, Washington, D.C.
THEORY AND MODELS
R. F. Fellows 202-755-3660

The objective of work performed under this RTOP is to foster and to develop a broad base of theory explaining the phenomena of planetary atmospheres including their origins, evolutions, present states, and future behavior. Theoretical models of the atmospheres of the planets are derived, modified, critiqued, and improved on a continuing basis using the fundamental principles of physics and chemistry supplemented by the most current information available from flight experiments, laboratory research, and astronomical observations. In order to achieve a better understanding of the nature and phenomena of planetary atmospheres it is necessary to develop models describing the properties of particular atmospheres and the variations in properties as a function of altitude. Also, theories must be developed which explain the behavior and interaction of the atmosphere of a planet with external influences such as solar radiation and the solar wind. These theories play a role in the design and selection of the experiments to be performed by planetary spacecraft and in turn the theories are tested against the results obtained from the flight experiments. As a result of this interaction, new ideas and theories, and revisions of existing theories are constantly developing.

W75-70571 **185-47-83**
National Aeronautics and Space Administration, Washington, D.C.
SPECTROSCOPIC INVESTIGATIONS
R. F. Fellows 202-755-3660

Work performed under this RTOP includes theoretical and laboratory investigations of the components of planetary atmospheres by spectroscopic, photometric, and radiometric techniques for the purpose of obtaining data necessary for the design of flight experiments and the interpretation of data obtained by flight experiments. Also included are the necessary studies in the theory of spectroscopy and radiative transfer necessary to interpret flight data in terms of physical properties such as temperature and density profiles in addition to the usual determinations of composition. The majority of tasks are concerned with infrared and ultraviolet spectroscopic studies of gaseous species although exploratory studies to define the potential of microwave techniques are also included. Tasks also include work directed at understanding auroral and airglow emissions since spectroscopic scrutiny of these natural processes offers strong clues to the composition and characteristics of the atomic and molecular species involved. Spectroscopic techniques are a very powerful means of obtaining information about the composition, number density, temperature, and energy states of gaseous molecules. It is possible to obtain spectra either by remote observations or by in-situ methods. Also, in many cases, spectrometers scanning over an appreciable wavelength interval report information on all components detectable, i.e., the instrument does not have to be programmed or designed in advance for each suspected or---

W75-70572 **185-47-85**
National Aeronautics and Space Administration, Washington, D.C.
ATMOSPHERIC CHEMISTRY
R. F. Fellows 202-755-3660

The objectives of this RTOP are to support a broad base program of laboratory investigations directed at obtaining data essential to the analysis of flight experiments and the development of new and improved theories and explanations of atmospheric chemical processes. Research included under this program includes investigations of chemical kinetics, photochemistry, reaction mechanisms, intermediates and metastable reaction species, collision processes and other phenomena connected with the interchange of energy between photons, atoms, ions, and molecules and the interaction of such species with electromagnetic radiation. Also included is research concerned with determining the physical and chemical properties of low molecular weight molecules, free radicals, and other species stable at cryogenic temperatures that are likely to be present in comets or the atmospheres of the outer planets. In order to obtain a better understanding of planetary atmospheres it is necessary to have *a quantative understanding of the many different chemical* reactions occuring in atmospheres and the responses to various energy inputs. As a result of solar irradiation the various chemical species present in planetary atmospheres are photolysed into ionized, disassociated, and excited states. The extent to which this occurs is highly dependent on the pressure (altitude), the identity of neighboring constituents, and the wavelengths of the solar radiation---

W75-70573 **185-47-91**
Langley Research Center, Langley Station, Va.
PLANETARY ATMOSPHERIC PROCESSES AND MEASUREMENTS
E. S. Love 804-827-2893

Properties and processes of the earth's upper atmosphere, as well as the atmospheres of other planets, will be studied using ground-based and satellite measurements, laboratory simulations, and theoretical studies. Earth aeronomical measurements employing various techniques are 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 is determined spectrophotometrically from ground-based measurements of satellites passing into the earth's shadow. Photochemical models of ozone are formulated. A number of studies concerning atmospheric processes and measurements apply to other planetary atmospheres. Studies of the meteorology of Mars, Venus, and other planets are being employed to evaluate and improve instruments and measurement techniques on other planets. A unique molecular beam mass spectrometer system is being developed to study reactive and non-reactive gases in planetary atmospheres. Theoretical studies are being performed on the composition, density, temperature, and evolution of the thermospheres and exospheres of Mars, Venus, and other planets and planetary satellites. Improved techniques are being developed to analyze radio tracking data, solar occultation data, and other data types to determine characteristics of planetary atmospheres. 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.

W75-70574 **185-50-51**
Langley Research Center, Langley Station, Va.
REMOTE DETECTION OF SURFACE PROPERTIES OF PLANETS
E. S. Love 804-827-2893

The objective of this research is the determination of planetary surface properties (e.g., particle sizes, phase functions, interparticle separations, albedos, dielectric constants, and surface roughnesses) from analyses of the characteristics of radar signals and solar radiation that have been reflected from planets and are detected by planetary orbiters or earth-based instruments. The research is divided into three parts as follows: (1) a theoretical part that includes rigorous derivations of photometric functions that describe reflected radiation in terms of scattering geometries and surface properties, quantitative treatments of polarization phenomena, studies of the photometric effects of rough topographies, and the development of a comprehensive mathematical formalism for accurate interpretations of radar-backscatter data from small planetary areas; (2) an experimental part that includes brightness measurements of laboratory soil samples for the purpose of verifying, refining, and supplementing the theoretical formulae; (3) an applications part that includes the interpretation (by means of the theoretical expressions) of existing and future photometric, polarimetric, and radar data on Mars and possibly other planets.

W75-70575 **185-50-60**
Ames Research Center, Moffett Field, Calif.
PLANETOLOGY: GEOMORPHOLOGY AND SURFACE PROCESSES OF PLANETARY BODIES
D. R. Chapman 415-965-5065
(383-21-02; 384-50-60)

Objectives are to: (1) study the relative expressions of the impact processes on the production of surface features of inner planets and their satellites, (2) study volcanic regions in the United States to determine the origin, structure and geomorphology of analog basaltic features, (3) determine parameters governing eolian processes in the Martian environment and use this information to perform wind tunnel experiments, and (4) study the spacial distribution of craters on Mars to test the hypothesis that tidal fission of incoming bodies may produce crater clusters. The approach involves efforts to: (1) derive estimates of the flux of meteorite masses at the orbit of Mercury and compare cratering histories of Mercury, Mars and the Moon, (2) relate morphology of surface features to petrology and structure of basaltic units of the Snake River Plains, (3) construct a new wind tunnel and carry out experiments at Martian pressures to obtain data for interpretation of Martian eolian processes and to determine aerodynamic flow fields around topographic features, and (4) determine circularity and nonrandom distribution of Martian impact craters to test the tidal fission hypothesis.

W75-70576 **185-50-61**
Ames Research Center, Moffett Field, Calif.
PLANETARY STUDIES
Dean R. Chapman 415-969-5065

The objectives are to obtain a better understanding of selected problems pertaining to planetary surface phenomena, the composition, structure and evolution of planetary bodies and their satellites, and to understand the origin of the solar system by means of theoretical investigations employing the results of spacecraft 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 planetary processes and structure. Analysis and interpretation of the results of these model calculations are applied to such topics as: the evolution of Jupiter, wind-blown surface features on Mars, and the calculation of conditions within the early solar system.

W75-70577 **185-50-72**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
PLANETOLOGY STUDIES
D. P. Burcham 213-354-3028
(185-50-73)

The subject of this research is the study of the present occurrence of volatiles in planetary atmospheres, on surfaces of planetary objects, and in meteorites. The objective is to decipher the history of the volatile component of solar system material in terms of: (1) the manner of its initial incorporation into solid solar system material and planetary objects, (2) the mechanism of its release from the interiors of these objects and (3) the subsequent chemical evolution of volatiles condensed on planetary surfaces, or in planetary or cometary atmospheres, chemically recombined in regolith material, or present in the gas phase of planetary atmospheres. Current and proposed experimental work includes: (1) ion-counting mass spectrometric analyses of rare gases in appropriate terrestrial rocks and meteorites, (2) experimental studies pertaining to the adsorptive equilibrium on Mars between CO2 and H2O in the atmosphere and regolith, including the effects of variable insolation on atmosphere/regolith exchange, (3) differential scanning calorimetric analyses and simultaneous evolved gas analyses of candidate Martian surface materials and carbonaceous chondritic meteorites, and (4) measurement of the refractive indicies of solid CH4 and NH3 as a function of wavelength in the near infrarred region of the spectrum.

W75-70578 **185-50-73**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
PLANETOLOGY INSTRUMENT DEVELOPMENT
D. P. Burcham 213-354-3028

The goal of this work is the development of six spacecraft-borne instruments which should be particularly effective in the study of planetary surfaces. Extension beyond present capability for the exploration of Mars is the prinicpal objective in each case, and these specific experiments were selected on their potential for shedding new light on significant questions regarding that planet. However, there also exist potentially important applications for these instruments on other planetary missions. The six instruments are: X-ray diffractometer/spectrometer, differential scanning calorimeter, linear array camera using CCD sensors, radar sounder for Mars stratigraphy, orbiting gamma-ray spectrometer, and alpha/X-ray analyzer using solid state detectors. A complementary camera development activity to the linear array camera described herein is covered in an Advanced Technical Development (Code 186) RTOP; sensor development is being supported by an OAST task. The alpha/X-ray analyzer task is in

support of effort at the University of Chicago to extend the alpha scattering technique first used on Surveyor missions.

W75-70579 **185-50-81**
National Aeronautics and Space Administration, Washington, D.C.
PLANETARY GEOSCIENCE STUDIES
S. E. Dwornik 202-755-3645

Planetary Geoscience Studies is a program encompassing geology, geochemistry, geophysic and soil physics which has the broad objective of understanding the genesis, distribution, composition and inter-relationships of the condensed matter in planets, their satellites, comets, asteroids, and other solid materials in the solar systems. The geology of the planets bears directly on three basic aims of lunar and planetary exploration: determination of the origin and evolution of the solar system, determination of the origin and evolution of life, and clarification of the nature of the processes shaping man's terrestrial environment (National Academy of Sciences, 1966). In order to meet these objectives, it is necessary to perform theoretical analysis, instrument development and spacecraft experiments that lead to understanding the nature and properties of the surface, regolith, crust, and core. This knowledge will lead to an understanding of individual planets, the origin of the solar system, planetary physical and chemical properties interactions between the atmosphere and lithosphere interactions of the flux of interplanetary particles and fields with planetary bodies, and will also aid in the discovery and understanding of the origin of extraterrestrial life. One important result of geological exploration of the planets will be increased knowledge of the earth. Very little is known of the first 2 billion years of the earth's history. Mars, Mercury, and the Moon on the other hand have no oceans, and the erosive effects of water are, therefore, virtually absent.

Planetary Exploration SR&T - Advanced Technological Development

W75-70580 **186-68-52**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
IMAGING SYSTEM TECHNOLOGY FOR PLANETARY MISSIONS
R. R. McDonald 213-354-6186
(185-50-73; 506-18-11)

The objective of this program is the development of imaging instrument technology using line and area array CCD (charge coupled device) sensors. Expected advantages of cameras using these sensors, compared to current Mariner technology, are extended red and near-IR response, increased sensitivity and dynamic range, lower cost, lower instrument weight, decreased power, and a more simple interface that is adaptable to different types of spacecraft. The camera development will be coordinated with development of CCD sensors, with the initial objective of developing a medium-resolution area array camera for a 1979 launch, and continuing with development of more sophisticated cameras as sensors become available. A complementary camera development activity is described in a Code 185 RTOP. Sensor development is being supported by an OAST task. Development of a line array camera is in progress, with the objective of laying the groundwork for future camera designs. Beginning in FY-75, area array camera development will be started, with the goal of demonstrating a feasibility model for a 1979 launch by the end of FY-76.

W75-70581 **186-68-53**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
MICROMINIATURE TRANSPONDER DEVELOPMENT
R. R. McDonald 213-354-6186
(506-20-21; 506-20-22)

The objectives of this RTOP and OAST RTOP 506-20-21 are to jointly develop microwave radio transponder techniques, components, and subsystem technology required for NASA planetary missions in the period 1977 to 1982. Particular emphasis will be placed on substantially reducing the cost of transponders, while improving performance capability, reliability, and lifetime and reducing size, weight, volume, and power consumption. By the end of FY-74 the technology readiness of the S/X-band multimission transponder in a discrete component-printed circuit board miniature version appropriate for flight missions beginning in 1977 will have been demonstrated. This version has the following advantages over the Viking Orbiter Design: an order of magnitude improvement in differential phase and group delay stability; and reductions of 35% in per unit cost; 80% in power consumption; 72% in volume; and 64% in weight. Key future targets are: (1) in FY-75, demonstrate an order of magnitude improvement in transponder turnaround phase delay stability (through the use of quartz surface wave filters); and (2) by the end of FY-76 demonstrate the technology readiness of the transponder in a micromin version (beam-leaded parts on ceramic substrates) for flight missions beginning in 1979 which has the following advantages relative to the discrete component version: a doubling of mission life potential (adequate for 10-year missions without additional redundancy); and reductions of 56% in weight and volume.

W75-70582 **186-68-54**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
GUIDANCE AND CONTROL TECHNOLOGY FOR PLANETARY MISSIONS
R. R. McDonald 213-354-6186
(506-19-14)

The objective of this RTOP is to develop spacecraft guidance and control sensor technology which will be critically needed for the post-MJS missions. The development of a highly reliable, long-lifetime image dissector tube to replace the currently-used unit will be completed. An accelerated life test in addition to functional and environmental testing will be used to flight qualify the newly designed image dissector tube. The currently used image dissector design has a reliable lifetime too short for usage on the long term missions planned beyond MJS-77. In addition, it is believed that the tube will not be available at all after completion of the present VO-75/MJS flight procurement. The advanced image dissector initial development contract (with EMR-Photoelectric in Princeton, New Jersey) has now reached a successful conclusion. Image dissectors meeting the contract specifications in all important aspects have been delivered and full documentation packages have been submitted. This work will complete the development and flight qualify the new image dissector by thorough functional and environmental testing of three tubes, procured from EMR-Photoelectric with firm process and documentation control. Two tubes will be selected for accelerated life tests. Tube qualification will be completed in time to meet an FY-76 technology readiness date.

W75-70583 **186-68-55**
National Aeronautics and Space Administration, Washington, D.C.
MARS ROVING VEHICLE
Paul Tarver 202-963-4352

The primary objective of this program is to promote the capability for developing concepts, subsystems, and components for controlling the motion of unmanned planetary surface roving vehicles. The program is a long-term research and advanced development effort and will include analyses, simulations and hardware development for Mars roving vehicle mission. The effort during the next year, will support research contracts at Cornell University and Rensselaer Polytechnic Institute. The benefits derived from these contracts are twofold. First, the results are useful in maintaining and improving the capability of NASA to develop an unmanned roving vehicle for planetary exploration. And second, the student participants are confronted with a practical engineering problem during their course of study. This significantly increases the student's ability to cope with engineering problems upon his graduation.

W75-70584 **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. In addition, new tasks for Cornell University and Rensselaer Polytechnic Institute will be developed.

W75-70585 **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 a system and subsystems based on the selected technologies and design concepts and to perform the conceptual design for the spacecraft system required for the proposed Pioneer Venus 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 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, and maneuver and navigation studies. The results of these studies will be used to conceptually design the spacecraft systems for the Pioneer Venus Multiprobe and Orbiter Missions.

W75-70586 **186-68-61**
National Aeronautics and Space Administration, Washington, D.C.
LONG RANGE PLANNING STUDIES FOR SOLAR SYSTEM EXPLORATION
Paul Tarver 202-755-3770

The objective of this effort is to obtain scientific and technical data and to evaluate or develop methodologies that will aid in planning for planetary advanced missions and advanced technology. Mission studies to be conducted will typically cover science objectives, trajectory/payload/launch vehicle analyses and representative spacecraft characteristics and technology requirements. For FY-1975, planned studies are: (1) Titan mission study data base, (2) shuttle impact mission planning, (3) Jupiter orbiter lifetime study, (4) cost estimation research, (5) planetary missions handbook, (6) advanced planning activity. Individual study reports and an annual report will be issued; with interim reports or presentations as appropriate.

W75-70587 **186-68-62**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
PROPELLANT COMPATIBILITY WITH MATERIALS FOR LONG DURATION MISSIONS
R. R. McDonald 213-354-6186

The objective of this work is to provide the technology for propellant/material compatibility that will be used on future outer planetary missions. Current objectives include work to determine which materials are acceptably inert for use in the construction of propulsion subsystem components in contact with earth storable liquid propellants for long duration missions. 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.

W75-70588 **186-68-63**
Ames Research Center, Moffett Field, Calif.
PIONEER VENUS SCIENTIFIC INSTRUMENT DEVELOPMENT
J. V. Foster 415-965-5083
(186-68-60)

The objective of this effort is the development of scientific instruments and theoretical investigations for the Pioneer Venus 1978 Multiprobe and Orbiter 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.

W75-70589 **186-68-65**
Ames Research Center, Moffett Field, Calif.
PIONEER FOLLOW-ON MISSION TECHNOLOGY
J. V. Foster 415-965-5083
(186-68-60; 186-68-63)

The objective is to develop basic spacecraft and probe configurations, using existing technology, as close as possible to Pioneer F/G, PAET, and Pioneer Venus configurations, respectively, consistent 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. Program costs are determined by the ability to define realistic system and subsystem requirements. 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.

W75-70590 **186-68-72**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
SOLAR ELECTRIC PROPULSION ADVANCED SYSTEM TECHNOLOGY - MISSION AND SYSTEM ENGINEERING
R. R. McDonald 213-354-6186
(186-68-74; 502-24-10)

The broad objective of the Solar Electric Propulsion Advanced System Technology (SEP/AST) Project is to bring solar electric propulsion (SEP) and allied technologies to a state of development where they can be applied to a flight project with a reasonable understanding of related cost, schedule, performance and risk factors. Specific SEP/AST objectives are to: (a) establish mission and spacecraft design requirements, (b) demonstrate the satisfactory operation of a SEP thrust subsystem (TSS) (RTOP 502-24-10), (c) establish power management strategies (RTOP 502-24-10), (d) establish low thrust navigation technologies (RTOP 186-68-74), (e) develop SEP spacecraft attitude control technologies, (f) improve the physical model and ephemeris of the comet Encke. Since development of SEP technology is assigned to JPL, MSFC and LeRC working in mutually supportive roles, this RTOP provides for the necessary coordinative and integration activities as well as for efforts related to the specific objectives identified above. The approach to this effort will be to investigate initially the application of SEP to a comet Encke mission to be launched in December 1978. Using this initial mission and system design information as a baseline, the investigation will gradually be broadened to examine a complete set of planetary missions for which SEP appears attractive. Overlaid throughout this effort is a heavy coordination activity with MSFC to maximize compatibility between the JPL SEP module concept proposed for planetary program purposes and the MSFC SEP stage concept proposed for earth-orbiting and other applications.

W75-70591 **186-68-73**
Goddard Space Flight Center, Greenbelt, Md.
EPHEMERIDES AND RECOVERY ANALYSIS FOR COMETARY MISSION PLANNING
R. W. Farquhar 301-982-5063

The principal goals of this RTOP are to: (1) initiate cataloging of cometary data for proposed target comets of interest for space probes in the 1980's. Particular emphasis will be given to the 1986 return of comet Halley; (2) improve existing ephemerides for target comets by updating orbit determinations with all relevant observations, and investigating alternative methods of mathematically modeling nongravitational perturbations; (3)

conduct statistical error analysis of ephemerides for proposed target comets subsequent to comet Encke's 1980 apparition; and (4) verify and supplement statistical error analyses by utilizing real observations at past apparitions to compare observed and computed ephemerides. The rocket effect due to cometary outgassing introduces significant nongravitational perturbations of the motions of several target comets under consideration for future flyby missions. Appropriate mathematical modeling of these forces in the equations of motion will be determined for comets of interest. Recent observations will then be employed to update existing orbits and ephemerides. Analyses will then be undertaken to determine error ellipsoids for target comets at proposed spacecraft-comet intercept points. To facilitate future cometary mission studies, physical data, ephemerides and error analysis information will be cataloged and made available to all users.

W75-70592 **186-68-74**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
SOLAR ELECTRIC PROPULSION ADVANCED SYSTEM TECHNOLOGY - NAVIGATION
R. R. McDonald 213-354-6186
(186-68-72; 506-19-21; 506-22-31)

The overall objective of this effort is the development and verification of SEP navigation system technology to ensure flight project readiness. The substantial technology base established in prior years under OAST support will continue to contribute to the AST objectives. The primary emphasis to date has been on software technology aiming at the development of breadboard software for each of the basic navigation functions: trajectory, orbit determination, and guidance. The breadboard software system will play a key role in the development and verification of a viable navigation system. It is both a prototype for flight software and a versatile analysis tool whereby the effect of spacecraft subsystem specifications, guidance strategies, data accuracies, measurement techniques, filter designs, error models, etc. on delivery accuracy may be evaluated and translated into navigation system requirements. The navigation technology will be paced by the desired application to an Encke slow flyby launching in 1978-79, but also will be largely applicable to a 1984 Encke rendezvous and other planetary missions. The navigation accuracy analyses, orbit determination and maneuver strategy development, and trade studies begun in FY-74 will be continued in FY-75. Software capabilities will be expanded to facilitate the analysis. Navigation requirements will be identified and supplied to the AST in a standardized document. Promising new measurement concepts and processing techniques such as adaptive filtering and the simultaneous interference tracking technique (SITT) will be investigated and evaluated with emphasis on the role of these techniques in the total navigation system.

Physics and Astronomy - SR&T

W75-70593 **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 concommitant improvement in measurement techniques, and interpretation of appropriate space and laboratory experiments. The interpretation requires corresponding improvements in numerical techniques.

W75-70594 **188-36-55**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
MAGNETODYNAMICS IN SPACE
D. P. Burcham

The vector helium magnetometer is being developed for use on missions to the outer solar system where extremely weak interplanetary or interstellar fields will be measured and where intense planetary fields may also be encountered. Scientists and engineers from JPL will carry out tests and experiments to establish the fundamental principles of the magnetometer operation and design. Improved components are developed, the design is changed to yield improved performance, and new modes of operation are investigated. Selected areas of current scientific interest (interplanetary discontinuities and shocks, spectral analysis of solar wind fluctuations, waves and density fluctuations in the magnetosheath, analytic models of the magnetosphere) are being investigated by a theoretical physicist. Theoretical models are developed and compared with available space data. Field and plasma data acquired with spacecraft are analyzed using sophisticated techniques such as cross spectral analysis. The scientific results are published and presented at meetings.

W75-70595 **188-36-55**
Ames Research Center, Moffett Field, Calif.
MAGNETOSPHERIC PHYSICS - PARTICLES AND PARTICLE/FIELD INTERACTION
Dean R. Chapman 415-965-5065
(385-36-01)

The objective of the 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 temperture 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 aperatures, 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. The interaction of the moon with the solar wind is to be modeled for a better understanding of the magnetized solar wind and the lunar plasma environment. Theoretical studies of models of the solar plasma have been accomplished.

W75-70596 **188-36-55**
National Aeronautics and Space Administration, Washington, D.C.
MAGNETOSPHERIC PHYSICS - PARTICLES AND PARTICLE/FIELD INTERACTIONS
E. R. Schmerling 202-755-3685

Objectives are to: investigate the processes occuring 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. Investigate ions were also made of the processes which result from the arrival of solar particles near the earth, and the consequences of variations in the incident flux. Instruments were developed for measuring neutral and charged particles from several eV to several tens of MeV, dc magnetic fields from below 0.1 gamma to several oersted, electric fields, and VLF wave activity. Theories, needed to understand the magnetosphere, the auroras, the solar wind, the interplanetary regions, and the observed boundary effects, down to roughly the plasmapause, were developed.

W75-70597 **188-36-56**
Langley Research Center, Langley Station, Va.
MAGNETOSPHERIC PHYSICS
E. S. Love 804-827-2893

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 third stage of the Scout vehicle or the second stage of a Delta vehicle with only modest modifications.

W75-70598 **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: (1) to conceive, design, develop and test new techniques for space measurements of electric fields, auroral particles, trapped particles, solar-interplanetary particles, plasma waves, wave-particle interactions, photon-particle interactions, plasma composition, ionospheric winds, electron density and atomic and molecular collision processes with particular emphasis on magnetospheric and ionspheric regions, and (2) 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: (1) 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, (2) accurate models of fields in space which have both scientific and technological utility, (3) indices which describe the instantaneous degree of disturbance in the ionosphere and magnetosphere, (4) advances in the understanding of plasma instabilities, and (5) new techniques for studying the transport of ion and neutral particles in the ionosphere.

W75-70599 **188-36-56**
Ames Research Center, Moffett Field, Calif.
MAGNETOSPHERIC PHYSICS - PARTICLES AND PARTICLE/PHOTON INTERACTIONS (AERONOMY)
Dean R. Chapman 415-965-5065
(185-47-67)

Attempts were made 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.e., 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.

W75-70600 **188-36-56**
National Aeronautics and Space Administration, Washington, D.C.
MAGNETOSPHERIC PHYSICS - PARTICLES AND PARTICLE/PHOTON INTERACTIONS
E. R. Schmerling 202-755-3685
(188-36-57)

The objectives are to investigate the absorption of solar photons and particles in the earth's upper atmosphere, investigate the processes by which the absorption products are dissipated, and investigate 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 were developed. Coordinated investigations to be conducted for cause-and-effect studies, together with the development of the appropriate theories were discussed. The region covered extends roughly from the lowest ionosphere the plasmapause.

W75-70601 **188-36-57**
National Aeronautics and Space Administration, Washington, D.C.
MAGNETOSPHERIC PHYSICS - RADIO SCIENCE
E. R. Schmerling 202-755-3685
(188-36-56)

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. Attempts were made to: (1) 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, (2) develop instruments for generating electromagnetic waves in space and measuring the effects of the medium, together with the appropriate theory, (3) model, in the laboratory, the plasma interactions and resonances observed in space, and (4) test the theories developed to explain them.

W75-70602 **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 the 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 ground based observations. Specifically, the development of specialized optical components, the development or improvement of optical instrumentation, and the development or improvement of various techniques or instruments for support of solar observations is included. The approach used to accomplish this objective GSFC is by conducting an in-house, University grant, and contract experimental and theoretical studies in the following technology: (1) design, fabrication, and testing of glancing incidence optical systems for the 8A to 300A spectral region including the problems of increased energy throughput and scattering, (2) diffraction grating technology especially that related to the production of large gratings required for high resolution low light level ground based observations. Other technology areas will be included to support current programs or problem areas identified by the solar physics community. References for identifying key technology include NASA Document SP-213, 'A Long Range Program in Space Astronomy' and working group reports such as the Solar Physics Working Group Report.

W75-70603 **188-38-51**
National Aeronautics and Space Administration, Washington, D.C.
DEVELOPMENT OF EXPERIMENTS AND HARDWARE FOR SOLAR PHYSICS RESEARCH
Goetz K. Oertel 202-755-8490

The objective of the work under this RTOP is the development of experiments for space or laboratory application to solar physics research and the development of critical technology items which are needed for solar observations, or which can improve them significantly. Included are the following activities: (1) development of a device for the production of optical components for use in solar and astronomical telescopes, spectrographs, etc., on the ground and in space; (2) development of techniques for improving the performance of optical instrumentation in space and on the ground; (3) development of techniques for accurate calibration of solar experiments in space and on the ground in parts of the spectrum where the available accuracy is insufficient for effective

use of data from space; (4) development of novel techniques for increasing the information value of present solar experiments; and (5) development of improved ground-based instrumentation for obtaining solar data in support of spaceflight solar experiments.

W75-70604 **188-38-52**
Marshall Space Flight Center, Huntsville, Ala.
GROUND-BASED OBSERVATION OF THE SUN
William C. Snoddy 205-453-3103

The real time solar magnetograph (RTSM), built jointly by the Naval Research Labs and MSFC, allows studies of small scale variations of the sun's magnetic field in order to determine their 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. An H-alpha brightness distribution analyzing system is being operated in support of the RTSM for active region and flare classification. In direct support of the real time solar magnetograph, a study is being 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. Calculated thermal X-ray and mm emissions from the flare volume as functions of various parameters will be compared with ground-based mm and Skylab/ATM X-ray data. The third part of this study is to observe and investigate millimeter emissions from the sun at the shortest practical radio wavelengths before, during and after solar events and during the quiet sun and to correlate the results with EUV wavelength (OSO 7) on a systematic basis to determine the height and location of mm emission regions during solar activity.

W75-70605 **188-38-52**
Goddard Space Flight Center, Greenbelt, Md.
GROUND BASED OBSERVATIONS OF THE SUN
J. C. Brandt 301-982-4701

Daily operation of the Zeiss filtergraph previously used to obtain supporting observations for the GSFC OSO-5 wheel experiment and to provide live video H-alpha images to the OSO Control Center and GSFC OSO-7 experimenters has been temporarily suspended. The observatory is being maintained and upgraded for support of OSO-I, Solar Maximum Mission and Sounding Rocket experiments. Photographic spectroscopy of active and quiescent prominences and other solar phenomena are 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 was tested at a site near Charlottesville, Virginia for observation of Comet Kohoutek and will be operated at future eclipses when weather conditions permit. The vidicon system is being used with the McMath Solar Telescope at Kitt Peak to obtain high dispersion spectra of stars. The spectra will be interpreted in a manner similar to that used for solar chromospheric studies to study stellar chromospheres.

W75-70606 **188-38-52**
National Aeronautics and Space Administration, Washington, D.C.
GROUND-BASED OBSERVATIONS OF THE SUN
K. Goetz 202-755-8490

Ground-based observations of the sun in wavelengths for which the atmosphere is transparent are carried out at a number of suitable observatories and ground stations throughout the United States. The purpose of these ground-based observations is to obtain information on the solar atmosphere, from the photosphere and sun spots, to the chromosphere and the corona, and on the fine and gross structure of the solar atmosphere, and activity in it. This information is then used in correlation with observations from sounding rockets, OSOs, ATM and other spacecraft to determine the physical conditions in the objects studies, and to understand the physical mechanisms at work in them. The following types of activity are covered under this RTOP (ground-based here refers to aircraft and balloons as well as to fixed installations on the ground): (1) the definition and design of experiments for ground-based observatories; (2) the construction or purchase and operation of such experiments; (3) the observing of the sun, and features in it, from the ground; (4) the analysis of ground-based data in correlation with data from space or from other ground-based observatories; and (5) scientific interpretation in terms of physical conditions and mechanisms.

W75-70607 **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. 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 mechanical fixtures, will produce a detector able to record the spectrum of a solar X-ray burst with 100 milliseconds resolution. Design of high resolution coronal spectrometer/polarimeters for the wavelength ranges 1-20 A and 1200-1500 A is underway and bench testing will be carried out. COS/MOS type integrated circuits which have reduced power needs, volume and weight have been successfully flown in a rocket experiment and will continue to be environmentally tested in typical space solar experiment electronic units. Developmental work includes an imaging infrared up-converter for use at 5 microns. Development and implementation of imaging detectors for visible-light solar physics includes line profile devices and vidicon techniques. Methods for improved solar observations at radio wavelengths include mm-wave radiometers and interferometry.

W75-70608 **188-38-53**
National Aeronautics and Space Administration, Washington, D.C.
LABORATORY AND THEORETICAL SOLAR PHYSICS
G. K. Oertel 202-755-8490

Laboratory and theoretical studies are carried out on current problems in solar astronomy and solar physics, and on important areas of atomic and molecular physics which contribute basic information required for the analysis or understanding of solar data from the ground and from space. Theoretical studies of the sun include the following types of activity: (1) the analysis of ground-based and space data to produce models of the solar atmosphere, and to understand the underlying physical conditions and mechanisms; and (2) prediction of future events on the sun, such as predictions of coronal structures from features observable on the disk; of the development of future active regions from magnetic and H-alpha features; and the occurrence of flares from magnetic field complexity and configuration. Theoretical and laboratory studies in atomic and molecular physics include the following activities: (1) the measurement of computation of atomic or molecular quantities such as wavelengths, energy levels, f-values, line broadening parametes, ionization and excitation functions, etc; and (2) the production of plasmas which simulate by scaling part of all of the conditions in particular solar phenomena or structures in the laboratory.

W75-70609 **188-38-53**
Langley Research Center, Langley Station, Va.
LABORATORY AND THEORETICAL SOLAR PHYSICS
E. S. Love 804-827-2893

The principal objective is to experimentally determine rate coefficients for ionization by electron impact for various stages of ionization of elements of astrophysical interest. These coefficients play an important role in the determination of the ionization balance in nonequilibrium astrophysical plasmas such as the solar corona. Elements to be investigated include carbon, nitrogen, oxygen, neon, silicon, and argon, which are also of interest in a large number of laboratory experiments. The theta-pinch facility is uniquely suited for the investigation of

collisional rate coefficients since the initial shock heating phase the atomic processes are dominated by electron collisions. Accurate measurements of electron number density and electron temperature are obtained by the Thomson scattering of ruby laser radiation (presently in operation but some further development work is required). The one megajoule theta-pinch facility will shock heat a plasma up to temperature of two million to three million K in about 0.000003 seconds. This temperature is adequate to produce the high stages of ionization found in the solar corona. In addition, the electron density is adequate insure the ionization by electron collisions, the dominant process during the shock heating phase. Observation of the time of peak emission of the resonance line of each stage of ionization and a measurement of the electron number density and electron temperature at that time give the needed information to determine the rate coefficient from a time-dependent corona model computer code.

W75-70610 **188-38-64**
National Aeronautics and Space Administration, Washington, D.C.
DEFINITION OF SOLAR PHYSICS EXPERIMENTS FOR SPACE SHUTTLE
G. K. Oertel 202-755-8490

The objective of the effort under this RTOP is the early definition of various types of solar instrumentation, for flight on the space shuttle, required for obtaining data necessary to the pursuit of solar research goals identified for the 1980s. The following activities are among those included: (1) preliminary design of instruments to meet observational requirements, as determined for the shuttle era, for improved spatial, spectral and time resolution, covering spectral ranges from gamma-rays and X-rays up through the infrared. Types of instruments include telescopes, photoheliographs, spectrometers, spectrographs, spectroheliographs, coronagraphs, polarimeters, magnetographs, solid state detectors, spark chambers, etc; (2) development of methods to exploit fully the advantages and capabilities of shuttle oriented solar observations, by incorporating instrument design concepts which permit maximum utilization of the presence of man as an observer, an instrument operator, and a technician. Implicit in the design would be built-in maintainability and the capability for changeout of the instrument or major modules or components; (3) studies to determine techniques and methodology for application toward developing instruments at significantly lower cost, without sacrificing performance or reliability; and (4) technology development in critical areas of concern in instrument design such as optical surfaces, filters, crystals, coatings, grating, detectors etc.

W75-70611 **188-38-64**
Goddard Space Flight Center, Greenbelt, Md.
DEVELOPMENT OF SHUTTLE PAYLOADS FOR THE STUDY OF SOLAR FLARES AND FLARE RELATED PHENOMENA
K. J. Frost 301-982-4811

The laboratory for solar physics and astrophysics and optics branch, Mission Technology Division, GSFC, propose to build a group of instruments to observe solar flares and related solar phenomena from shuttle sortie and free-flier platforms in 1979, 1980, and 1981. The scientific objective of this payload will be to advance our understanding of the nature of the mechanism of a solar flare. This will be done by observing a flare over a wide range of the electromagnetic spectrum from the visible to the gamma-ray region. A number of different instruments will be required to cover this range. They will be selected on the basis of making comprehensive measurements in their specific wavelength regions in a format which is coordinated with and complimentary to the other instruments in the payload. For example, all instruments will operate with the same temporal and spatial resolution to the maximum possible extent. The instruments considered for this payload are: (1) a solar telescope (Photoheliograph) with aperture equal to or greater than cm, (2) a high resolution 1000-2850 A spectrometer used at the focus of the telescope and observing line profiles from the chromosphere and the transition region.

W75-70612 **188-41-51**
Ames Research Center, Moffett Field, Calif.
THEORETICAL ASTROPHYSICS
Dean R. Chapman 415-965-5065

The objectives are to conduct theoretical studies on important fundamental problems in Astrophysics and Astronomy, and to provide theoretical advice and technical assistance 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 time variability of quasars and of X-ray sources, pre-main sequence stellar evolution, structure and evolution of white dwarfs and binary star systems, galactic evolution, interpretation of airborne infrared observations of stars, planets, and H II regions, and others.

W75-70613 **188-41-51**
National Aeronautics and Space Administration, Washington, D.C.
ULTRAVIOLET (UV) AND OPTICAL ASTRONOMY
N. G. Roman 202-755-3649

The objective is the advancement of stellar and galactic astronomy through observations and interpretations of data secured in the ultraviolet and visible electromagnetic portions of the spectrum. The emphasis is on research in direct support of ongoing flight programs, or in anticipation and preparation for future ones. The four elements supported are laboratory astrophysical studies, theoretical astrophysics, instrumentation development, and direct observational programs. A balanced program involving all these elements is required in order to insure full utilization and healthy development of the space science program, with the goal of the advancement of our understanding of the universe. The approach is to develop theoretical models, perform theoretical studies, and determine basic atomic and molecular parameters. Interpretation of data, especially that obtained in the relatively unexplored UV spectral region, requires the additional information provided by these efforts. A broad and sound theoretical framework allows new observations to be interpreted and new directions to be instituted. In addition to atomic and molecular physics, specific areas of study include stellar atmospheres, stellar systems, and cosmology.

W75-70614 **188-41-51**
Goddard Space Flight Center, Greenbelt, Md.
UV AND OPTICAL ASTRONOMY
Albert Boggess 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.

W75-70615 **188-41-51**
Marshall Space Flight Center, Huntsville, Ala.
UV AND OPTICAL ASTRONOMY
E. R. Miller 205-453-3103

The objectives are to perform ground-based and balloon measurements and theoretical studies of galactic and extra galactic objects in which energetic processes may be taking place (galactic nuclei, novae, super-novae, X-ray sources, and galactic H II regions). Also, included in the objectives are the photometric studies of periodic (e.g. mira types and binary stars) and eruptive variables. The above data will be used in support of flight experiments under development and being planned at MSFC, such as HEAO and space missions. Measurements will be

performed using equipment which is mostly already developed and on hand, including photometers, radiometers, spectrometers and an integrating vidicon system. A state-of-the-art integrating vidicon system being developed under another program will also be utilized.

W75-70616 **188-41-51**
Langley Research Center, Langley Station, Va.
UV AND OPTICAL ASTRONOMY (COMPUTATIONAL PHYSICS)
E. S. Love 804-827-2893

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 how the bar-forming instability can be stabilized to allow formation of normal spirals and the method 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. A threedimensional computer model will be developed to allow investigation of the development of flat or disk systems from originally elliptical or spherical systems. Numerical experiments on the evolution of the asteroids with Jupiter will be investigated. Similar calculations will be made for Saturn's rings. Another problem to be investigated is the particle acceleration and other phenomena occurring in solar flares. It appears that particle acceleration occurs near magnetic neutral points and involves magnetic flux annihilation in solar flares, in laboratory experiments, such as the plasma focus and possibly also in phenomena on a galactic scale.

W75-70617 **188-41-51**
Lyndon B. Johnson Space Center, Houston, Tex.
ULTRAVIOLET STELLAR SPECTROMETER DEVELOPMENT FOR SPACE SHUTTLE
Y. Kondo 713-483-6467

The objectives are to develop astronomical space-UV instrumentation for use in shuttle sortie missions, which will demonstrate state-of-technology detector and tracking performance, flexibility of interfacing instrumentation with a general purpose telescope platform, and versatility of man's real-time operational involvement. The development of the ultraviolet stellar spectrometer for space shuttle is performed through the flights of the balloon-borne ultraviolet stellar spectrometer (BUSS) payload as well as through other concurrent laboratory-based developments. The BUSS payload performs high resolution spectrophotometry of astronomical objects in the mid-ultraviolet. The first version of the BUSS payload has been developed and flown successfully twice. It comprises a pointable telescope (40 cm aperture, f/7.5 modified Ritchey-Chretien) to which a variety of instrumentation can be attached. Payload functions are commanded from the ground in real time, and the data are telemetered to the ground in real time, where they are monitored in real time and recorded. Further development of the payload is planned in conjunction with the proposed collaborative program with the Space Research Laboratory, Utrecht, the Netherlands. In this collaborative program, we shall jointly investigate stellar UV spectra in the range 2000-3400 A with a resolution of 1/10 A, employing an echelle spectrograph in combination with an image intensified, storage vidicon detector. Subsequent flights will develop the star tracking system for targets as faint as 10th magnitude and for improved spectral resolution.

W75-70618 **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 (8 GHz) 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 to measure frequencies, absorption coefficients and linewidths for presently known interstellar molecules and for other molecules whose presence in the interstellar medium is strongly predicted by theory. The 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. 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 isotopic 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.

W75-70619 **188-41-52**
Goddard Space Flight Center, Greenbelt, Md.
GROUND-BASED RADIO ASTRONOMY
R. G. Stone 301-982-4631
(161-05-03; 369-05-03)

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 the magnetic fields, energetic particle composition and dynamic processes within the source. The approach taken involves the use and development of high resolution radio telescopes which permit remote observations of phenomena occurring in extensive and inaccessible regions.

W75-70620 **188-41-54**
National Aeronautics and Space Administration, Washington, D.C.
RELATIVITY
N. G. Roman 202-755-3649

The primary objective is to make experimental tests of the theory of relativity and thereby elucidate the interrelationship among space, time, and gravity. In particular, the test of Einstein's General Theory of Relativity is paramount. This formulation is fundamental and of high scientific interest. Experimental verification is difficult but the ability to orbit large, complex, and extremely precise apparatus, shielded from deleterious perturbations should obviate them. In addition to the scientific goals, improvements and innovations in the technological areas of cryogenics, gyroscope design, and precision clocks are expected. Specific objectives include the development and operation of a flight qualified cryogenic gyroscope, complete gyroscope system error analysis, and the consideration of various theoretical formulations of relativity and their subsequent experimental implications. Possible future benefits apart from the scientific ones include improved timing for navigation, communication and geodesy as well as cryogenic systems capable of extended operation in space.

W75-70621 **188-41-54**
Marshall Space Flight Center, Huntsville, Ala.
RELATIVITY AND CELESTIAL MECHANICS
R. A. Potter 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, and the ability to maintain these gyroscopes and record their precessions, while in earth orbit, over a period of twelve months or more. The work will be accomplished by continuing the technology development programs being carried out in the laboratories of the Marshall Space Flight Center (MSFC) supported by the work on the gyro development at Stanford University and the University of Alabama at Huntsville and the Dewar development work at Ball Brothers Research Corporation. A Phase A study will be accomplished which will determine the most economical and scientifically rewarding flight program. A well coordinated, experimental, theoretical and engineering program in which Stanford University and MSFC effort complement each other is well under way. These activities are oriented toward a satellite flight that will establish the validity of the General Theory of Relativity.

W75-70622 **188-41-54**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
RELATIVITY AND CELESTIAL MECHANICS
D. P. Burcham 213-354-3028
(385-41-01)

The astrophysical consequences of missing matter in the universe will be studied, first by formulation of general models with conducting plasma matter content, and then by introducing inhomogeneities through perturbation techniques. This research will support interpretation of data on intergalactic matter, its composition, excitation and ionization history, which will result from far ultraviolet quasar spectra taken with the forthcoming IUE satellite. We will formulate selected anisotropic cosmological models and study their observational consequences. The simplest models of interest will be so-called Bianchi type 7 sub 0 big bang universes, with incoherent matter content. These have recently been shown by Hawking and Collins to be the only set of non-zero measure, among non-collapsing models, which tend toward isotropy. Consequences for observational cosmology will also be considered, especially experiments in space for the detection of anistropy in the universal microwave background radiation. Advances in techniques of nonlinear applied mathematics will be applied to selected problems of relativistic gravity, in particular to the calculation of fields of axisymmetric spinning sources, and to cylindrical gravity waves.

W75-70623 **188-41-55**
National Aeronautics and Space Administration, Washington, D.C.
INFRARED ASTRONOMY
N. W. Boggess 202-755-3688

The objective is to advance stellar and galactic astronomy in the spectral region between 1 and 1000 microns through observational and theoretical programs. Observations in the infrared portion of the electromagnetic spectrum are particularly important for an understanding of the early and late stages in stellar evolution, interstellar matter, galaxies and quasistellar objects and the energy mechanisms associated with them, and the residual radiation of the universe. A balanced program including observation, technique and instrumentation development, and theory is required to insure the advances needed for full utilization of future platforms in space. The approach includes the following elements: (1) support observational programs using ground-based telescopes, balloons, and airplanes; and (2) promotion of the development of infrared techniques and apparatus. Special emphasis is placed on far IR narrow band filters, spectral interferometers, modulation techniques, and multiple detector arrays in order to enhance the information content of an observation; and more recently, on development of cryogenic and low-background telescopes.

W75-70624 **188-41-55**
Ames Research Center, Moffett Field, Calif.
INFRARED ASTRONOMY
Dean R. Chapman 415-965-5065

The broad objectives of this program are to obtain and interpret astronomical data in the far infrared region of the spectrum and to develop and evaluate improved platforms and instrumentation for infrared astronomy. A 28' balloon-borne telescope has been modified for observing in the far infrared. Engineering test flights have verified that repeated launchings can be performed with turn-around times of only a few days. An offset tracking capability has been developed for the telescope to permit prolonged observations of infrared sources that do not have bright visible counterparts. Broad-band photometric observations are planned for early flights and spectroscopic data are expected for flights later in this program. Specific objectives include planets, HII regions circumstellar dust clouds and extragalactic objects.

W75-70625 **188-41-55**
Goddard Inst. for Space Studies, New York.
MILLIMETER-WAVE AND FAR-INFRARED ASTRONOMY
Patrick Thaddeus 212-866-3618
(176-31-53)

The main scientific purpose is (1) to observe interstellar molecules at millimeter and submillimeter wavelengths, in order to study the dynamics of dense interstellar clouds, the process of star formation, isotopic ratios, interstellar chemistry, and other astrophysical topics, and (2) to obtain laboratory data on molecular spectra in order to interpret these observations, and in order to search for new molecules in space. The main technical purpose is to extend radio frequency techniques into the far infrared for use on aircraft and space vehicles.

W75-70626 **188-41-55**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
INFRARED ASTRONOMY
D. P. Burcham 213-354-3028

The objective of this research is to develop an improved type of detector of radiation in the microwave and far infrared region from 100 microns to 3mm, 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 W/Hz, a response time of 10 to the minus 9th power sec or better, and to be narrow-band and tunable. The program proposed here is the development of the Notary-Mercereau form of superconducting weak-link structure as a practical infrared detector. The N-M structure provides reproducibility, stability and reliability difficult to achieve in Josephson tunneling junctions and weak-link point-contact junctions. The major problems to be faced in applications are the improvement of the sensitivity at millimeter and submillimeter wavelengths, and the improvement of coupling of electromagnetic radiation to the junction. The first of these will be approached by decreasing the size of the weak-link section to sub-micron dimensions. The second will be approached by fabricating the devices in arrays, which will increase impedance and sensitivity. In both cases, fabrication to high accuracy at sub-micron sizes is necessary. It is proposed to do this by use of the scanning electron microscope (SEM) as a machining tool. The effort in this fiscal year will be devoted to the application of an already available SEM to the task of fabrication of the necessary structures and to testing of the resultant devices. Preliminary work in FY-74 has proven the feasibility of this approach.

W75-70627 **188-41-55**
Lyndon B. Johnson Space Center, Houston, Tex.
INFRARED SPECTROSCOPY OF COOL STARS AND PLANETARY NEBULAE
Andrew E. Potter 713-483-2071

Infrared spectra of planetary nebulae and cool stars are measured using a Michelson interferometer using infrared with photomultiplier tube detectors and the 107 in McDonald Observatory telescope. Analysis of the spectra yields information on the composition and structure of nebular gases and stellar atmospheres. Principal objectives of the work are to clarify the nature of Wolf-Rayet stars, omission features in B-type stars, and composition of planetary nebulae.

W75-70628 **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. Hence, by studying the X-ray emission from stellar objects, nebulae, the interstellar medium, and extragalactic 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 gas counters of advanced design or a large array of cooled solid state detectors (Ge and Si). 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 small specialized detectors at the focus of grazing incidence optics. Cooled solid state detectors and gas X-ray filters are being investigated.

W75-70629 **188-41-59**
National Aeronautics and Space Administration, Washington, D.C.
X-RAY ASTRONOMY
N. G. Roman 202-755-3649

The objective is to investigate and understand the nature of sources of X-ray emission. The number of such sources detected has been increasing by virtue of the active observational program being conducted with balloons, rockets, and satellites. As experimental techniques have been refined, a number of point sources have been identified with unusual optical objects both galactic and extragalactic in origin. In addition, X-ray variability of different characteristic forms has been found; some sources are analogous to the radio and optical pulsars. The general cosmic X-ray background, as well as the point sources need further study in order to elucidate the emission mechanism and the cosmological significance of these objects. Specific objectives are the detection of additional sources, spatial mapping of the background, accurate positional determination, and correlation with optically identifiable objects. These objectives are met by supporting laboratory studies, flight programs, and theoretical work. Research and development of advanced detectors, shielding systems, and focussing optical systems are being conducted. Data processing methods are being refined.

W75-70630 **188-41-64**
Goddard Space Flight Center, Greenbelt, Md.
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. Relativistic electrons radiate X-rays characteristic of their interactions with magnetic fields, ambient electromagnetic waves, and interstellar grains. Subrelativistic suprathermal charged particles, including cosmic ray nuclei as well as electrons, generate X-rays characteristic of collisions with ambient gas (e.g. bremsstrahlung continuum radiation and characteristic line emission resulting from electron charge exchange between highly stripped nuclei and ambient atoms). Hot plasmas generate X-rays characteristic of thermal electron-ion interactions. Hence, by studying the X-ray emission from stellar objects, nebulae, the interstellar medium and extragalactic space we get direct information on energetic processes over a broad range of physical conditions and astronomical scales. A large array of cooled solid state detectors (Ge and Si) provides the optimum spectral resolution available over a broad band (approximately 0.5 keV to tens of kilovolts) that effectively covers the entire continuum spectrum for a wide class of sources. At lower energies, photo-electric detectors with gas filters provide a potentially sensitive means of identifying line emission.

W75-70631 **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 experimentation relevant to the physicochemistry behavior of matter in space. Theoretical analysis of astronomical problems using experimental and theoretical results is a second aim. A third aspect involves observations from spacecraft 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, cometary or interstellar molecules by impact of photons, electrons and 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 star formation chemical evolution and the origin of life will be examined. In support of other research use of image intersifiers to study comets and interplanetary matter will be investigated. Part II of the Atlas of Cometary Forms, illustrating dust and plasma tail phenomena will be prepared.

W75-70632 **188-45-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
COMETS AND ASTEROIDS
D. P. Burcham 213-354-3028

The Apollo missions to the Moon and Mariner missions to Mars have shown that these bodies have been subject to extensive modification since their origin. Only small bodies may still preserve evidence information on the original formation of the solar system. Asteroids, meteorites, and fireballs are all small bodies in the solar system. The long term evolution of their orbits under gravitational forces can be studied with common techniques. The intent is to study the origin and evolution of all three classes of small bodies in a simular manner. The work in this RTOP over the past two years has resulted in the development of a mechanism which transports material from the asteroid belt into the orbit of the earth in a length of time (and amounts) consistent with the evidence from stoney meteorites. Until recently, proposed transport mechanisms failed to satisfy the time and mass constraints. The specific objectives for FY-75 are as follows: (1) it now seems likely that some meteorites can come from the asteroid belt by secular resonances. The dynamics of individual asteroids near these resonances will be studied to pick the most likely sources; (2) update the asteroid belt and family study as new asteroid data becomes available. Do special studies of families where useful; and (3) investigate the long-term orbital evolution of special objects by numerical integration.

W75-70633 **188-45-52**
Langley Research Center, Langley Station, Va.
METEOR ASTRONOMY - OBSERVATION, SPECTRA AND DATA ANALYSIS
E. S. Love 804-827-2893

The primary objective is to obtain trajectory, orbit, and spectral data of chemically differentiated meteors, and of meteors of special interest. Additional objectives include radiation studies, and studies of earth-orbital, far-UV meteor spectroscopy. Airborne UV observations of nebulae and comets as part of the Fall 74 ASSESS II mission in preparation for far-UV meteor photometry and spectroscopy from space shuttle launched platforms (LDEM) and (ATL) will be performed. (Contract) The objectives of the Smithsonian Astrophysical Observatory (SAO) research are to further investigate orbital distributions of sporadic meteors and meteor streams within the SAO radar meteor sample, and to determine the selection effects of fragmentation in space on orbit distributions. The research will be accomplished by expanding and upgrading the two-station, direct-photography and meteor spectra patrol. Statistical studies of data in hand and detailed reduction of selected data will continue. Radiation studies will continue. An engineering model of a far-UV meteor photometer will be developed for intended use on the Long Duration Exposure Module (LDEM), i.e., on the first space shuttle deployed experiment-module. (Contract) The SAO synoptic year radar data will be further reduced and analyzed. Particular attention will be directed to selection effects of meteoroid collisions in space and to characteristics of meteor streams. Theoretical studies of meteor phenomena will be performed to aid analysis of the meteor data.

W75-70634 **188-45-53**
Ames Research Center, Moffett Field, Calif.
COSMIC DUST MEASUREMENTS

D. R. Chapman 415-965-5065

The objectives are 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 is 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. Laser-mass spectrometer and electron probe technique will also be applied to determine isotope ratios, structural chemistry, and major element contents of terrestrial and extraterrestrial material, and pollution particles. The laser microprobe continues to prove an ultrasensitive method for trace element study. The elements Zn, Cu, Cr, Mn, Si, Ni and Fe have been analyzed in atmospheric aerosol material and found to be absent, even though they would have been detected if present at exceedingly low levels. A laser-to-mass spectrograph hookup is nearing completion. This will enable determination of radical groups and perhaps isotope ratios in unknown particles. An electronprobe may also be used to help detect light ($Z < 8$) elements.

W75-70635 **188-45-53**

Goddard Space Flight Center, Greenbelt, Md.

COSMIC DUST RESEARCH

Charles C. Schnetzler 301-982-2282

The objective of this research will be to understand the nature and history of condensed matter in the solar system. The multidisciplinary approach will involve the analyses of meteorites by the following techniques: (1) chemical analyses: major, minor and trace element composition by conventional wet chemistry, X-ray fluorescence and high precision atomic absorption; (2) non-destructive gamma-ray analyses; naturally-occurring K, U and Th, and cosmic-ray-produced radionuclides (such as A1-26) by low-background gamma-gamma coincidence spectrometry; (3) major, minor and trace element analyses in individual mineral grains and grain boundaries by electron microprobe, and ion microprobe microanalyzer; (4) cosmic-ray and fission track analyses by track etching techniques; and (5) mineralogical and petrographic analyses.

W75-70636 **188-46-56**

Goddard Space Flight Center, Greenbelt, Md.

PARTICLE ASTROPHYSICS

F. B. McDonald 301-982-4801

(188-46-64)

The objective is to measure the energy spectra, charge and isotopic composition of the primary cosmic radiation and of solar cosmic rays. Supporting this objective is the development of new detector systems for the study of the properties of cosmic radiation, and the associated development of theoretical studies related to these experiments. The results will be used in astrophysical considerations concerning the origin, acceleration and propagation of cosmic radiation. Specific goals are enumerated as follows: (1) measurements of the high energy composition of the cosmic radiation, including spectral, charge and isotpic studies from electrons up through the heaviest elements; (2) development of detectors to study the low energy composition of solar and galactic cosmic rays, with the goal of measuring the intensity of cosmic rays at great distances from the sun on deep space missions; and (3) improved measurements of the positron ratio 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 for obtaining new scientific information. New measurements will be made of the properties of cosmic radiation available for study at balloon altitudes.

W75-70637 **188-46-56**

National Aeronautics and Space Administration, Washington, D.C.

PARTICLE ASTROPHYSICS

Albert G. Opp 202-755-8493

(188-46-57)

The objective of this RTOP is to study the isotopic and charge composition and energy of galactic and solar cosmic rays. 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 of the stellar processes responsible for the cosmic radiation and information on the interstellar material transited by the cosmic radiation. The observation of solar cosmic rays provides information on the abundances of different elements in the sun and information on the solar processes that accelerate energetic particles to their observed energies. The design, construction and test of cosmic ray detectors is the prime activity supported by this RTOP. Solid state detectors, magnetic spectrometers, scintillators, Cerenkov counters and ionization spectrometers are typical instruments developed and tested under the support of this RTOP. Research balloons are employed extensively in high energy astrophysics. Balloon flights are used both to test new instruments and to obtain new scientific information on the properties of cosmic radiation. New instrument concepts are also tested at particle accelerations and from mountain top laboratories.

W75-70638 **188-46-56**

Marshall Space Flight Center, Huntsville, Ala.

PARTICLE ASTROPHYSICS

T. A. Parnell 205-453-5130

The objectives to develop instrumentation and perform theoretical calculations and develop data analysis techniques for measurements on high Z cosmic rays and for gamma rays between 0.1 and 10 MeV. To test the instrumentation and techniques for shuttle era experiments by performing observations of the cosmic ray and gamma ray flux on balloons. Using detectors and technique already developed for HEAO, a large area (.25 sq m) multi dE/dx Cerenkov counter system will be flown on a balloon to perform a high resolution measurement of the iron group nuclei. The goal will be the determination of individual abundances from $Z = 22$ thru 30. A study will be made to extend this class of detector system to very large area for use in shuttle era experiments for high charge resolution measurements in the $Z > 30$ region. The use of the gas-filled detectors to measure transition radiation will be studied. These detectors and others will be used to design an automated instrument for definitive measurements on the gamma ray bursts as well as to perform observations of other objects and regions of interest. This instrument will be designed for long flights on super-pressure balloons. Theoretical work and calculations concerning detector response will be carried out in the cosmic ray and gamma ray field.

W75-70639 **188-46-57**

National Aeronautics and Space Administration, Washington, D.C.

GAMMA RAY ASTRONOMY

Albert G. Opp 202-755-8493

(188-41-59)

The objective of this RTOP is to measure the characteristics of energetic photon emission from celestial sources and to understand the physical processed responsible for the emission. This RTOP includes photonic radiation approximately 10 keV in energy upward to as high as can be measured, that is, from hard X-rays to ultra-high energy gamma rays. Several hard X-ray sources have been identified, which have spectra extending into the tens to hundreds of keV. The spectra of discrete sources and the spectra and distribution of the diffuse background will provide information on the physical processes active in stars, galaxies and interstellar space. 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 photon gives information on the location of the gamma ray sources.

W75-70640 **188-46-57**

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

GAMMA RAY ASTRONOMY
D. P. Burcham 213-354-3028

This describes the JPL program in X- and gamma ray astronomy, part of which is a cooperative effort with UCSD. The primary objective of the program is to observe nuclear gamma ray line spectra from extraterrestrial sources in the .02 to 10MeV energy range. Such observations could provide improtant information on nucleosynthesis, galactic history and the physical nature of various celestial objects including cosmic X-ray and gamma ray sources, both constant and transient. Under this program, a high resolution gamma ray spectrometer balloon system will be used in a series of astronomical observations. Additional activities will be the development of advanced concepts in instrumentation and data analysis. The specific objectives for this program for FY-75 are to reduce, analyze, and publish the data from the FY-74 balloon flight series; conduct two observational balloon flights in the spring of 1975; and develop a gamma ray burst detector.

W75-70641 **188-46-57**
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 has been 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. Additionally, the theory of shaped scintillation detectors for measurement of medium energy gamma rays on small satellites is being studied, and design work of a detector system will being in the near future. 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. Special attention in the digitized chamber research is now being directed at designing and building a low cost chamber of significantly larger size. At the same time several different approaches are being explored to improve angular resolution, as well as sensitivity for future gamma ray telescopes.

W75-70642 **188-46-64**
Goddard Space Flight Center, Greenbelt, Md.
SHUTTLE DEFINITION STUDIES FOR HIGH ENERGY ASTROPHYSICS
F. B. McDonald 301-982-4801
(188-46-56)

The objective of this program is to develop a variety of new detector systems for high energy astrophysics research, including cosmic-ray, X-ray and gamma ray astronomy. Meaningful new experiments in these fields presently require the development of several new devices, incorporating new improvements in energy, charge and isotope resolution, in temporal resolution and directional resolution, and utilizing very large payloads of great size and weight, capable of orbit with the the shuttle. The technical objective is to measure the energy distribution and the charge and mass composition of the several components of the primary cosmic radiation. These components include both electrons and nuclei from hydrogen to iron, lead, uranium, and beyond. Beyond 10 to the 12th power eV, no information is presently available, primarily because particles in this range are very rare. The spectra fall steeply with increasing energy requiring large area detectors and long exposure times. This large exposure must be obtained while maintaining the resolution of much smaller detectors. Energy measurements in this highly relativistic range are currently being done using ionization spectrometers. Development of new techniques such as transition radiation detectors, large area gas filled counters, magnetic spectrometers, etc. will be required to extend existing measurements to beyond a TeV/nucleon. The properties of charge measuring devices, direction detecting devices, and total ionization spectrometers will be calibrated on the ground and studied at balloon altitudes.

W75-70643 **188-48-51**
Marshall Space Flight Center, Huntsville, Ala.
INTERDISCIPLINARY SPACE RESEARCH
E. Stuhlinger 205-453-3033

The 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 overall purpose of enhancing in-house scientific capabilities of the MSFC. Such research is related to the physics and astronomy programs of NASA. Under the direction of the Associate Director for Science, Dr. Ernst Stuhliner, research is initiated in scientific and technical areas which influence the scientific missions of the center. 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.

W75-70644 **188-48-52**
Goddard Space Flight Center, Greenbelt, Md.
BASIC THEORETICAL RESEARCH
A. Temkin 301-982-4441

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 falls into 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) charge exchange of iron nuclei with cosmic gases; (5) study of electron-atom scattering methods; (6) investigation of atomic matter-antimatter annihilation and its cosmic significance; and (7) study of photoionization processes.

W75-70645 **188-78-51**
Goddard Space Flight Center, Greenbelt, Md.
ADVANCED TECHNOLOGICAL DEVELOPMENT, GENERAL: SIGNAL AND DATA PROCESSING ELECTRONICS; SOLID STATE NUCLEAR DETECTORS
J. H. Trainor 301-982-6282

The technical objectives of this research project are to develop and test new on-board signal handling, data processing, storage, computing and auxillary electronics circuitry for use in energetic particle and astrophysics experiments on Pioneer, HEAO, Helios, shuttle missions, explorers, outer planet missions, rockets, balloons, etc., as well as special test and analysis equipment applicable also for both ground and shuttle usage. The growing complexity of experiments and the often corresponding increase in the 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 at low cost. The use of u-processors and minicomputers will be pursued both for ground testing and in-flight data systems.

W75-70646 **188-78-51**
Marshall Space Flight Center, Huntsville, Ala.
LOW GRAVITY SUPERFLUID HELIUM ADVANCED TECHNOLOGY DEVELOPMENT
R. A. Potter 205-453-3431

Several experiments are currently being developed which will require a low temperature environment for their proper 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.

W75-70647 **188-78-51**
National Aeronautics and Space Administration, Washington, D.C.
ADVANCED TECHNOLOGICAL DEVELOPMENT, GENERAL; CRYOGENICS
M. J. Aucremanne 202-755-3676

Physics and Astronomy experiments are being developed which will require a low temperature environment for their proper operation in space. Superfluid helium will undoubtedly be used for many of these applications. The purpose of this work is to investigate theoretically and experimentally, where possible, the properties of superfluid helium to be expected when liquid helium dewars are flown in space. Properties of superfluid helium and other cryogens for application in IR astronomy, cosmic ray physics and relativity will be assessed and methods to deal with problems will be developed.

W75-70648 **188-78-56**
National Aeronautics and Space Administration, Washington, D.C.
INSTRUMENTATION TECHNOLOGY - IMAGE TUBE AND DETECTOR DEVELOPMENT
M. J. Aucremanne 202-755-3676

Development of Large Space Telescopes are fundamental to the objectives of the Astronomy Research Program. It is essential that normal incidence image forming systems operating with maximum spatial and spectral resolution in the IR, visible, and ultraviolet regions be evolved. These instruments will be required to detect and present astronomical data in extreme fidelity. In order to accomplish this it will be necessary to develop a series of instruments that both accomplish their scientific objectives and at the same time provide technological data to permit a burgeoning capability. In order to fully utilize such advanced telescopes it will be necessary to concurrently develop suitable electronic image sensing system.

W75-70649 **188-78-56**
Goddard Space Flight Center, Greenbelt, Md.
SCIENTIFIC INSTRUMENT DEVELOPMENT FOR THE LARGE SPACE TELESCOPE
G. M. Levin 301-982-6688

The long range goal of the LST project is to build and operate a large, diffraction limited optical telescope, exploiting the capability for detection of faint sources, high angular resolution studies of all sources and measurement over a wide wavelength range. The broadest expertise in astronomical instrument design and consequently the best definition of instrument needs lies with the body of ultimate users, the astronomical community, which must be brought into LST activity. This will be done through the Instrument Definition Team organization developing scientific instrument definitions and identifying science and engineering tradeoffs between potential instruments and through contracts to develop supporting technology based on the recommendations of the Instrument Definition Teams. Contracts will be let by GSFC to members of the Instrument Definition Teams. Contracts for supporting technology will be let by GSFC.

W75-70650 **188-78-60**
National Aeronautics and Space Administration, Washington, D.C.
ADVANCED MISSION STUDIES
M. J. Aucremanne 202-755-3676

The objective of the Advanced Mission Studies is to initiate studies both in-house and on contract for the Explorer Series, and for the disciplines represented in Physics and Astronomy Programs. This RTOP will permit studies to be initiated for those disciplines outlined in the recent announcement of flight opportunities. The need for observations in the disciplines of physics and astronomy has been expressed by the National Academy of Sciences (NAS). Endorsement of the Explorer Series has been provided by the NAS in their summer studies and by others in the scientific community. The purpose of this RTOP is to expedite preliminary and conceptual studies by the appropriate field centers. If OSS is to continue to meet the goals of this agency, then it is imperative that we initiate the studies required to meet our scientific commitments to the nation. The technical objectives of the planned effort include: (1) support activities in definition studies; (2) the review of prior projects, such as SAS; (3) to ascertain whether existing subsystems, systems and hardware can be used in a minimum cost approach to designing the basic spacecraft; and (4) the resources required to conduct the missions.

Planetary Biology

W75-70651 **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 beginnings of life on the earth. 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 surfaces. 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, and H were converted by abiotic processes into the complex organic molecules which are direct precursors of the macromolecules essential to life.

W75-70652 **192-55-61**
National Aeronautics and Space Administration, Washington, D.C.
PLANETARY BIOLOGY
Dr. R. S. Young 202-755-3732
(192-55-62)

Chemical evolution is the laboratory study of the non-biological synthesis of biologically significant organic molecules under conditions presumed to have existed on the primitive earth, or any primitive planet before the event of life. The study is relevant to understanding the origin and evolution of life. Experiments relevant to prebiological organic chemistry can, in principal, explain the processes by which primitive cells could have originated on the earth. The greatest of evolutionary puzzles, the origin of life, takes on a new immediacy in light of recent laboratory advances and experiments which have a different approach but have the same common denominator, i.e., pathways by which biologically significant molecules arose prior to life.

W75-70653 **192-55-62**
Ames Research Center, Moffett Field, Calif.
ORGANIC GEOCHEMISTRY
H. P. Klein 415-965-5904
(192-55-61)

The principles and practices of organic geochemistry can be applied in any cosmological study wherein a solid matrix is investigated for the presence or absence of organic compounds.

Thus, not only are geological materials from earth candidates for study, but also included in organic geochemical investigations are extraterrestrial samples such as meteorites, lunar materials, and in the future, samples returned from planets. The main focus of organic geochemistry here is to study the occurrence, distribution and fate of organic compounds in terrestrial substances, such as contemporary environments, recent and ancient sediments (including Precambrian rocks), and fossils. The methods and results of these studies are applied to the interpretation of the significance of organic substances in extraterrestrial materials. By using the earth and its geochemical processe as a model, information about extraterrestrial processes can be better interpreted. Highly refined analytical techniques are used in organic geochemistry to separate organic compounds from mineral matrices. These compounds form the basis for understanding geochemical processes including diagenesis. From these studies, chemical criteria can be developed to distinguish between organic matter of biological and nonbiological origin. These criteria are essential for understanding the mode of origin of extraterrestrial organic materials.

W75-70654 **192-55-62**
National Aeronautics and Space Administration, Washington, D.C.
PLANETARY BIOLOGY
Dr. R. S. Young 202-755-3732
(192-55-61)

Organic geochemistry is the study of ancient terrestrial rocks for organic molecules and inclusions of biological origin. The development of techniques for the isolation of organic matter and distinguishing organic matter of biological origin from that of non-biological origin is discussed along with the applications of such technology to returned extraterrestrial samples.

W75-70655 **192-55-63**
Ames Research Center, Moffett Field, Calif.
LIFE DETECTION
H. P. Klein 415-965-5094
(192-55-66)

Those attributes of life which can be used for the remote detection of life are being studies. 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.

W75-70656 **192-55-63**
National Aeronautics and Space Administration, Washington, D.C.
PLANETARY BIOLOGY
Dr. R. S. Young 202-755-3732

The development techniques for the detection of extraterrestrial life and life related molecules, including evidence of life, past, present or future is discussed. The search for organic molecules of biological or non-biological origin, metabolic activity, growth and reproduction, and visual identification is also described.

W75-70657 **192-55-64**
Ames Research Center, Moffett Field, Calif.
BIOLOGICAL ADAPTATION
H. P. Klein 415-965-5094

The objective is to study terrestrial microorganisms which have adapted to life under environmental extremes. Models for organisms which may be found on other planets, possible terrestrial contaminants of other planets, and examples of organisms which may be present in samples returned from Mars in the future are considered. There are microorganisms which live in conditions of high and low temperatures, low humidity, high radiation flux, acidity, alkalinity, and salinity which are environments found on one or more of the other planets. The enzymes, structural components, and genetic systems of these organisms are being studied to determine how they have been modified during adaptation to such conditions. The information will suggest whether it is reasonable to expect that life forms resembling terrestrial life could have evolved on a particular planet, and what characteristics might be present in those forms. If it appears that a terrestrial type of life has a low probability of existing there, the study will suggest what properties may be present in the native life. In addition, there will be information important to the questions of forward contamination of another planet, and back contamination of earth.

W75-70658 **192-55-64**
National Aeronautics and Space Administration, Washington, D.C.
PLANETARY BIOLOGY
Dr. R. S. Young 202-755-3732

The study of the ability of microorganisms to survive and grow in environmental extremes approaching those of the planetary environments is discussed in terms of temperature and pH extremes, water availability, and salt concentrations. This is relevant to an understanding of biological processes in environments very different from those usually considered as being typical of the earth.

W75-70659 **192-55-65**
Ames Research Center, Moffett Field, Calif.
BIOINSTRUMENTATION
H. P. Klein 415-965-5094

The broad objectives of this effort are to develop instrumentation and techniques for the detection and characterization of life on other planets. The primary emphasis of the program is directed toward the planet Mars, but consideration will be given to application of the instrumentation to other planets. The work projects involve the continued development of operational breadboard models of the unified biology experiment and the wet-chemical amino acid analyzer, which are being developed as candidate post-Viking experiments. In addition, instrumentation feasibility studies are planned for other biological experiments in order to ready them for later potential planetary missions. Development of operational breadboards for the unified biology and the wet chemistry analyzer experiments will be continued with emphasis on test programs, to insure that the current designs will adequately perform the scientific goals of the experiments, and to identify engineering problems which will require further design and development efforts.

W75-70660 **192-55-65**
National Aeronautics and Space Administration, Washington, D.C.
BIOINSTRUMENTATION
Dr. R. S. Young 202-755-3732

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 compound such as amino acids, to feasibility studies of experiments involving the in situ study of soil gas evolution, microscopy, and calorimetry, and gas chromatography/mass spectrometry. The approach is to: (1) develop, fabricate, and test, in breadboard form, specific critical components of the wet-chemical processor; (2) establish feasibility and perform preliminary design of in-situ gas exchange experiment; (3) establish feasibility and perform preliminary design studies of remotely operated microscope systems; and (4) determine feasibility of combining gas chromatograph/mass spectrometry with wet-chemical analytical systems.

W75-70661 **192-55-66**
National Aeronautics and Space Administration, Washington, D.C.
PLANETARY ENVIRONMENTS
Dr. R. S. Young 202-755-3732

Analytical methods will be developed for the determination of biologically important planetary environmental characteristics, such as composition of the atmosphere, presence or history of water, and occurrence of organic emissions. The methods and instruments developed for planetary exploration will be useful in assessing a planet's ability to sustain a biota.

W75-70662 **192-55-66**
Ames Research Center, Moffett Field, Calif.
PLANETARY ENVIRONMENTS
H. P. Klein 415-965-5094
(192-55-63)

Scientifically justifiable methods of analyzing biologically important parameters are being studied for instrumental implentation in order to assess the extent of a planet's biological habitability based on the planet's atmosphere and water history, and for selecting biologically enriched areas based on water availability and organic emissions.

W75-70663 **192-55-68**
National Aeronautics and Space Administration, Washington, D.C.
SUPPORT ACTIVITIES
Dr. R. S. Young 202-755-3732

The AIBS Advisory Panels for OSSA are established to perform the following functions: (1) to evaluate the scientific merits of research proposals submitted by OSSA Program Chief(s) and to advise Program Chief(s) on the scientific merits of said proposals; and (2) to plan, conduct and coordinate meetings of the panels, providing necessary secretarial service, including minutes of the meeting.

Planetary Quarantine

W75-70664 **193-58-61**
National Aeronautics and Space Administration, Washington, D.C.
PLANETARY QUARANTINE ADVANCED STUDIES
Lawrence B. Hall 202-755-3760

It is NASA's policy to avoid contaminating the planets with viable terrestrial life and to avoid negation of life detection experiments by contamination with terrestrial life. This can be accomplished by: (1) avoiding contact with the planet; or (2) landing only space flight hardware that carries limited life on board. The research will result in sterilization methods specifically tailored to the spacecraft. The technology that is being developed in the use of dry heat may have limited application to other fields, but alternative methods being developed to supplement dry heat may have widespread and economically important use in the sterilization of foods, pharmaceuticals, surgical supplies, and other fields in which biological contamination cannot be tolerated. The major approach to the sterilization of spacecraft has centered on dry heat. Other methods have been examined and found wanting on the basis of reliability, cost, safety, and other factors. In dry heat heavy emphasis has been, and will continue to be, placed on the definition of the amount needed to accomplish the purpose. Concurrently, a search is being made for acceptable alternative methods of sterilization that may be used for specific applications in which dry heat is not acceptable because of materials degradation. Included in this approach are studies of the lethal effect of the space environment encountered during the period of interplanetary cruise.

W75-70665 **193-58-61**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
PLANETARY QUARANTINE ADVANCED STUDIES
C. W. Craven 213-354-5322

Planning and analytical studies will be carried out which support the evolution of defendable requirements in planetary quarantine, and which develop basic analytical techniques for their effective implementation in flight programs. Potential contamination events of future missions will be evaluated. Specifically, these studies will include: (1) an evaluation of the impact of planetary quarantine constraints on Jupiter Saturn flyby missions, satellite, and Saturn rings encounters, Jupiter orbiter and probe missions to both Jupiter and Saturn; and (2) studies to determine the effects of the natural space environment on the survival of microorganisms. These studies are to be conducted to identify planetary quarantine constraints for planned missions to better understand the requirements and to develop the procedures and methodology by which NASA can reliably satisfy these requirements. This technical work package provides for Planetary Quarantine Project Office functions as directed by the NASA Headquarters Program Office. These include program planning, definition of resource requirements, technical monitoring of research work, solicitation and evaluating technical proposals, and establishment of research contracts. In addition, a JPL detailee is provided for location at NASA Headquarters to interact with the Planetary Quarantine Program Office on day to day activities and provide support in budget and funding analyses.

W75-70666 **193-58-62**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
MICROBIAL ANALYSIS
C. W. Craven 213-354-5322

The objectives of this technical work package 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 and verify the analytical recontamination models; and (2) to perform sensitivity analyses to assess the impact of different mission strategies on recontamination. In addition, investigations will be conducted concerning: (1) buried contamination; (2) types and distribution of psychrophilic organisms isolated from soil samples from spacecraft assembly areas; and (3) study of nonlinearity of the probability of growth on Mars will be conducted through contract.

W75-70667 **193-58-62**
National Aeronautics and Space Administration, Washington, D.C.
MICROBIAL ANALYSIS
Lawrence B. Hall 202-755-3760

The research program on microbial analysis stems primarily from the need to sterilize space flight hardware by the application of some form of stress to the organisms. As the organisms are stressed, they die, not all at the same time, but progressively in what is termed the 'logrithmic order of death.' Thus, the more organisms that are present, the more stress (usually dry heat) must be applied. Acting in the opposite direction, however, is the need to keep the stress to the essential minimum so that hardware reliability will not be degraded. For these reasons the number distribution, and types of microorganisms must be known in order that the optimum sterilization cycle may be applied. The applications of this technology are being and will be applied largely to spacecraft but the methods will also spill over into the hospital, food preparation, pharmaceutical and surgical supply fields. The approach being taken includes: (1) the development of precise methods for the removal, numeration, and identification of all the bacteria from a representative surface; (2) the recovery of a representative sample of the organisms that are buried in solids; (3) the propagation of bacteria in aerosols; and (4) the estimation by mathematical and computer techniques of the total bioload on, and in, a spacecraft. Concurrently, field applications are being carried out to provide experience with the technology and the base line data on missions that have been or will be landed.

W75-70668 **193-58-63**
National Aeronautics and Space Administration, Washington, D.C.
CONTAMINATION
Lawrence B. Hall 202-755-3760

The probability of contaminating a planet by a flyby or orbiter spacecraft and the difficulty of achieving sterility of a landing spacecraft is related directly to the amount and characteristics of the biological contamination on the spacecraft. Therefore, the probability of contaminating the planet and the difficulty of sterilizing a landing vehicle can be reduced by controlling the amount and kind of viable contamination that gets on, and in, the spacecraft during manufacture, assembly, test, and launch. The concepts and procedures resulting from this effort provide the pressures used to keep a spacecraft

biologically clean. The dissemination of these biological cleanliness procedures is of major importance to industry, particularly pharmaceutical and surgical supply industries. In the former, the procedures developed for contamination control are saving millions of dollars a year by preventing false positives that result in the needless destruction of large batches of product. The approach to this problem centers largely in the evaluation, dissemination, and application of ultraclean techniques and in the gathering and recording of planetary quarantine publications.

W75-70669 **193-58-63**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
CONTAMINATION CONTROL
C. W. Craven 213-354-5322

The objective of this technical work package is to develop methodology and procedures for the reduction of microbial burden on an assembled spacecraft at the time of encapsulation or terminal sterilization or during flight. This technology is required for: (1) determination of the sterilization process for a planetary lander or probe; and (2) the reduction of excessive 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 needed information concerning cleaning techniques that could significantly reduce microbial burden on spacecraft hardware. This technical work package contains two work units which provide for activities at the Planetary Quarantine Laboratory at the Air Force Eastern Test Range. This laboratory's research is directed at improving and evaluating assay techniques, enumeration estimates, sterilization procedures and rapid identification of microorganisms associated with spacecraft and their environments. This technical work package also contains a work unit to study the impact of planetary quarantine on shuttle launched spacecraft.

W75-70670 **193-58-64**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
PLANETARY BACK CONTAMINATION
C. W. Craven 213-354-5322

The objective of this technical work package is to develop a better understanding of the implication of a planetary back contamination constraint and its impact on a sample return mission. Specifically, the studies included are: (1) developing a generalized definition of the planetary back contamination constraint; (2) understanding the impact of such a constraint on a typical sample return mission; and (3) the teneration of information that will be useful to NASA management in the formulation of a planetary back contamination constraint and policy. These studies are also being conducted to begin to develop the methodology by which a flight program can reliably satisfy the emerging constraints.

Lunar Science - SR&T

W75-70671 **195-20-01**
National Aeronautics and Space Administration, Washington, D.C.
EARTH BASED OBSERVATIONS
F. I. Roberson 202-755-1602

Continued study is planned of the lunar surface using earth-based instruments. Studies of broadband reflection spectroscopy are used to determine the chemical and mineralogical composition of the lunar surface. Study is also planned of the moon in terms of composition, surface processes, and regional geology using data from telescopic spectral reflectivity. Using telescopic measurements of minute color differences, studies will be conducted on separating lunar maria into chemical and stratigraphic units and dating these units.

W75-70672 **195-20-02**
National Aeronautics and Space Administration, Washington, D.C.
THEORETICAL STUDIES
F. I. Roberson 202-755-1602

Development of scientific concepts about the composition, structure, stratigraphy, origin, and history of the moon and its constituent features requires an iterative process of data acquisition, synthesis, and theory. The evolving theoretical models of the moon have been constantly refined through testing and modification in this series of studies. Major areas of research include temperature-pressures studies, cosmogenesis, seismology, electrical conductivity, geologic mapping, interactive of lunar materials with energetic particles, and thermodynamics of lunar processes.

W75-70673 **195-20-03**
National Aeronautics and Space Administration, Washington, D.C.
LABORATORY SIMULATION
F. I. Roberson 202-755-1602

The objective is to study the moon by experimentation in the laboratory. This includes: study of the lunar surface by laboratory observations of the effect of various types of solar radiation of silicate glass; study through models, the lunar interior structure and evolution as constrained by the physical and chemical properties of the same minerals found on the moon; study the shock effects, in the laboratory, of rock-forming minerals and the synthetic materials under a wide range of temperature and pressures; and study shock metamorphism effects and cratering phenomena to impact parameters of meteoroids using the laboratory facilities.

W75-70674 **195-20-04**
National Aeronautics and Space Administration, Washington, D.C.
EXTRATERRESTRIAL MATERIALS
F. I. Roberson 202-755-1602

The objectives of extraterrestrial materials program are to improve and extend scientific and technical knowledge of meteorites in order to increase our understanding of the composition and history of the solar system, give detailed information on present and past conditions of cosmic radiation in interplanetary space (space probes), and supplement studies of the chemical, physical, and geological properties of the lunar samples. The wide variety of experimental techniques available for meteorite study, including measurements in crystallography, mineralogy, radioactivity, particle tracks, chemical and isotopic composition, etc. - serve to give us detailed information on the origin, age, and history of these extraterrestrial objects.

W75-70675 **195-20-05**
National Aeronautics and Space Administration, Washington, D.C.
ANALOGUE STUDIES
F. I. Roberson 202-755-1602

Studies of terrestrial features that have been formed by similar processes to those that are believed to have shaped the moon's surface provide the data needed to interpret lunar history. The type of features being extensively studied are: terrestrial meteorite impact structures, terresterial volcanoes, mass waste erosion, lava ridges, ash flows and ejecta flows. These are the type of features that appear to be dominant on the lunar surface.

W75-70676 **195-20-06**
National Aeronautics and Space Administration, Washington, D.C.
SCIENCE EXPERIMENT CONCEPTS
F. I. Roberson 202-755-1602

Experimental concepts are conceived, developed, and demonstrated that pertain to the lunar orbit and surface which require perfection of techniques of data reduction and analysis, and interpretation as well as investigation of concepts, instruments and hardware including testing and calibration. These experiments emphasize geophysics and geochemistry.

W75-70677 **195-21-02**
Ames Research Center, Moffett Field, Calif.
THEORETICAL STUDIES OF THE MOON AND METEORITE PARENT BODIES

Dean R. Chapman 415-965-5065

The objectives are to obtain better understanding of the structure, origin, and evolutionary history of the moon by means of theoretical investigations employing the results of lunar and ground based experiments. Theoretical and experimental knowledge of physical processes, and mathematical modeling techniques are used, together with astronomical and geological data, to construct and analyze mathematical descriptions of lunar and meteorite processes and structure. The results of these calculations are interpreted in terms of such topics as: composition, material properties, and thermal history of the moon; solid state convection in the lunar interior, the interpretation of rare gas studies of meteorites and lunar samples, lunar cratering and the tidal fission of lunar orbiting bodies.

W75-70678 **195-21-03**
Ames Research Center, Moffett Field, Calif.
IMPACT CRATERING IN GEOLOGIC MATERIALS
D. R. Chapman 415-965-5065
(383-21-02)

Scars of large ancient terrestrial impact events are being recognized at a steadily increasing rate and this unfolding record, together with evidence of impact craters on Mars as well as those on the Moon and probably on Mercury, serves to emphasize that meteoroid cratering has been an important geologic process in planetary evolution. For most atmosphere-free bodies such as the moon, impact has been a major geologic agent for erosion and metamorphism (shock). Appreciation and thorough understanding of the effects of impact at all scales are, therefore, essential in unraveling lunar (and planetary) history. Moreover, knowledge of cratering processes and the influence of variables controlling crater formation and geometrics provide invaluable means for interpreting physical properties and structural details of the surfaces exposed to the meteoroid environment. Impact studies using the Vertical Gas Gun (VGG) Range already carried out have contributed significantly to the interpretation of planetary geology. The most recent publications in which these studies played a major role are: V. Oberbeck and R. Morrison, Laboratory simulation of the herringbone pattern associated with lunar secondary crater chains, The Moon, 1974 (In Press) V. Oberbeck and R. Morrison, The Lunar Herringbone Pattern, Apollo 17 Prelim Science Report NASA SP, 1973 (In Press).

W75-70679 **195-21-04**
Ames Research Center, Moffett Field, Calif.
CHEMICAL AND ISOTOPIC STUDIES OF METEORITES AND ABLATION PRODUCTS
D. R. Chapman 145-965-5065
(195-42-51; 385-45-01; 879-10-00; 188-45-53)

Chemical analyses via the electron microprobe permit determination of coexisting mineral compositions in meteorites, terrestrial analogs, and lunar samples. Knowledge of mineral compositions, together with textural studies, is needed to determine more precisely the physicochemical conditions of their origin, post-solidification thermal histories and shock events. On-going experiments are being utilized to determine the feasibility of forming meteorites from a cold beginning. Concentrations of volatile and nonvolatile elements in high temperature inclusions and minerals of carbonaceous chondrites, together with O18/O16 will be determined to test the condensation vs. extrasolar system origin for carbonaceous chondrites. In addition, several other meteorites, consistent in composition with the high temperature condensation theory will also be examined. This portion of the task will be conducted by ion probe analyses. 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, ion microprobe and scanning electron microscopy.

W75-70680 **195-22-02**
Goddard Space Flight Center, Greenbelt, Md.
THEORETICAL STUDIES
John A. OKeefe 301-982-4445
(195-22-03; 195-22-04)

This work consists of diverse theoretical studies on the structure and history of the moon. Included are: (1) backward calculations of the orbit of the moon to find out where it was in times past; (2) chemical calculations aiming to explain the absence of nickel and precious metals from the moon's surface; (3) dynamical studies of the mechanics of splitting the earth; and (4) studies of tektites, testing the hypothesis that they are actually a kind of inexpensive and abundant lunar sample. Work so far suggests that the moon may have formed by fission of the earth so most of the effort is being channeled along this line. The question of possible lunar volcanism (in our times) is also being carefully studied.

W75-70681 **195-22-03**
Goddard Space Flight Center, Greenbelt, Md.
MAGNETIC PROPERTIES OF CONDENSED SOLAR SYSTEM MATTER
J. A. Philpotts 301-982-5206
(195-22-04; 383-22-04)

The objective is to characterize the mechanisms of magnetization for iron based alloys of lunar and meteoritic composition and to relate the mechanisms within a time-temperature scale in a process-response model. Laboratory experiments involving man-made alloys which have been subjected to known dynamic and thermal histories will be conducted concurrently with experiments on meteoritic material whose history is incompletely known. The magnetic response of the magnetic systems to specific thermal and dynamic processes will be characterized, and metallographic recognition criteria for the response will be established and tested with meteorites. The systematic process-response knowledge will then allow lunar samples to be analyzed for paleointensity and petrogenetic implications. The evolution of the excess iron in the lunar regolith can also be evaluated.

W75-70682 **195-22-04**
Goddard Space Flight Center, Greenbelt, Md.
GEOCHEMISTRY OF CONDENSED SOLAR SYSTEM MATTER
J. A. Philpotts 301-982-5206
(195-22-03; 383-22-04)

The objective is to determine the nature and evolution of condensed matter in the solar system. Laboratory determinations will be made of major and trace element abundances, mineralogy and petrology, radiometric ages, isotopic compositions, and radioactivities. Meteorites will be the prime samples studied but terrestrial samples of wide planetological significance such as impactities and tektites will also be included. Field studies, in situ or via remote sensing, will be conducted where indicated. Laboratory simulations of natural phenomena such as igneous equilibrium and plasma and radiation effects will also be carried out. Instrument and technique development will be carried out as needed.

W75-70683 **195-22-06**
Goddard Space Flight Center, Greenbelt, Md.
SYSTEM AND RADIATION EFFECTS STUDIES FOR ORBITAL X-RAY AND GAMMA SPECTROMETERS
J. I. Trombka 301-982-5941

The overall objective is the development of improved systems for lunar orbital X-ray and gamma ray spectrometry. Three efforts involved in this are: (1) adapting a central data system for a lunar orbital vehicle; (2) solid state detectors; and (3) determining the detectors radiation background. The central data system will improve data handling by consolidating the data accumulation, acquisition, and transmission for multiple input detectors such as proportional counters, scintillation counters and solid state detectors. This will simplify the detector spacecraft interface. Solid state detectors will give improved resolution of characteristic line radiation used for elemental identification of the lunar surface. The development of such detectors for space flight use will be encouraged. Studies of their response over the energy range of interest will be performed using neutron irradiation of extended media. Background radiation in the detector and surrounding

material due to trapped and cosmic proton flux will be studied using space flight data as well as proton irradiation measurements on earth. Theoretical models will be used in the interpretation of this data.

W75-70684 **195-23-01**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
EARTH BASED LUNAR OBSERVATIONS
D. P. Burcham 213-354-3028

We propose to conduct ground-based observations of the moon using several techniques. Two dimensional observations in the visible and near infrared will be made using the Silicon Imaging Photometer System (SIPS). These observations will yield two dimensional images of spectral reflectance which can be used to define compositional and stratigraphic units. The Image Processing Laboratory facilities will be used to optimize data for comparison with other data sets obtained under this program. Two types of radar investigations are also planned: (1) the mapping of polarized and unpolarized radar echoes to facilitate correlation with Apollo bistatic radar results and existing ground based radar maps; and (2) topography measurements along great circles using Arecibo Observatory 70 cm radar. These measurements will be tied to Apollo topography data to obtain accurate topographic control over a large lunar area. The results from all of the investigations will then be used along with other data sets (such as gravity) to investigate: (1) the source of gravity anomalies in irregular mare; (2) large scale roughness variations; and (3) age stratigraphic relationships among mare units.

W75-70685 **195-23-02**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
THEORETICAL STUDIES
D. P. Burcham 213-354-3028

We propose to solve a series of boundary value problems appropriate to the moon which relate the deformation of the surface under prescribed loads of finite mass distribution to other observed geological parameters. The time-dependent problem will be considered in which viscosity at depth is allowd to vary in response to variation in subsurface temperature. The subsurface temperature is in turn to be determined by appropriate models of the thermal history. The ultimate aim is to solve the inverse problems, i.e., what the history of the temperature profile is under a given load or mass distribution and a given deformation. The formalism of the inverse problem is the subject of a current lunar synthesis proposal. Here we seek to solve and make useable the forward problem of surface deformation resulting from various possible distinct lunar thermal models, and to study the sensitivity of the differences in deformation to initial assumptions implied by such models at the present time. From such calculations a framework can be provided to study: (1) various structural models of the upper part of the moon; and (2) early near-surface temperature distributions. The former may help distinguish between various models of lunar formation; in fact the method of analysis proposed here may be the only direct means of attacking the difficult questions of the paleotemperature distribution within the moon. The latter way aids in solution of the still unsettled question of locating anomalous masses, i.e., the mascons.

W75-70686 **195-23-06**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
ADVANCED EXPERIMENT CONCEPTS
D. P. Burcham 213-354-3028

Advanced gamma ray spectroscopy is investigated in anticipation of an opportunity to chemically map the entire lunar surface from a spacecraft placed in a close lunar polar orbit. Reference points will be the results of the Apollo 15 and 16 gamma ray experiment, and the scientific potential-design requirements of a high purity Ge detector instrument. Particle track cosmochronology is also investigated to develop fast neutron thorium mapping methods and expand particle track methods in preparation for more detailed chronology studies of ancient rocks. These studies answer questions about fractionation of the heat producing elements on a mineralogical and whole-rock scale. Support for application of these methods to lunar samples will be sought. When the results of these tasks are applied to the moon, valuable information will be gained on the nature and processes of the lunar surface. Application of this large and small scale information will enlarge our understanding of the moon's chemical and thermal history.

Planetary Astronomy SR&T

W75-70687 **195-25-03**
Lyndon B. Johnson Space Center, Houston, Tex.
LABORATORY SIMULATIONS
L. A. Haskin 713-483-4464
(195-35-01)

The conditions of origin and formation for naturally occurring geological materials can be experimentally determined through the production of synthetic analogs in the laboratory combined with geochemical and geological analysis of the products. The Planetary and Earth Sciences Division of JSC conducts such experimental work using controlled atmosphere furnaces and hydrothermal and gas high pressure equipment to produce synthetic minerals and rocks and a 20 mm flat plate accelerator capable of performing controlled shock loading experiments of up to 700 kb peak pressure in geological materials.

W75-70688 **195-25-04**
Lyndon B. Johnson Space Center, Houston, Tex.
EXTRA TERRESTRIAL STUDIES (METEORITES)
L. A. Haskin 713-483-4464
(195-35-01)

Meteorite studies are performed to generalize our knowledge from lunar and terrestrial studies to other parent bodies in the solar system, to investigate the commonality or uniqueness of processes involved in the primary accretion and differentiation of bodies in the solar system and to decipher the record of subsequent processes that is preserved in surface samples. Research involves the use of a variety of analytical geochemistry methods of analysis.

W75-70689 **195-25-05**
Lyndon B. Johnson Space Center, Houston, Tex.
LUNAR ANALOG STUDIES
L. A. Haskin 713-483-4464
(195-35-01)

Selected areas of the earth bear considerable similarity to areas of the moon and are chosen for detailed geological analysis so that the information derived can be used in interpreting the scientific findings from the lunar science program. Certain large scale impact structures and other terrestrial occurrences are chosen to provide information on ejecta blankets surrounding impact craters, strontium isotope ratios as important parameters in determining the petrogenesis of plutonic rocks, origin and evolution of basaltic and gabbroic rocks, melt-derived versus non-melted fragmental products of large terrestrial impacts, and Precambrian anorthosite complexes.

W75-70690 **195-25-06**
Lyndon B. Johnson Space Center, Houston, Tex.
ADVANCED EXPERIMENT CONCEPTS
L. A. Haskin 713-483-4464
(195-35-01; 383-35-01)

The objective of this plan is to develop the ion microprobe microanalyzer as a high resolution instrument for the determination of trace elements in geochemical research. The development program consists of three parts: (1) analysis and evaluation; (2) electronic system development; and (3) data reduction methods development.

W75-70691 **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 planet thermal emission spectra. 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, and 1100-1200/cm with a spectral resolution of 0.2/cm. Evident of the spectra are numerous CO2 molecular absorption lines and several diffuse absorption features in the 850-1200/cm region. Interpretation of the diffuse features with homogeneous model atmospheres strongly indicates a 75% solution of H2SO4 for the composition of the clouds of Venus. The full potential of the present instrumentation has been reached for Venus. 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 will allow further valuable planetary observations to be obtained. These observations would initially be concentrated on measurements of Jupiter at approximately 1/cm spectral resolution in the 10 and 20 micron terrestrial atmospheric windows.

W75-70692 **196-41-51**
Goddard Space Flight Center, Greenbelt, Md.
RADIO AND RADAR PLANETARY STUDIES
J. K. Alexander 301-982-5461

The objective of this program is to obtain information on the nature, extent, and dynamical behavior of planetary magnetic fields, trapped radiation belts, and magnetospheres by studying the nonthermal radio emissions from the planets. The three major approaches to this investigation are: (1) synoptic observations of Jupiter's decametric radiation via a five-station network of monitoring instruments; (2) observations of Jupiter and Saturn at meter and decameter wavelengths via very long baseline interferometry (VLBI); and (3) theoretical analyses of the generation and propagation of nonthermal radiation in a planetary magnetosphere. The Jupiter Monitor Network is providing unique data relative to the rate and stability of the magnetic field rotation, and the physics of satellite-plasma interactions in the magnetosphere, and correlative data for fly-by in situ measurements. The VLBI measurements may provide the first positive detection of a Saturnian magnetic field.

W75-70693 **196-41-52**
Goddard Space Flight Center, Greenbelt, Md.
GROUND-BASED OPTICAL SOLAR SYSTEM ASTRONOMY
S. P. Maran 301-982-4703

This RTOP provides for the operation of two small observatory facilities, the principal one being a high-altitude observatory, and the other a mobile, expedition-type facility for qualitative and quantitative observations and measurements of solar system phenomena. These include imaging research on comets and their interactions with solar radiation and the solar wind, as well as photoelectric photometry and spectroscopy of asteroids, comets, planets and natural satellites of the planets. In addition, if a suitable bright comet appears radio observations will be made.

W75-70694 **196-41-67**
Ames Research Center, Moffett Field, Calif.
PLANETARY ASTRONOMY AND SUPPORTING LABORATORY STUDIES
D. R. Chapman 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 objectives of this work are to study airborne and ground-based observations of planetary spectra, to obtain in the laboratory the spectroscopic parameters needed to analyze the obsevatory spectra and to develop the analytical and computational techniques to interpret the spectra in terms of real planetary atmospheres. Spectroscopic parameters, such as absorption line and band intensities and absorption line half-widths as well as their dependence on pressure and temperature, will be obtained for molecules of planetary interest using long path gas cells, cooled and heated gas cells, and high resolution spectrometers and interferometers operating primarily in the infrared.

W75-70695 **196-41-71**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
GROUND-BASED OPTICAL ASTRONOMY
D. P. Burcham 213-354-3028

The general objective of this task is the comprehensive study of solar system bodies through ground-based astronomical observations. Specific emphasis is placed on high-resolution spectroscopic observations of the outer planets, Jupiter, Saturn, and Uranus. The principal instuments used in this effort are the Table Mountain Observatory 24-inch telescope with its high-resolution coudie spectrograph, the McDonald Observatory 82 and 107 inch telescopes, and the Mount Wilson 60-inch telescope. A laboratory spectroscopy program is operated in conjunction with the astronomy program in order to provide molecular data necessary for the interpretation of the astronomical data. Specific objectives for FY-75 include the following: (1) a program of observation of the spatial and temporal variations of H2, CH4, and NH3 on Jupiter, and H2 and CH4 on Saturn and Uranus. Analysis of these data in terms of abundance, temperature and pressure structure, and dynnamics of the planets' atmospheres; (2) observation and analysis of temporal variations of the recently discovered sodium-emission region around the Jovian satellite Io (J-I); (3) a systematic program of photometry and spectroscopy of comets, with emphasis on comet P/Encke; (4) a program of multicolor photometry to investigate the colors and light curves of selected minor planets, with emphasis on those for which the least amount of observational data are available; (5) laboratory spectroscopy to provide molecular parameters required to analyze observations of planetary atmospheres; (6) evaluate the performance of the recently developed breadboard Transform Camera by imaging Jupiter in wavelengths of the reflected solar spectra and in wavelengths close to 5 microns. This later spectral region is a region in which the principal atmospheric constituents of Jupiter are highly transparent and in which J. Westphal has detected localized 'hot spots'.

W75-70696 **196-41-72**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
GROUND-BASED INFRARED ASTRONOMY
D. P. Burcham 213-354-3028

The objective is to obtain and analyze high resolution infrared spectra of the planets in the 1-6 micron region in direct support of on-going and planned planetary missions. The primary approach employed is the analysis of spectra produced with a Connes'-type Fourier spectrometer at the 107' telescope, McDonald Observatory, University of Texas. Ancilliary approaches involve the use of laboratory infrared spectroscopy and data compilations for the analysis of spectra, together with significant operational efforts in the fields of radiative transfer and model atmospheres. Interpretation of the data also feeds back to the development of new instrumentation to support both the present work and potential spacecraft missions. For instance a spatial/spectral multichannel scanner for the investigation of the temperature profile and cloud morphology in the upper Jovian atmosphere using the 5 micron CH3D bands discovered in 1971 is being constructed.

W75-70697 **196-41-73**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
RADIO AND RADAR PLANETARY STUDIES
D. P. Burcham 213-354-3028

The objective of the radio astronomy task is to conduct a comprehensive ongoing program in earth-based planetary radio astronomy. Primary interest is focused on Venus and the four major planets and their satellites. Studies of the properties of the atmospheres, magnetospheres and surfaces of these bodies are conducted with radio astronomical observations providing valuable input to theoretical models. The observational work of this task is conducted at JPL's Table Mountain Observatory (TMO), Goldstone Tracking Stations, Caltech's Owens Valley Radio Observatory (OVRO) and other observatories as required by specific needs of the program. Research programs at these facilities are planned in order to take full advantage of the various unique capabilities of the individual systems, especially the new 36 GHz interferometer at TMO and the 64-m antenna and advanced low-noise receivers at Goldstone. The objective of the Deep Space

Instrumentation Facility (DSIF) astronomy task is to obtain radar data on the planets for determining properties of their surfaces, orbits and spins, with Venus, Mercury, Mars, and Saturn's rings as prime goals. This work employs the unique facilities of the DSIF, and exploitation of synthetic aperture techniques. The microwave radiometer development effort is supportive of the Radio Astronomy task. The objective are to design, develop, construct, test and maintain advanced microwave radiometer systems for use at the Table Mountain, Goldstone, Owens Valley and other radiotelescope facilities. During FY-75, the specific objectives are to maintain and upgrade the existing equipment and to expand the operation of the 36 GHz interferometer to the two-baseline capability.

W75-70698 **195-35-01**
Goddard Space Flight Center, Greenbelt, Md.
LUNAR POLAR ORBITER DESIGN STUDY
W. D. Hibbard 301-982-4474
(686-20-00)

The objective of this RTOP is to provide the necessary technical, scientific and management information to justify and initiate the design and fabrication of a Lunar Polar Orbiter payload and its support functions. The approach is to conduct a detailed mission definition study, including mission and payload system engineering studies, cost/weight/risk trade-off analyses, experiment definition studies, resource estimates, implementation plans, and other activities required. The major products will be a system design report, a procurement package covering all major contracts, and a project implementation plan. Supporting reports will be issued as required. It is anticipated that the payload will be Delta-launched and will comprise two lunar satellites: (1) a low-altitude polar orbiter carrying the primary scientific instruments; and (2) a high-altitude, low-inclination relay satellite that provides a precise tracking link to the far side of the moon.

W75-70699 **195-35-01**
Lyndon B. Johnson Space Center, Houston, Tex.
S AND AD SUPPORT FOR SUPPORTING RESEARCH AND TECHNOLOGY TASKS
L. A. Haskin 713-483-4464
(195-25-03)

This plan provides the institutional type support for S and AD in-house geoscience supporting research and technology tasks. Typical support is provided in the form of analytical and experimental instrumentation design and fabrication, instrument maintenance and repair, instrument up-grade as state-of-art improvements become available from vendors or are developed in-house, liquid nitrogen storage and remote terminal computer rental, purchase of technical publications, analytical instrumentation operation, in-house computer maintenance and repair, purchase of thin sections and rocks samples, and purchase of computer programs.

W75-70700 **195-40-02**
Langley Research Center, Langley Station, Va.
NEW TECHNIQUES FOR THE ACCURATE DEFINITION OF THE LUNAR GRAVITATIONAL FIELD
E. S. Love 804-827-2893

The objective of this work is to develop new techniques for analyzing the data from lunar missions so as to better define the physical properties of the moon. Lunar gravity analyses have been hampered by the absence of direct measurements of the lunar farside gravity environment, by the considerable roughness of the lunar gravity field, and by the limited data situation. These factors require the estimation of a large number of coefficients which are highly correlated. Emphasis this year will be in two areas. The first area will be science optimization for future lunar missions. Specifically, parametric studies of satellite-to-satellite Doppler tracking will be made to determine the efficiency of these data for very high degree, intermediate degree, and low degree gravity field determination. The second area involves development of a theory for combining available satellite tracking data with lunar retroreflector data. In order to do this, various methods will be evaluated, the optimum method selected, and finally, the detailed theoretical development will be performed.

OFFICE OF TRACKING AND DATA ACQUISITION

Tracking, Orbit Determination & Ground Base Navigation

W75-70701 **310-10-22**
Goddard Space Flight Center, Greenbelt, Md.
MISSION SUPPORT COMPUTING SYSTEMS AND TECHNIQUES
D. S. Woolston 301-982-5571
(310-10-26)

The major objectives of this RTOP are to provide generalized, flexible and economical mission support and mission analysis computing systems to meet the operational needs of forthcoming spacecraft missions. Much of the effort will be directed toward finding the most effective and most efficient combination of techniques for a given application. New statistical filtering techniques which decouple orbit and model parameter estimation have been developed under this RTOP and will be evaluated and extended to permit the use of newly available data types. A further objective will be to explore the possibility of reducing ground based tracking and orbit determination requirements by examining new and unique ways of determining a spacecraft's orbit. The information content of on-board attitude data and/or landmark data, for example, should be useful in orbit determination and could reduce the need for tracking. In a task picked up from a companion RTOP, halo-orbit stationkeeping technique will be explored with the objective of determining the proper magnitude, direction, and timing of orbit adjust maneuvers.

W75-70702 **310-10-26**
Goddard Space Flight Center, Greenbelt, Md.
ATTITUDE/ORBIT ANALYSIS
E. J. Lefferts 301-982-5508

The objectives of this RTOP are to increase the efficiency and decrease the resources needed to meet the requirements for forthcoming spacecraft missions by: (1) the use of new data types from telemetry to decrease the quantity and usage of tracking data for orbit determination and guidance control; (2) the provision of generalized and flexible computing systems using on-board sensors and computers along with small ground computers to reduce the demand upon the central computation facility; and (3) providing standardized sensor combination and telemetry software interfaces to effect a reduction in the attitude determination development cost. The approach involves the development of computational software to permit the analysis of the coupled attitude/orbit determination process. An error analysis program will be developed to examine the sensitivity of sensor combinations in the combined model. Cost models for the mix of on-board, ground based mini-computers and large central computers will be developed. Simulations of the attitude and orbit determination process will be performed using on-board computer systems and small ground-based systems (PDP-11).

W75-70703 **310-10-42**
Goddard Space Flight Center, Greenbelt, Md.
FREQUENCY STANDARD SOURCES
H. E. Peters 301-982-5946

This RTOP is to develop improved atomic hydrogen frequency and time standards for critical NASA applications: optical and microwave tracking (.2 microsecond time stability required); very long baseline interferometry in geodesy and astronomy; experimental requirements for Spacelab Applications Facility (ranging, timing, and relativity goals); and precise time and frequency dissemination or basic standard reference. The objective of task A, Operational Atomic Hydrogen Maser Standards, is to complete tests with new hydrogen masers built in FY 1974, test new teflon high line Q bulb configuration, develop improved synthesizer, and complete advanced cavity auto-tuner system. The objective of task B, Hydrogen Maser Basic Calibration Standard, is to design and construct variable volume hydrogen maser for evaluation of operational maser inaccuracy effects. A

new design, capable of 1 x 10 to the minus 14th power accuracy, will be completed and tests will start in FY 1975. The objective of task C, Atomic Hydrogen Beam Standard, is to design a new device based on free atom resonance for absolute accuracy capability of 1 x 10 to the minus 14th power or better. Resident Research Associates, now on-board, will follow earlier successful work.

Spacecraft-to-Ground Communications, Telemetry and Command

W75-70704 **310-20-20**
Goddard Space Flight Center, Greenbelt, Md.
TRACKING AND DATA RELAY SATELLITE TECHNOLOGY DEVELOPMENT
George Q. Clark 301-982-6331
(310-20-46)

The objectives are: (1) to provide for the simulation and system design of a Tracking and Data Relay Satellite System (TDRSS) 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 1979. Various studies, simulations, and model fabrications will be performed to establish the parameters for a TDRSS, while other studies will identify and provide solutions to problems inherent in the system. In addition, technology will be developed as required for the improvement of a first-generation TDRSS.

W75-70705 **310-20-27**
Goddard Space Flight Center, Greenbelt, Md.
NETWORK TIMING AND SYNCHRONIZATION TECHNOLOGY
A. R. Chi 301-982-2502

The objectives of this research are to: study and develop techniques for time synchronization; coordinate time determination methods and dissemination formats to meet NASA needs and network requirements; apply known technology to planned or existing systems which may or may not be solely NASA supported programs; initiate and review development programs which meet present and future needs of the network including hardware and software development where appropriate; and conduct theoretical investigations and experimental tests for network applications. A single worldwide time synchronization reference system using the Navy's OMEGA navigation system as a carrier was investigated. Receiver hardware for time extraction from the carrier signals was developed. A field test of the receiver and system capability is ready and planned for FY-74. Construction of OMEGA transmission format as presently constituted includes two side frequencies which are separated by 250 hertz for time transmission. The system precision is 90 microseconds at cycle identification level and 1 to 5 microseconds after a carrier cycle has been identified.

W75-70706 **310-20-31**
Goddard Space Flight Center, Greenbelt, Md.
A GROUND ANTENNA FOR WIDEBAND DATA TRANSMISSION SYSTEMS
L. R. Dod 301-982-5319

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 giga hertz. 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 wideband (approximately 1 giga hertz) 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.

W75-70707 **310-20-32**
Goddard Space Flight Center, Greenbelt, Md.
HIGH RELIABILITY CONTROL SYSTEMS FOR ANTENNAS
N. A. Raumann 301-982-6579

The objective is the development of a high performance servo and control system for large tracking antennas. There is a trend in the networks toward higher RF frequencies, switching from S-band to Ku-band of operation. This switch will require an improvement in tracking accuracy of the antennas from a present 0.9 mrad to 0.2 mrad. At the same time there is a requirement for increased link reliability due to concentration of data acquisition responsibilities and increasing data bandwidths resulting from reduction in the number of network stations. Thus link downtime has to be minimized by providing a high reliability control system and by reducing routine alignment and maintenance requirements. These objectives are met by use of a small digital computer in the antenna tracking loop. An experimental system, the computer controlled antenna system, has been developed under this RTOP and is in operation of the Network Test and Training Facility. The capabilities of this system will be extended by development of control algorithms to improve the tracking accuracy and by providing high reliability control system to minimize antenna downtime.

W75-70708 **310-20-46**
Goddard Space Flight Center, Greenbelt, Md.
R.F. TECHNOLOGY FOR TDRSS USER SPACECRAFT
F. J. Logan 301-982-4901

The objective of the work under this RTOP is to achieve technological advances in R.F. and antenna systems in order to satisfy the future requirements of spacecraft projects that require the near global real-time coverage of the Tracking and Data Relay Satellite System (TDRSS). The program: (1) identifies the basic operational requirements of these missions (2) investigates R.F. components and types of antennas that are available to attain the required parameters, and (3) develops system designs incorporating the optimum subsystems to permit the spacecraft projects to obtain proven reliable flight hardware within a reasonable time frame. These advances will be utilized in the development of S-band and Ku-band spacecraft systems, including the antenna, transponder, transmitter and receiver. These systems will be capable of direct communications to ground stations or to the TDRSS.

Network Operations and Control Theory

W75-70709 **310-30-21**
Goddard Space Flight Center, Greenbelt, Md.
ADVANCED PROJECTS SUPPORT STUDIES
F. L. Stetina 301-982-5730

The objective is to provide detailed analysis of advanced spacecraft mission interfaces with the STDN and the most efficient utilization of existing and projected NASA Spaceflight Tracking and Data Network (STDN) capabilities, including TDRSS, in the field of telecommunications and related data systems. Advanced projects are those in the mission and systems definition phases; such as, Large Space Telescope (LST), shuttle, spacelab, Interior Observation Satellite (IOS), Earth Resources Satellite Operational System (EROS), Earth Observation Satellite (EOS), Tracking and Data Relay Satellite, etc. Studies will be performed to optimize spacecraft to ground RF link and data systems. Studies will be used to identify new technology and support capability that can be used to upgrade or augment existing network capabilities. Consideration will be given to trade-offs made between spacecraft

systems whose implementation could be impractical or more costly than augmenting ground systems and vice versa.

W75-70710 **310-30-24**
Goddard Space Flight Center, Greenbelt, Md.
WIDE BAND STATION DATA HANDLING EQUIPMENT
Henry J. Franks, Jr. 301-982-2649
(757-54-01)

The wide band station data handling equipment research program will investigate concepts for receiving, demodulating, synchronization, and recording spacecraft telemetry data at rates up to 300 megabits per second. A high data receiver/demodulator will be developed which can accommodate the data rates transmitted by spacecraft such as EOS, TDRSS and shuttle. These wide band data rates will require the use of frequencies at which the necessary bandwidth can be allocated. Quadriture modulation techniques will be utilized to make more efficient use of the bandwidth that is available. A high data rate recorder will be developed. The initial effort will be towards a 30 megabit per second magnetic tape recorder to complete the upgrading of the present network to a 30 megabits per second capability. This will be followed by a 240 megabits per second recorder to complement the high data rate receiver/demodulator. This will also be a magnetic tape unit to take advantage of the work presently underway in the area of spacecraft tape recorders.

Data Handling and Processing

W75-70711 **310-40-25**
Goddard Space Flight Center, Greenbelt, Md.
AUTOMATIC COMPUTER PROGRAM DOCUMENTATION
E. P. Damon 301-982-6886

The purpose of this project is to extend the capabilities of the Automatic System for Computer Program Documentation Software System, which is now under development for the IBM 360, to operate on the UNIVAC and CDC computers. Furthermore and more significantly, the purpose of this project is the investigation into the existence, availability, and applicability of automated verification tools, and the evaluation of current approaches to software modeling.

W75-70712 **310-40-36**
Goddard Space Flight Center, Greenbelt, Md.
AUTOMATIC DATA HANDLING
J. C. Rodgers 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 and shall result in two end products: (1) the design and development of the Data Accountability System with the necessary capability to monitor, coordinate, and account for the data messages transferred between the remote ground stations and the GSFC facilities; and (2) the design and development of a prototype Integrated Telecommunications Distribution System providing a communications network between the operational M and DOD computers. The Data Accountability System shall interface with the M and DOD computer facilities and NASCOM concentrating on the particular problems inherent data coordination, and accountability when data is automatically transmitted between ground stations and GSFC by computer to computer transfers. The Integrated Telecommunications Distribution System will permit any computer on the telecommunications network to communicate with any other computer on the network.

W75-70713 **310-40-38**
Goddard Space Flight Center, Greenbelt, Md.
COMPUTATIONAL REQUIREMENT DEFINITION
A. Goodson 301-982-5308

A continuing need exists to reassess the functional capability of the M and DOD computer facilities in the light of present and future mission support requirements, advances in computer technology, and cost-effectiveness considerations. The purpose of this RTOP is to find practical answers to different aspects of this problem. Emphasis is on determining the practical guidelines and constraints which limit productivity on large computers operated in a multiprogramming environment.

W75-70714 **310-40-39**
Goddard Space Flight Center, Greenbelt, Md.
IMAGE PROCESSING FACILITY PERFORMANCE EVALUATION AND IMPROVEMENT
J. Y. Sos 301-982-2841

In the future several new Office of Applications (OA) projects, such as Nimbus-G, SEASAT, will require image data processing capabilities. It is planned to augment the existing GSFC image processing facility (IPF) to support, in addition to ERTS, the above projects. This plan proposes to conduct studies leading to the development of specifications for new IPF equipment, to define operational concepts for the facility, and to continue the development of efficient image processing algorithms. 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 conjunction with existing IPF hardware. It is also neccessary to study methods for generating image products that could be less expensive and more useful to the investigator, and to eliminate un-needed and expensive products. This plan proposes to develop efficient and accurate methods for monitoring and controlling performance of equipment, and assuring the quality and usefulness of products generated in the IPF. Higher time resolution will be required on future spacecraft consistent with more sophisticated experiments and with the desire to correlate data from one spacecraft with data from another. It is necessary to study several spacecraft systems with different types of timing problems.

W75-70715 **310-40-40**
Goddard Space Flight Center, Greenbelt, Md.
PROJECT OPERATIONS CONTROL CENTER COMPUTATIONAL SYSTEM OF THE 1980'S
Richard desJardins 301-982-6222

The goal of this RTOP is to develop a control center computing system concept (hardware/software) for the shuttle era, embodying the following features: ultra reliable, fail-soft hardware/software design; high visibility of systems implementation status; flexibility and ease of reconfiguration; simplified integration and test; reduced development time and cost; special attention to human interfaces; and high visibility of systems operational state. The effort will be distributed among three areas: (1) identification of probable computational requirements on GSFC project operations control centers anticipated in the shuttle era; (2) identification of probable system hardware/software capabilities and applicable technologies; and (3) to develop system hardware/software configuration concepts, including any models needed to prove feasibility or select system parameters.

W75-70716 **310-40-41**
Goddard Inst. for Space Studies, New York.
INCREASING COMPUTER EFFICIENCY
Paul B. Schneck 212-866-3600

The objective is to develop and apply techniques for increasing computer efficiency. Specific objectives are to: (1) derive operating system designs which minimize idle CPU time; (2) develop preprocessing programs capable of analyzing and optimizing an input program to decrease its running time; and (3) develop preprocessing programs capable of transforming a program to a form suitable for parallel or vector processing machines of the type now being introduced. A design philosophy, embracing the GISS operating system structure, will be extended to include effects of virtual memory, multiprocessing, and interactive processing. A FORTRAN to FORTRAN optimizing compiler employing all conventional optimizations will be used as the basis of investigations into additional common subexpression detection, code motion, interprogram optimizations. A preprocessor, performing global topological analysis will restructure

a conventional program for another class of machines (e.g. parallel or vector).

W75-70717 **310-40-44**
Goddard Space Flight Center, Greenbelt, Md.
STORAGE SYSTEM STUDIES
William B. Poland, Jr. 301-982-4592
(310-40-38)

The actual reliability of data storage systems used for long-term storage affects both performance and cost of ground data handling equipment. Current work under this RTOP is directed to improved magnetic tape system reliability and performance evaluation. Cost savings can be achieved by improving the efficiency and reliability of magnetic tape systems used in data interchange. Means for full standardization of the ground instrumentation tape record/playback process are not available, and the error-producing mechanisms arising in computer tape have not been well evaluated. This RTOP implements two key studies needed to obtain quantitative data for computer tape failure mechanisms and to establish the specifications for an international standard reference tape system. A data flow rate of approximately 10 to the 12th power bits per year from the STDN network through computer data processing to the experimenters is carried by instrumentation and digital magnetic tape. Planned modifications to the ground data handling facilities will decrease or modify somewhat current tape system use, but magnetic tape will remain a major NASA cost and performance factor in the next decade. The work under this RTOP has no environmental impact.

OFFICE OF MANNED SPACE FLIGHT

Advanced Development

W75-70718 **909-81-08**
Goddard Space Flight Center, Greenbelt, Md.
CONTROL COMPONENTS FOR EARTH ORBITAL SYSTEMS
H. E. Evans 301-982-5194

This task covers design, development and evaluation of prototype drive motors speed reducers, and ultra low friction systems for manned earth orbital systems support. Goals for this program are component and systems design that will be cost effective and meet 10 years operating life in the space environment. Initial efforts cover design, development and evaluation of components for CMG spin motor and gimbal torquers utilizing electronic commutation and unique speed reducing assemblies. Electronic circuitry required to provide control over the duty cycle range will also be designed and evaluated. Component studies will also include the integrated power and attitude control system elements such as ultra low friction rotor suspension and motor-generator design. Close coordination will be maintained with related efforts at LaRC, MSFC and JSC to insure program compatibility.

W75-70719 **909-04-04**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
ATTITUDE CONTROL PROPULSION
P. J. Meeks 213-354-2546
(506-21-21)

The objective of this plan is to design and test a flight weight ignition device based on the resonance tube concept for hydrogen/oxygen propellants at reduced temperatures. Empirical data gathered during the previous FY will be correlated analytically. Using this information a flight weight resonance ignition device will be designed and fabricated. The device will be made to fit into a hydrogen/oxygen engine. The final effort during this FY will be to experimentally optimize this unit with reduced temperature propellants and revise the analytical model if necessary.

W75-70720 **909-44-02**
Lyndon B. Johnson Space Center, Houston, Tex.
THERMAL CONTROL
W. E. Ellis 713-483-4941

The objective of the proposed effort is to (1) 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, (2) develop a modular, heat pipe radiator system which would replace conventional pumped-fluid radiators in order to improve performance capabilities, reduce system complexities, and possibly reduce weight, and (3) develop a radiator system that can operate as a condenser in a vapor compression cycle where it can reject heat at much higher temperatures and, thus, operate in very severe external environments with a minimum area. The approach in developing the inflatable, deployable radiator concept will include an analytical investigation and a feasibility test of candidate inflatable radiator concepts followed by the development of prototype hardware. A modular, wide heat load range capability heat pipe radiator system will be developed by extending an on-going Grumman effort initiated in FY-72 in order to develop a more flight representative panel design configuration leading to a three-panel modular heat pipe radiator system test in a thermal-vacuum environment.

W75-70721 **909-44-03**
Lyndon B. Johnson Space Center, Houston, Tex.
SPACE SYSTEMS PROPULSION
Charles W. Yadzis 713-483-4924

The objective of the first task is to generalize design criteria for acoustic resonator configurations and experimentally verify for the control or elimination of combustion instability without the aid of injector baffles. The end product is the design and test verification of acoustic cavities capable of simultaneously damping the basic and higher modes of combustion instability. The objective of the second task is to understand the mechanisms that cause reactive stream separation for hypergolic propellants. A basic understanding of the problems associated with unlike elements operating with hot fuel is necessary if advanced high performing engines are to be developed at a reasonable cost. The objective of the third task is to investigate new solutions to valving problems of propellant compatibility contamination, dynamic stability, and vibration sensitivity. The program will emphasize: (1) design approaches to minimize sliding friction (2) optimization of ceramic and elastomer materials; and (3) modeling techniques for sealing and dynamic valve performance. The objective of the fourth task is to develop technology for a nonintrusive flowmeter which can be used as a method of gauging cryogenic and earth storable propellants. The program will develop methods of measuring to 1% accuracy or less, the dynamic as well as steady state flow of liquid propellants in both one g and zero g. The objective of the fifth task is to investigate feed system/combustion chamber coupled instabilities. Passive devices for suppression of low frequency oscillations as well as the capability of operating with a low pressure drop injector will be designed and tested. The objective of the sixth task is to develop design criteria for a large continuous propellant acquisition system using earth storable propellants. Emphasis will be placed on successful operation under adverse g loading.

W75-70722 **909-44-05**
Lyndon B. Johnson Space Center, Houston, Tex.
SPACE SYSTEM ELECTRICAL POWER
David Bell, III 713-483-5361

Various in-house and contracted analytical and test programs will be performed to: provide advancements in solid polymer fuel cell technology to take advantage of associated inherent characteristics of long-life, invarient performance, low specific weight and low cost.

W75-70723 **909-44-07**
Lyndon B. Johnson Space Center, Houston, Tex.
COMMUNICATIONS
Jack G. Sheppard 713-483-6301

This RTOP will improve the productivity of communication and tracking systems to support Spacelab, payloads and

subsequent programs. Improvements will be achieved by taking advantage of advances in solid-state electronics, particularly in LSI (Large Scale Integration). Other gains will be achieved by transmission system improvements at new frequencies (high microwave and optical). Television will be important in future programs. It will gather experiment data, control payloads, assist docking operations, inspect damage and provide information to users on the ground. These diverse uses require a family of cameras, monitors, and controls. It is highly desirable that these components be solid-state. This RTOP continues the design of required systems and development of key components. RF spectrum crowding and data increases place a burden on communication signal processing. Careful selection and design can maximize through-put within system constraints (frequency, power, gain, and noise figure). LSI reduces size, component count, and interconnections by orders of magnitude, giving an attendant gain in reliability and reduction in program costs, making techniques previously ruled out by such factors practical. This RTOP continues the LSI implementation of key signal processing components. RF spectrum crowding and data rates are driving systems to higher frequencies--both microwave and optical. These new systems offer greater performance, but require careful implementation. In particular, the integration of electronics and antennas must be investigated to ensure that propogation losses do not negate the advantages of operation at high frequencies. Likewise, hardware demonstrations of optical (laser) systems are required to ensure that the projected unique capabilities of such systems are realizable.

W75-70724 **909-44-13**
Lyndon B. Johnson Space Center, Houston, Tex.
INSTRUMENTATION
Dave H. Owen, Jr. 713-483-4407

The Space Environment Simulation Laboratory at JSC represents the state of the art in advanced thermal-vacuum test (space simulation) facilities. Continuing efforts are being made to reduce required manpower and total operating costs, while, at the same time, maintaining the high standards of test posture and capability of the facilities. Research is required to understand and predict operational characteristics as they apply to actual thermal-vacuum chambers, payloads, and spacecraft. This is to include molecular migration and sticking coefficient, condensation, re-evaporation, corona phenomena, test articles geometric shapes and surfaces; and to develop methods and systems for identification, measurement, control and improvements. The following tasks are proposed: (1) Task 32 - corona detection system (continuing effort); (2) Task 33 - molecular flux math model development (continuing effort); and (3) Task 52 - development of low cost techniques for optics refurbishment and fabrication.

W75-70725 **909-44-21**
Lyndon B. Johnson Space Center, Houston, Tex.
MANUFACTURING AND INSPECTION
Evans C. 713-483-2941

The objective of this program is to further develop methods of electrical termination techniques. These electrical termination techniques are to be utilized on the proposed Advance Aircraft Avionics Systems, Earth Resources Program, Department of Defense applications, unmanned and manned space efforts, and deep-sea oceanographic studies. This will necessitate improved materials and hardware integrity due to their intended extended usage on these programs, as well as the planned numerous flights. This program will identify the techniques which have the potential for joining, reworking, and inspection of various electrical conductors (copper, nickel, Kovar) in such configurations as the following: Stranded copper with various platings to stranded, stranded to solid round with various platings, stranded to flat, flat to flat, flat to round, and round to round. The electrical conductors and terminations will be of various standard aerospace and commercial metals, platings, and dimensions. Under this program techniques will be developed which will expand existing techniques and give consideration to new methods in order to accomplish the above purposes. An additional task under this RTOP will be to complete a series of tests on hydraulic/pneumatic fittings. The fitting are separable, or permanent type of 11 different designs procured from aerospace suppliers. The sizes to be tested are 3/8',5/8' and 1' on titanium and stainless steel tubing.

W75-70726 **909-44-25**
Lyndon B. Johnson Space Center, Houston, Tex.
ADVANCED SCHEDULING
R. H. Brown 713-483-4346

This RTOP continues the language development initiated with RTOP 909-44-25-03. An extension of Phase I, the language definition phase, and Phase II, the prototype implementation phase, of the development are supported by this RTOP. The functional specification of the basic Plans language, the support and algorithm modules of the language library, and the data structure are the end products of Phase I. Phase II will implement these specifications on a specified computational system. The detailed design specification of the language, the formulation of the specific routines, the final coded deck, and associated documentation will be produced by Phase II.

W75-70727 **909-44-26**
Lyndon B. Johnson Space Center, Houston, Tex.
ALGORITHM DEVELOPMENT
E. Dupnick 713-483-4431

Task 41 - Resource Allocation Algorithm Study. This study will continue investigating the applicability of certain mathematical programming procedures to a special class of resource allocation problems. The basic problem to be solved is development of an algorithm for use in allocating limited resources to competing activities. Task 51 - Development of an Advanced Variable Metric Iterator. This study will develop an advanced variable metric iterator for trajectory shaping that combines the best features of several known techniques, achieving improvements in computational speed and cost. The resulting algorithm will be widely usable in various special purpose trajectory optimization programs and in general mission design and analysis programs. Task 52 - Explicit Guidance Algorithm Development for Third Stage Guidance. This study will develop the capability for explicit computation of guidance commands that will allow a space vehicle to achieve all required orbital transfers with minimum propellant expenditure. A specific required application of the algorithm is the unique situation of long powered maneuvers performed by a space vehicle having very low thrust-to-weight ratio propulsion capability.

W75-70728 **909-44-27**
Lyndon B. Johnson Space Center, Houston, Tex.
ADVANCED SOFTWARE DEVELOPMENT
Bond V. 713-483-4581

Task 32 - Development of Mission Design Tools Using Linear Transformation Orbit Theory. This study will produce new techniques for the calculation of precision trajectories based on a theory recently introduced by Drs. Kustaanheimo and Stiefel. This theory, named K-S theory, involves linear transformation of classical orbital elements. Recently the K-S theory has been extended from its numerical domain into generalized Delaunay elements. This study will continue that development so that it can be applied in low altitude earth orbit simulations. Task 51 - Development of an Interactive Computer Program to Provide Software Structure Analysis and Test Design Aid. This study will continue the development of an experimental technique to aid software verification. The basic concept is to design a computer program which can analyze the code of other programs and generate data useful in verifying these programs. It is proposed that this program be made interactive so that the software programmer may provide information about his software, and may receive information developed about the structure of that software, and thus be able to make that software more easily testable and more error-free.

W75-70729 **909-44-28**
Lyndon B. Johnson Space Center, Houston, Tex.
SOFTWARE PROCESSES (GENERALIZED DATA MANAGEMENT SYSTEM TOOLS)
L. R. Kirbie 713-483-3281

The objective of this RTOP is to perform research in data management system techniques leading to the development of

tools to aid JSC personnel in implementing new applications, selecting among data management system approaches and evaluating the performance of the applications on the host system. Research is also being performed on new data structuring techniques. One tool is a Math Model Simulator which will simulate various data base structures and access techniques for various host computers and background loads to provide data concerning resource utilization and response time for a particular application. The second tool is a piece of software called the Real Time Simulator which will interface actual Data Management Systems to permit creation of actual data bases on an actual host computer system to provide instrumentation data for use in calibrating and validating the Math Model Simulator and user requirements.

W75-70730 **909-44-29**
Lyndon B. Johnson Space Center, Houston, Tex.
COMMUNICATIONS/NAVIGATION/TRACKING
MENT OF ALL-DIGITAL TELEVISION PROCESSING (AND)
TRANSMISSION SYSTEM)
Dr. B. H. Batson 713-483-2981
(909-44-29)

This RTOP provides for development of prototype hardware for an all-digital television processing and transmission system. Much effort has been directed towards the study of TV digitization, compression, coding, and modulation techniques, but only recently (with the advent of large-scale integrated circuit technology) has an all-digital system appeared truly competitive with conventional analog techniques. It is now felt that an all-digital approach to picture transmission is not only feasible for the shuttle operational era, but that such an approach will have very significant advantages, such as low cost, high reliability, light weight, low power consumption, small volume, and high performance.

W75-70731 **909-44-31**
Lyndon B. Johnson Space Center, Houston, Tex.
SPACE OPERATIONS TECHNIQUES
Walter Scott 713-483-3458

Task 32 - Task 2 of the Consumables Management Requirements for Space Shuttle. For this study, a four part statement of work has been written; the first part (Task 1) has been completed. This, the second part (Task 2), will define the ground support system that complements the onboard consumables management baseline concept defined in the previous RTOP; will evaluate this ground system with respect to other candidate onboard consumables management concepts also defined in the previous RTOP; and define a system that performs the complete consumables management function. Task 41 - Development of Cryogenics PVT Algorithm for Space Applications. This study will resume and complete the study of the equations-of-state for hydrogen. It will provide in computerized form the thermodynamic properties of slush oxygen and hydrogen; will provide a computer program of a density explicit equation-of-state for hydrogen, oxygen, and nitrogen which will be 100 times faster and at least 1/3 smaller in core storage size than any presently existing; and will provide data on properties of ammonia at pressures less than one atmosphere.

W75-70732 **909-44-32**
Lyndon B. Johnson Space Center, Houston, Tex.
ADVANCED TECHNOLOGY/SUBSYSTEMS (DEVELOPMENT
SEMICONDUCTOR MEMORY TECHNOLOGY)
Saverio Gaudiano 713-483-4061

An activity will be undertaken to upgrade two technical areas critical to the performance of electronic memories used in earth resource programs, shuttle, and spacecraft avionics. This effort will consist of a program to develop a non-volatile (information is retained if power to the device is lost) semiconductor memory and a second program to evaluate a memory employing a peristaltic charge coupled device (CCD). (1) A study will be conducted to define the design requirements for a nonvolatile semiconductor memory with respect to performance, cost, reliability, and data storage requirements. The memory chip will be designed, fabricated, and tested to determine the feasibility of using non-volatile semiconductor memories in spacecraft systems. (2) A study will be conducted to determine the current status of peristaltic charge coupled devices to define the requirements for a fast general purpose CCD mass storage aerospace memory system. A CCD memory will be designed, fabricated, packaged, tested, and documented. This program will result in a further development of CCD memories and a careful evaluation of their potential application to aerospace hardware.

W75-70733 **909-44-35**
Lyndon B. Johnson Space Center, Houston, Tex.
SYSTEMS ENGINEERING APPLICATIONS (AVIONICS COST/SYNTHESIS MODEL)
Humboldt C. Mandell, Jr. 713-483-4551
(908-44-35)

The objective of this plan is to improve JSC and NASA capability to use costs and schedules as parameters in avionics system design and development. 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) to use the data base developed for each subsystem in determining relationships between cost, schedules, and readily-known parameters, such as desired technical performance characteristics; (3) to perform cost and schedule sensitivity analysis over state-of-the-art and advanced (expected) performance ranges for each subsystem; (4) to 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); and, (5) to determine the influence of cost related parameters on advanced avionics system designs. Special studies will be performed to investigate low cost approaches to avionics development. These will include investigations of the use of previously-developed subsystems, and the relaxation of NASA specifications to ARINC standards and the use of commercial fabrication and testing techniques. Investigations will include the study of least costly lot sizes for the purchase of NASA avionics equipment.

W75-70734 **909-44-36**
Lyndon B. Johnson Space Center, Houston, Tex.
MECHANICAL SYSTEMS
Richard F. Smith 713-483-3491

This RTOP will develop and fabricate seals for evaluation which will not adhere/cohere to mating seals under simulated docking conditions of future spacecraft missions. It will be the added objective that the techniques used to prevent seals adhering/cohering will in no way compromise scaling integrity or seal compression requirements. This RTOP will perform design, fabrication and verification testing of a sufficient number of windows to evaluate proposed methods of prestressing in terms of reliability and weight savings.

W75-70735 **909-44-37**
Lyndon B. Johnson Space Center, Houston, Tex.
SPACE SYSTEM CRYOGENICS
R. K. Allgeier 713-483-4771

The summary of this effort consists of two subprograms, one, an advanced insulation concept employing optically thin dielectric layers, the second, on testing evaluation of an 8' x 22' hydrogen thermal test article (HTTA). (1) The preceding contractual effort was partially successful in demonstrating feasibility. This effort will explore the feasibility of optically thin film stacks for cryogenic insulation when applied to a suitable substrate which theoretically will provide a substantial improvement in insulation performance. Prototype samples will be fabricated and tested with the early samples containing several layers and subsequent samples containing dozens of layers. A vessel with conventional insulation will be tested and then reinsulated with the dielectric insulation and retested. (2) FY-74 funds in the amount of $62K were allocated for testing evaluation of the HTTA. Due to leakage encountered in final checkout prior to test, an additional $45K is needed on this task. The test evaluation funds above would be utilized as intended following correction of the problem leakage. It is desirable to fund enough of the repair and corrective work to permit implementation of the funded test program.

W75-70736 **909-44-38**
Lyndon B. Johnson Space Center, Houston, Tex.
MATERIALS
F. S. Dawn 713-483-2059

This RTOP covers the development of improved nonmetallic materials for furbishing spacecraft interiors. The materials developed for previous programs (Apollo, Skylab) were optimized for maximum flame resistance in oxygen-rich environments at the expense of long term durability. Present aircraft interior materials either fail to meet NASA flammability requirements or produce copious quantities of vision-impairing and toxious smoke. The objective of this RTOP is the development of durable nonmetallic materials which are capable of meeting spacecraft habitability and engineering requirements while meeting NASA flammability requirements and generating little or no smoke, and to advance the state of the art in the development of durable, flame resistant fibrous materials to satisfy long duration and reusability requirements. The significant pace of advancement made in fibrous materials from Mercury through Skylab programs must be continued in to the future mission configurations.

W75-70737 **909-44-39**
Lyndon B. Johnson Space Center, Houston, Tex.
(ENGINEERING DESIGN INTEGRATION (EDIN) COMPUTER PROGRAM DEVELOPMENT)
Robert W. Abel 713-483-3851

The objective of the EDIN development is to develop a computer aided design capability in which the bulk of the design analysis, technology intracommunication and data storage are managed directly on the computer. In addition, it will be an objective to automate, as much as possible, the menial tasks of design so that the engineer is more free to address the design rather than mechanisms of the design. The approach to the objectives will be to: (1) develop the required data base and data management capabilities, (2) develop the required software to support interactive graphical design and design analysis, (3) develop additional technology modules to help span completely the discipline of design, and (4) develop a host of utility software to support general management functions of design.

W75-70738 **909-44-42**
Lyndon B. Johnson Space Center, Houston, Tex.
SIMULATION
Donald W. Lewis 713-483-3048

Purpose of this study is to develop/modify a real time digital computer program that resides in the CDC 6400 computer and is run in conjunction with the spacecraft procedures man-in-the-loop simulator. The digital computer program developed during this study will be used for the definition, verification and modification of spacecraft flight techniques and procedures in an efficient manner. The procedures development program will be used to produce step-by step detailed crew procedures from simulation runs, compare developed procedures with reference runs stored in mass memory, evaluate crew and system performance and produce spacecraft flight checklist.

W75-70739 **909-54-02**
Marshall Space Flight Center, Huntsville, Ala.
THERMAL CONTROL
J. L. Vaniman 205-453-3821

This RTOP contains 4 tasks. The first two will investigate feasibility of standardizing thermal control techniques to meet thermal requirements that are common to many of the potential future payloads. Objective is to reduce repetitious development costs by providing a technology that can be used by all payloads having similar thermal requirement. These technologies include: (1) liquid helium temperature (3 K) and very low temperature (80 K-210 K) thermal control for specific low heat dissipation instruments, such as IR detectors, UV sensors, etc., and (2) thermal standardization of payload equipment modules. The third task will streamline analytical modeling techniques used to design phase change heat exchangers in fluid loop thermal control systems. Objective is to reduce computer time without loss of design accuracy. The fourth task will develop a fluid mixing device utilizing fluidic and viscosity change principles. The device will be used on shuttle payload fluid loop thermal control systems. Objective is to provide improved, more reliable performance at lower system costs.

W75-70740 **909-54-05**
Marshall Space Flight Center, Huntsville, Ala.
ELECTRICAL POWER
R. M. Aden 205-453-4950

The effort described in this RTOP is in support of Space Systems in the electrical power area and is divided into two tasks; switch gear and circuit protection, and power conditioning. In the area of switch gear and circuit protection FY-75 efforts will continue to perform the necessary research and discrete part evaluation to fabricate breadboard power controllers to switch 5 and 10 amperes. Power conditioning and analysis will continue in circuit development in which built-in test and advanced concepts will be investigated. Prototype standardized modular power supplies will also be designed, built and tested.

W75-70741 **909-54-07**
Marshall Space Flight Center, Huntsville, Ala.
COMMUNICATIONS
D. O. Lowrey 205-453-1578

The objective of this effort is to develop active electronically steerable microwave phased array systems operating in the S-band and Ku-band frequency regions for space communications and tracking purposes. These systems will provide high data rate, telecommunications capability with simultaneous or separate transmit, receive and tracking functions. Considerable system advancement and performance with decreased size and weight will be realized over conventional systems using separate transmitters, receivers, antenna, transmission lines, control and driving motors, and associated supporting structures. This is a continuing effort that will produce active electronically steered phased arrays that are light weight, highly redundant, have low dc power drain, uses 100 percent microwave integrated circuitry and utilizes a modular building block construction concept with standardized modules for maximum design versatility and minimum cost. The study of application of active electronic modular techniques to the Ku-band electronically steered phased array will be continued.

W75-70742 **909-54-21**
Marshall Space Flight Center, Huntsville, Ala.
MANUFACTURING AND INSPECTION (NDT)
R. M. Henritze 205-453-1426

The objectives of this effort are to develop and demonstrate the capability of a system using TV and fiber optics to permit visual inspection of space hardware in areas usually inaccessible to such inspection techniques and to extend and demonstrate the applicability of holography to nondestructive testing. A low light level color TV camera will be equipped with coherent fiber optics and appropriate light sources and filters will be provided to permit illumination and viewing of generally inaccessible areas of space hardware. This system will be modeled after, and extend the capability of an existing black and white system. Holographic techniques and systems previously developed to permit nondestructive testing of specific items of space hardware in response to testing problems encountered in specific development programs will be further developed and configured to provide a more broadly applicable testing capability. An integrated program consisting of contracted and in-house tasks will be pursued.

W75-70743 **909-54-33**
Marshall Space Flight Center, Huntsville, Ala.
INFORMATION MANAGEMENT SYSTEMS (SUMC AND TUG)
H. Garrett 205-453-4070

The objective of this SUMC effort is to develop advanced space computer hardware, software, and peripheral devices. Also the development of computer/scientist languages and interactions will be performed. This effort will lead to the development of advanced space computers, multiprocessors, and multicomputer systems, and the associated software; development of advanced computer peripheral devices such as displays, history plotters keyboards, hardcopy devices, and mass storage units; and development of high level computer/scientist languages to

facilitate man-machine interaction. The objective of this tug effort is to define, develop and space qualify an onboard information management system which can best accomplish the requirements of the space tug missions. Areas in which analyses and technology developments are required will be identified. The requirements for memory will be determined and an effort initiated to provide a reliable mass storage capability for the space tug with emphasis upon reliability within reasonable cost. A computer will be supplied for use in the design and development of a redundant intertial measuring unit.

W75-70744 **909-74-35**
Langley Research Center, Langley Station, Va.
INTEGRATED POWER/ATTITUDE CONTROL SYSTEM FOR SPACE VEHICLE APPLICATIONS
E. S. Love 804-827-2893
(506-19-13)

This work will establish the required technology for an integrated power/attitude control system (IPACS) capable of performing the dual function of power generation and attitude control for a large variety of spacecraft and missions. Results from in-house and contractual efforts are being used to investigate power generation and control capability of IPACS; to generate requirements for critical hardware components; to develop IPACS configurations and control laws; and to define multimission applicability of IPACS to provide low cost modularized vehicle subsystems. Viability of the IPACS concept will be verified through integration of critical hardware components into a laboratory IPACS and through thorough evaluation of this unit in a realistic mission and dynamic environment using LRC static and dynamic test facilities. Associated development programs will be directly coordinated with LeRC, GSFS, JSC, and MSFC. Preliminary problem areas include the impact of reliability, maintainability, failure modes, and system integration on IPACS performance and multimission usage capability; performance limits of composite materials under cyclic stresses and extended-duration vacuum; development of bearings, seals, and lubrication systems capable of long-life at high speeds and under large cyclic loads; development of high power, high-efficiency motor generators units for operation at high speeds; development of high-power, long-life, low friction slipring assemblies for operation in a vacuum. Solutions to these problems will be verified through hardware tests and simulations, which will determine power generation capability, control effectiveness, and spinup, spindown cycling effects on system performance. Successful and timely completion of this program could result in significant cost savings resulting from large weight and volume savings and multimission usage of an IPACS module.

W75-70745 **909-55-02**
Lyndon B. Johnson Space Center, Houston, Tex.
THERMAL CONTROL (TUG)
J. L. Vaniman 205-453-3821

Thermal control of the tug is the maintenance of thermally sensitive tug equipment and structures within specified critical temperature limits through the control of heat flow to and from such equipment. Equipment includes such items as electronics components, fuel cells, batteries, APS systems, and hydraulic systems. It excludes thermal isolation and conditioning of main propellant tanks which is covered under a separate RTOP. Current studies have analyzed thermal control concepts for the worst case tug orbital environments. These studies show that sophisticated semi-passive thermal control methods are required to maintain satisfactory thermal conditions under the environmental extremes encountered by the tug. The objective of continuing effort is to design the necessary thermal control hardware and to demonstrate its application and feasibility through breadboard development and testing. This demonstrated technology, optimized for weight and power - critical to the tug, is to then be used for design of the NASA tug.

W75-70746 **909-55-03**
Marshall Space Flight Center, Huntsville, Ala.
PROPULSION
A. L. Worlund 205-453-3853

The objective of this effort is to develop an RL-10 O2 heat exchanger that will provide mixture ratio control during tank head idle mode operation, and GO2 for the tug vehicle tank pressurization.

W75-70747 **909-55-10**
Marshall Space Flight Center, Huntsville, Ala.
GUIDANCE AND NAVIGATION
D. O. Lowrey 205-453-1578
(502-23-42; 909-51-33)

This RTOP describes the program of research and technology development planned in the guidance and navigation area to establish an adequate technology base for the design and development of the space tug. The objective of this effort is to provide advances in the state-of-the-art in the inertial measurement unit and the scanning laser radar sufficient to support the design and development of the space tug mission requirements. The approach is the inhouse performance of specific improvements in operational characteristics, weight, cost and reliability of the guidance and navigation systems and components. This program takes advantage of other ongoing development programs at MSFC, such as the SUMC computer funded by OMSF and the laser gyro funded by OAST.

W75-70748 **909-55-37**
Marshall Space Flight Center, Huntsville, Ala.
CRYOGENICS
A. L. Worlund 205-453-3853
(909-55-03)

The basic program objective is to provide an integrated technology base to enable realistic trade studies involving cryogen propellant management subsystem options for the full capability tug. Analytical studies, environmental parameters and component development will be combined to establish design data on performance and reusability. Operational constraints and interface design criteria will be a principal output of the subsystem and system testing. Subsystem concepts will be integrated and tested to identify system interface problem areas and the maintenance/cost relationship. Advanced concepts developed under prior technology programs which have not been applied to flight vehicles but already have a hardware development history will be utilized.

W75-70749 **909-55-38**
Lyndon B. Johnson Space Center, Houston, Tex.
MATERIALS (TUG)
W. R. Morgan 205-453-5313

Thin gauge Al 2219-T87 is proposed for propellant tanks in the tug to minimize weight. Although much data exists on fracture properties of this alloy, it is on thicker sections. Thin gauge Al 2024-T6 is well characterized in thin sheets with stringer support for aircraft fatigue. Thin gauge Al 2219-T87 fatigue and fracture data are required. This program will provide design data not currently available. Fatigue crack propagation and toughness at cryogenic temperatures of thin parent metal and welded sheets unsupported by stringers will be determined.

W75-70750 **909-75-03**
Lewis Research Center, Cleveland, Ohio.
ADVANCED H2-O2 ENGINE COMPONENT TECHNOLOGY
J. W. Gregory 216-433-6849

The objective is to provide improvements in component technology applicable to advanced, high performance reusable hydrogen-oxygen rocket engines. Such engines must operate reliably in space for long periods of time and provide many restarts during a minimum of 20 missions. Included in this program are efforts on components such as: bearing and seals for turbopumps, complete turbopump assemblies, and thrust chambers. Technology will be developed for long life, small, high speed bearings for liquid hydrogen turbopumps. Both rolling element and hybrid (fluid film) bearings of 20mm size (shaft diameter) will be evaluated. Bearing design and fabrication will be provided under contract, and bearing testing will be performed in-house at LeRC. Effort will also be applied to the design, fabrication, and testing of controlled fluid film seals for small, high speed liquid oxygen turbopumps. This effort will evaluate seals of 30mm diameter capable of 10 hours operational life and 300 start/stop cycles at shaft speeds up to 90,000 rpm.

Work was initiated in FY-74 on the design, fabrication, and acceptance test of a high pressure (up to 4400 psia) liquid oxygen turbopump. Complete performance testing of the pump will be done in FY-75.

Space Life Sciences

W75-70751 **970-21-11**
Ames Research Center, Moffett Field, Calif.
NEUROPHYSIOLOGY
H. P. Klein 415-965-5094

The objective is to determine the effects on the nervous system of the unusual environmental factors encountered in space. This information will be applied in the evaluation, prediction and control of adverse effects resulting from exposure, for example, to high and low g forces and unusual linear and angular forces. Particular attention will be paid to (1) vestibular, visual and proprioceptive systems, (2) their anatomical substrates, (3) their interactions, (4) their roles in motion sickness, and (5) their relationships with the arousal mechanisms underlying sleep and wakefulness. Descriptive studies will define the influences of altered gravity on neurophysiological functions, orientation, sensorimotor coordination, postural control and locomotion. Analytical studies will be devoted to the understanding of the neural processes involved in the reception of gravitational stimuli, thresholds for detecting changes in acceleration and rotation, and the rate and level of adaptation to chronic exposure to altered gravity. In addition, studies will address the mechanisms which underlie changing levels of sleep and arousal, attention, alertness, and motivation in the presence of the gravitational and accelerative forces encountered in space flight. 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.

W75-70752 **970-21-12**
Ames Research Center, Moffett Field, Calif.
CARDIOVASCULAR PHYSIOLOGY
H. P. Klein 415-965-5094

The objectives are to describe and understand the mechanisms underlying the cardiovascular changes observed with space flight and the course of adaptation with readjustment upon reentry to normal earth environment. Studies will be directed towards an understanding of the cardiovascular changes associated with bedrest deconditioning and correlation with Skylab measurements. Ground-based studies utilizing humans and appropriately instrumented animals will be utilized to determine the extent and time course for observed changes and their implications in development of selection criteria for future passengers aboard space flight missions. Cardiovascular responses to gravitational stresses (LBNP, tilt, and centrifugation) will be determined before and after varying durations of bedrest simulation of weightlessness. Human studies will be accomplished using primarily non-invasive, non-destructive testing methods. Animal studies will involve the use of chronically instrumented preparations and will be tested for use in future biomedical spaceflight payload definition studies.

W75-70753 **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 in health and disease will be examined on subjects and patients to obtain baseline data and improve the prediction 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 CO_2 tensions, pulmonary blood volume and cardiac output. The effort includes: (1) investigations to determine the effects of gravity on normal human lungs with particular reference to mechanical deformation and its effects on pulmonary function; (2) continued work on baseline data on patients with early pulmonary disease; (3) feasibility domonstrations for hardware systems for testing pulmonary function.

W75-70754 **970-21-14**
Ames Research Center, Moffett Field, Calif.
METABOLISM AND NUTRITION
H. P. Klein 415-965-5094

Metabolism and nutrition studies conducted during, and subsequent to, space flight have shown transitory changes in several body functions. The objective of this RTOP is directed towards obtaining a greater understanding of the regulatory mechanisms associated with physiologic adaptations and readjustments to altered gravity levels. Work is to be performed using both experimental animals and human test subjects. Approaches are oriented towards a determination of gravity influenced subsystems and their mechanisms of response with a view to contributing towards future space flight science experiments definition. Animal studies are being conducted to develop a maintenance system for long term studies on unattended instrumented monkeys; to determine the biochemistry and physiology of muscle, bone and red blood cell mass changes during simulations of hypodynamic environments; and to evaluate general metabolism during long term exposure to elevated gravitational accelerations and upon return to normal environments. During human bed rest studies, newer methods are being applied to evaluate variations in lean body mass and fluid compartments, as well as renal mechanisms pertinent to the regulation of plasma electrolytes, volume, and blood pressure. Carbohydrate metabolism is being studied with emphasis on glucose regulatory mechanisms, and urinary hormone excretion is determined. Basic studies are being conducted to develop non-invasive measures of liver function and factors regulating body fat repletion/mobilization.

W75-70755 **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.

W75-70756 **970-21-17**
Ames Research Center, Moffett Field, Calif.
COUNTERMEASURES
H. P. Klein 415-965-5094

The objectives are to develop effective countermeasures to the altered physiologic responses demonstrated to accompany

manned space flight or bed rest simulations of weightlessness. Such countermeasures are to include physical, chemical or physiologic agents and/or techniques. Research will be conducted to determine the effectiveness of skeletal compression to avert bone calcium loss and intermittent body accelerations to alter orthostatic hypotension. The results of these measures will be assessed by sumulating the weightless state in experimental animals by immobilization.

W75-70757 **970-21-25**
Ames Research Center, Moffett Field, Calif.
CHEMISTRY AND MICROBIOLOGY
H. P. Klein 415-965-5094

The objective is to describe and study the potential microbiological immunological and biochemical problems of manned spaceflight and to describe the cellular and tissue response of the human body to prolonged expossure to the space flight environment. Studies will include the early (preclinical) detection of disease, microbial shock immunity to invection, measures to prevent or limit infectious disease, induction of latent viruses and the infectivity of large particle viruses. Tissue studies will investigate the effects of space flight factors on vascular permeability. Emphasis will be placed on the determination of the basic mechanisms involved at the cellular and tissue levels in the production of undesirable or harmful effects during prolonged space flight. This effort will be carried on by an integrated program of university grants and in-house research.

W75-70758 **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 in relation to human performance and health in spaceflight. Cellular consequences as well as physiological effects will be studied. Design limitations predicate that crew and passengers on space vehicles will be subjected to weightlessness for considerable periods of time during spaceflights. 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 variety of subjects as may be candidates for passengers in the shuttle. Correlations are also being made between morphological alterations and physiological changes caused by altered environmental factors such as altered G levels. Extent of damage and extent of reversibility are being ascertained using ultrastructural morphology as an endpoint.

W75-70759 **970-21-45**
Ames Research Center, Moffett Field, Calif.
MEDICAL SUPPORT
H. P. Klein 415-965-5094

The objectives are to assess the interference of prescribed drugs with routine physiological and biochemical measurements used for biomedical assessment of man in space, to study environmental influences on the efficacy of specific drugs likely to be used during manned space flight, and to develop selection criteria for candidate passengers aboard shuttle using standard and advanced physiological monitoring techniques and provocative tests. Selected drugs from those available to the crewmen during Skylab and those planned for shuttle missions will be studied for their interference with routine biomedical determinations. Three basic approaches will be used: (1) the evaluation of interference of the drug or its metabolites with the analytical procedures used; (2) the interference of the drug with physiological and biochemical responses used for the biomedical assessment of health status; and (3) the interference of the altered biomedical status on the effectiveness of the drugs used. Initially, work will involve the antimotion sickness drug combinations used, decongestants, analgesics and antibiotics. Work will be done primarily on man but animals will be used wherever necessary. Work on the aspirin/CO2 interaction will be completed this year. In order to develop a checklist on which the selection of candidate shuttle passengers can be based, work will continue to establish distribution of physical and emotional fitness for shuttle flights for categories of individuals of different age, race and sex. A package of biomedical tests derived from various ground-gased research efforts will be evaluated for predictive value of physiological and psychological tolerance to human shuttle re-entry acceleration profiles after Og exposures of short periods of time.

W75-70760 **970-21-51**
Ames Research Center, Moffett Field, Calif.
HUMAN BEHAVIOR AND PERFORMANCE
H. P. Klein 415-965-5094
(970-21-52)

The objective is to improve the effectiveness of future scientifically oriented space missions through research on selection methods and criteria, training techniques, performance evaluation techniques, and corrective procedures for individual performance of mission tasks and group cooperative and harmonious behavior. A research program for developing and integrating selection, training, evaluation procedures and countermeasures for individual and group functioning in the space environment will be conducted. The research will include short-duration laboratory experiments for evaluating selection and performance assessment techniques and longer duration confinement studies which also involve prevention (training) procedures and countermeasures. As the theoretical and operational integration of these procedures becomes better understood, the simulation fidelity of the expected space work environment will be increased in the longer duration confinement experiments. It is expected that such simulations will serve both for advanced research and as an integral part of selection and training for actual missions.

W75-70761 **970-21-52**
Ames Research Center, Moffett Field, Calif.
BEHAVIORAL PHYSIOLOGY
H. P. Klein 415-965-5094

The objectives are to establish in animals the brain mechanisms that regulate biologic rhythm synchrony and behavior and to apply this information via experiments in man to solving specific spaceflight related problems of behavior, performance and group interaction in confined environments. Experiments using instrumented unrestrained primates or rodents will investigate the central nervous system mechanisms controlling behavior and will assess the value of techniques such as self-determination of the photoperiod, or alteration of the dietary composition, in counteracting or preventing internal desynchronization. Studies in man will include studies of sleep-wake cycles and sleep deprivation in time free environments; correlating consumption of specific foods with serum amino acid rhythms and serotonin and catecholamine synthesis, sleep, alertness and thermoregulation; assessing the effects of short-term confinement of individuals in small groups on their internal synchrony, skill maintenance and response to LBNP or other provocative stresses; and determining the combined effects of 7 days bedrest and constant low light intensity on performance and the response to provocative tests.

W75-70762 **970-21-61**
Ames Research Center, Moffett Field, Calif.
REGULATORY BIOLOGY
H. P. Klein 415-965-5094

The objective is to identify and assess the biologic mechanisms by which living systems respond and adapt to space flight environmental parameters, particularly altered gravity and to determine functional variations and their regulating mechanisms at all levels of biologic organization in plant and animal systems. In the main, the studies will be directed toward the establishment of flight experiment concepts or definition. Biochemical, physiologic and anatomic changes in organisms exposed to altered gravity will be delineated and quantified. Altered gravity states will be introduced by means of acceleration (centrifuge) and gravity compensation (clinostat). Morphologic changes, modified biochemical pathways and changes in specific physiologic functions will be assessed in terms of exposure intensity and duration. A significant part of this effort will elaborate on the regulatory factors in homeostatic adaptation to and deconditioning from the metabolic stresses associated with a change in the gravity field. The principle of transient metabolic states (excitatory

and depressed) will be explored as a potential simulator of weightlessness.

W75-70763 **970-21-62**
Ames Research Center, Moffett Field, Calif.
DEVELOPMENTAL AND GENETIC BIOLOGY
H. P. Klein 415-965-5094

The objective is to determine the effects of spaceflight 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, cellular spatial relationships and in biochemical and biophysical reactions that control differentiation, growth, development and maturation of embryonic systems (plant and animal). Of general importance is the determination of any subtle or gross effects 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. 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 will be used to measure specific endpoints such as the use of electron microscopy in analyzing spindle malfunctions in plants. Radiation sources will be developed for inflight use to detect synergism of radiation and weightlessness in producing genetic damage. The effect of high Z cosmic ray particles will be determined.

W75-70764 **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 spaceflight factors. Both ground-based and spaceflight studies will be accomplished. The program plans are: (1) conduct intensive ground-based work utilizing a variety of biological materials and end-points and existing or modified particle accelerators for irradiation to establish and understand the mode of action and the biologic effectiveness of energetic, heavy ions (HZE) at the molecular, cellular, and organism levels; (2) assess the acute and chronic biologic effects of radiation, vibration, and compensated gravity; and (3) establish the rate of production and energy spectra of high-LET recoil particles in tissue equivalent nuclear track detectors and develop capability to identify track, energy and charge of particle impacting biologic targets.

W75-70765 **970-22-21**
Ames Research Center, Moffett Field, Calif.
AIR REVITALIZATION
H. P. Klein 415-965-5094
(970-22-30)

Ames Research Center will conduct a program to perform research and advanced technology development in air revitalization. The areas to be investigated are: (1) advanced academic life support research, (2) static-feed water electrolysis, (3) nitrogen generator development, (4) electrochemical oxygen concentration, (5) electrochemical CO2 concentration, (6) trace contaminant control, and (7) solid electrolyte oxygen regeneration system development.

W75-70766 **970-22-23**
Ames Research Center, Moffett Field, Calif.
WATER AND WASTE MANAGEMENT
H. P. Klein 415-965-5094

Ames Research Center will conduct a program to perform research and development in water and waste management. The areas to be investigated are: (1) reverse osmosis-membrane development; (2) urine pretreatment - chemical, enzymatic, electrochemical; (3) vapor diffusion water (VDR)-membrane development; and (4) an analytical assessment of reverse osmosis membrane and module technology.

W75-70767 **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 development in crew equipment systems. The areas to be investigated are: advanced space suit and glove development, advanced liquid-cooled garment (and LCG thermal control), regenerable portable life support system (RPLSS) CO2 control, and RPLSS-thermal control.

W75-70768 **970-23-20**
Ames Research Center, Moffett Field, Calif.
TELEOPERATOR MANIPULATOR AND END EFFECTOR TECHNOLOGY
H. P. Klein 415-965-5094

Ames Research Center will conduct a program to perform research and advanced technology development in remote manipulator systems for space exploration. The teleoperator manipulator and end-effector work will include: (1) improved manipulator arms and dexterous end effectors; (2) advanced visual sensing and display systems to provide 3-D view of the remote scene to a human operator; (3) predictor displays based on bybrid computer mapping, storing, and manipulating stereo pair information obtained from the stereo camera system; (4) study of man-machine integration problems associated with various levels of manual and automatic control; and (5) development and evaluation of advanced sensory aids and associated displays to provide relevant information of the remote scene to the human operator.

W75-70769 **970-23-30**
Ames Research Center, Moffett Field, Calif.
ADVANCED BIOINSTRUMENTATION
H. P. Klein 415-965-5094

The objective is development of bioinstrumentation techniques to enable the measurement of biological, physiological and psychological responses of man and/or selected animal species to actual or simulated space flight conditions. Non-invasive, non-destructive testing procedures will be utilized for obtaining data wherever possible and feasible. Approaches will be directed towards development of instrumentation associated with measurement of central and peripheral cardiovascular function, bone mineral content, deep body physiological and physical functions, new and unique biochemical measurement techniques and methods of sample preservation. Techniques involved in cardiovascular function testing will lead to development of implantable telemetry systems. Miniaturized multi-channel discrete part units will be developed techniques will be investigated utilizing ultrasound and microwave transducers as means for obtaining information from the body surface. Bone mineral content will be obtained from a dual beam radioisotope scanning approach. Advanced biochemical measurement techniques will be developed utilizing ion-specific electrodes and new miniaturized gas chromatographs.

W75-70770 **970-23-40**
Ames Research Center, Moffett Field, Calif.
INTEGRATED BIOINSTRUMENTATION SYSTEMS
H. P. Klein 415-965-5094

The objectives are to integrate presently available NASA cardiovascular bioinstrumentation measurement systems, and identify those methods presently under ground-based investigation which have potential applications for determining cardiovascular adaptative mechanisms during space flight. Those methods which need further research and development are also identified. Various methods for measuring cardiovascular function will be documented and assessed against methods being used for similar purposes at the bedside or during cardiac catheterization. Noninvasive,

nondestructive methods will be emphasized. Accuracy will be assessed against clinical standards. Efforts will be coordinated with JSC.

W75-70771 **970-43-10**
Flight Research Center, Edwards, Calif.
SHUTTLE PILOT REQUIREMENTS
L. R. Carpenter 805-258-3311
(970-23-10; 970-53-10)

This RTOP will establish requirements for a cost effective and reliable man/machine system for aircraft type landing of aerospace vehicle using indirect viewing. Outside visibility requirements for landings have been established by previous work accomplished under this RTOP, and it has been learned that limited visibility will cause the pilot's workload to increase significantly. Helicopter work at Langley has indicated that television does not provide the pilot with good altitude knowledge for landings. Therefore, the approach to this study shall be conducted in two parts. The first phase will include flight experiments in a PA-30. These flights shall establish base line data and explore the feasibility of using external altitude cues painted on the runway. For example, a series of diamonds may be painted on the center line of the runway to help facilitate altitude knowledge to the pilot when approaching and landing---

W75-70772 **970-51-11**
Lyndon B. Johnson Space Center, Houston, Tex.
NEUROPHYSIOLOGY
J. L. Homick 713-483-4731

The overall objective is to investigate and evaluate the effects of space light on the central nervous system of man. In view of past experiences and their implications for future manned flights, primary attention will be given to the study of those neuro-sensory and related physiological mechanisms responsible for the space flight 'motion sickness' syndrome. In this regard a broad-based program of studies will be undertaken which has as its goal the elucidation of mechanisms underlying this syndrome in O-g, the development of techniques for reliably predicting on an individual basis who is prone to this problem in O-g and, finally, the development of effective countermeasures. Additionally, research will be continued to determine overall central nervous system function as it influences man's performance during space flight. Particular emphasis will be given to understanding neurophysiological correlates of behavior and critical visual and auditory processes. With regard to underlying mechanisms appropriate studies will be performed to investigate semicircular cana and otolith organ interactions, fluid shift/vestibular response interrelationships, biochemical alterations, visual influences, and the role of idiosyncratic psychophysiological or behavioral responses to 0-g. The development of predictive techniques will be difficult; however, planned approaches include the investigation of motion sickness susceptibility as a function of g-load in the hope that extrapolation to sub-gravity states would have validity and ground-based correlational studies with non-astronauts as well as astronauts who have flown space flight missions---

W75-70773 **970-51-12**
Lyndon B. Johnson Space Center, Houston, Tex.
CARDIOVASCULAR PHYSIOLOGY
G. W. Hoffler 713-483-5554

The objectives are: (1) to design, implement, and conduct experimental programs and studies which will determine the nature of cardiovascular system responses and/or adaptations to the various environmental factors associated with manned space flight; (2) to provide from the foregoing such data necessary to formulate integrative concepts for understanding man's total physiological adjustments to space flight, and such inputs to vehicle and habitat design as may be required for preventative/therapeutic measures; and (3) to support ground-based operations attendant flight crew selection, training, and readiness preparations from a clinical cardiological perspective. Particular attention will be given to the physiological responses to weightlessness and mission-like workloads. Emphasis will be palaced on investigations pertaining to those factors which affect, and the mechanisms which control, the orthostatic responses to gravitational fields following exposure to long-duration weightlessness. Ancillary effort will be directed towards other factors and physiologica systems affecting cardiovascular function such as heat and metabolic loads, water and electrolyte balance, renal and endocrine control. Ground-based programs will include use of hypodynamic states (especially head-down tilt), study of regulatory mechanisms and related physiologic systems and responses, development of measurement techniques, hardware, and data management and analysis capabilities, conduct of pre- and postflight evaluations of space crews; data from inflight medical experiments---

W75-70774 **970-51-14**
Lyndon B. Johnson Space Center, Houston, Tex.
METABOLISM AND NUTRITION
J. A. Rummel, Ph. D. 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, into three overlaping area: (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 of 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---

W75-70775 **970-51-15**
Lyndon B. Johnson Space Center, Houston, Tex.
HEMATOLOGY
S. L. Kimzey 713-483-4086
(970-51-16; 970-51-25; 970-21-25)

Data collected in support of manned space flight missions indicate significant alterations of selected hematologic and immunologic functions as a consequence exposure to the space flight environment. A primary objective of this program is to provide information to elucidate the etiology and mechanisms of the observed changes in hematologic processes, and to establish the significance of these changes in limiting man's participation in space flights. The overall objective 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 (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 inflight and postflight physiochemical analysis.

W75-70776 **970-51-16**
Lyndon B. Johnson Space Center, Houston, Tex.
ENDOCRINOLOGY
C. S. Leach 713-438-5458

The overall program 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 effects within the total system, as pertains principally to the regulation of fluid and electrolyte balance, acid-base equilibrium cardiovascular atterations, protein and carbohydrate metabolism, and musculoskeletal changes. Additional studies will utilize ground based weightlessness simulation techniques to correlate Skylab urine and plasma endocrine data with fluid, electrolyte, circulatory and other observed changes. Improvement and validation of endocrine measurement techniques used on Skylab will also be addressed. Additional endocrine studies, such as thyroid function, may be included to further clarify the total endocrine response. The endocrine control of 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 change.

W75-70777 **970-51-17**
Lyndon B. Johnson Space Center, Houston, Tex.
COUNTERMEASURES
Malcolm C. Smith, Jr. D.V.M. 713-483-5056

The objectives of investigations undertaken within the countermeasures 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 (1-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 deminieralization, 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-g flights, and other less elaborate verification techniques. Particular emphasis will be placed on maintaining the integrity of the cardiovascular and musculoskeletal systems, as well as the general physical fitness of representative candidate crew and passenger populations. Bed rest will be the weightless 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.

W75-70778 **970-51-35**
Lyndon B. Johnson Space Center, Houston, Tex.
ENVIRONMENTAL FACTORS EFFECTS
D. J. Horrigan 713-483-5156
(970-51-14)

This effort is concentrated on both inhouse and contractor work in the acts of conditions in the environment on human performance. It includes spacecraft atmosphere and decompression evaluation, studies of inert gas and 100% oxygen effects, thermal physiology, and life support system evaluation. The approach is to seek out experts within universities, industry, and government to carry on required work in these areas; and to continue an in-house capability in the area of thermal physiology and life support system evaluation.

W75-70779 **970-51-45**
Lyndon B. Johnson Space Center, Houston, Tex.
MEDICAL SUPPORT
P. Buchanan 713-483-4021

The objective is to formulate programs, protocols and specifications for medical support of long duration space flight; to develop a data bank of space medical, physiological, and aphropomorphic data in a readily usable and easily updatable handbook format; to review Skylab health monitoring techniques and tose factors of spacecraft habitability which affected crew health and performance and formulate responsible recommendations for future techniques and designs. Continuing effort will be focused on the identification of parameters and other determinants for incorporation into a total history, psychological and physical examination protocol to be used for shuttle crew and passenger selection and other space flight requirements. Computer assisted health maintenance programs and required man/machine interface is the essence of the continuing search for better methods of medical support of aerospace personnel: The accumulation of available aerospace biomedical data into a readily usable human standards data book format will be of immeasurable assistance in future planning toward attaining the above goals. An expansion of current MEDICS/MEDATA capability into a flight hardware configuration for eventual inflight use by a crew physician and a computer-assisted diagnostic program for use where real-time consultation is not available, will be a part of this effort. This problem is primarily aimed at utilization in long duration space flights, but its terrestrial spinoff value will not be ignored.

W75-70780 **970-51-62**
Lyndon B. Johnson Space Center, Houston, Tex.
DEVELOPMENT AND GENETIC BIOLOGY
J. A. Mason 713-483-3169

The developmental biology program utilizes selected plant and animal systems to explore the problems and possibilities inherent in the space environment. Primary objectives are to evaluate dependency of plant growth upon specific (space related) environmental factors, to assess and to understand the mechanisms involved in the effects of reduced gravitational and geomagnetic forces on growth and development of plants and animals and to evolve concepts for use of biological systems in space for fundamental research or support of spaceflight capabilities. The general approach employed to accomplish these objectives is to cooperate closely with academic researchers using the unique resources of the JSC as a funnel for directing university research into the specific needs of the space program, concentrating the JSC efforts upon space-specific aspects of the problem. Approaches to the study of space environments involve the use of biological systems in which response to alteration of gravity, geomagnetism, or other space related factors is reflected in obvious modification in function or form. Several systems currently considered worthy of investigation are in various stages of experimental development. These include aromatic amino acid metabolism, responses in plants, including sleep (biorhythms) and rapid movements and teh bioelectrical activity associated with these various responses. One animal system Fundulus heteroclitus is being used as a model for studies of embryogenesis and the adaptation of sensory behavior in null gravity. Intimately associated with ongoing basic studies are efforts to evaluate and develop practical uses for plant systems in space and to develop the laboratory facilities necessary for support of future inflight experimentation.

W75-70781 **970-51-63**
Lyndon B. Johnson Space Center, Houston, Tex.
RADIATION BIOLOGY
R. A. Hoffman 713-483-3419

This research program is designed to investigate and further define the biological hazards of the space radiation environment to manned space missions. Although experimental animals comprise the major source of information, human response data resulting from radiation therapy and accidental exposures are included. Investigating the response to and mechanism of action of high energy high Z (HZE) cosmic particles is emphasized. Also emphasized is further definition of effects resulting from low dose, low dose rate, and fractionated dose exposures. Determining whether significant physiological changes have occurred even though gross responses may not be evident is of major importance throughout these studies. Considerably more data is needed in this area to more accurately specify safe and reasonable radiation safety criteria for manned space programs.

Although not included in current experimentation, studies planned for the future encompass consideration of preventive techniques or measures that space travelers may take when faced with unavoidable exposure to a relatively high radiation dose (e.g. solar flare).

W75-70782 **970-52-10**
Lyndon B. Johnson Space Center, Houston, Tex.
LIFE SUPPORT SYSTEMS PROGRAM
Frank H. Samonski, Jr. 713-483-2171

The objective of the Life Support Systems Program is to focus analysis, fabrication and testing efforts toward solving problems associated with the integration of life support system hardware. The basic approach involves the use of analytical studies to guide the selection of optimum subsystem combinations, the implementation of the results of these studies into hardware programs and the confirmation of the validity of these efforts through a coordinated ground test program. Specific programs involve the development of system level computer programs for analysis of shuttle and potential shuttle payload environmental control and life support systems, and the continuation of the development of a representative spacecraft environmental control system.

W75-70783 **970-52-21**
Lyndon B. Johnson Space Center, Houston, Tex.
AIR REVITALIZATION AND CONTAMINANT CONTROL
Frank H. Samonski, Jr. 713-483-2171
(970-22-21; 970-62-40)

The objectives of this RTOP are to provide advanced life support technology for components and subsystems for air revitalization, atmosphere storage and generation and control techniques for carbon dioxide, humidity and trace contaminants of manned spacecraft cabins. The general approach is to advance the subystem technology through to the design and verification of reliable hardware for shuttle and near term space missions, and for the development of flight experiments in support of the Life Sciences Payload activities. Performance data on subystems and components will provide a basis for selection of critical subsystems to make them adaptable to flight type hardware.

W75-70784 **970-52-22**
Lyndon B. Johnson Space Center, Houston, Tex.
ATMOSPHERIC PRESSURE, COMPOSITION AND THERMAL CONTROL
Frank H. Samonski, Jr. 713-483-2171
(970-62-40)

The objectives of this RTOP are to provide advanced life support technology for components and subsystems for cabin atmospheric control of such parameters as pressure, composition and temperature as well as required environmental control subsystem sensors. The general approach is to advance the subsystem technology through to design and verification of reliable hardware for shuttle and near term space missions. Performance data on subsystems and components will provide a basis for selection of critical subsystem to make them adaptable to flight type hardware.

W75-70785 **970-52-23**
Lyndon B. Johnson Space Center, Houston, Tex.
WATER AND WASTE MANAGEMENT
F. H. Samonski, Jr. 713-483-2171

The objectives are to provide advanced life support technology for components and subsystems for water management, including water purification and the management and control of manned spacecraft wastes. The general approach is to advance the subsystem technology through to the design and verification of reliable hardware for shuttle and near term space missions, and for the development of flight experiments in support of the life sciences payload activities. Performance data on subsystems and components will provide a basis for selection of critical subsystems to make them adaptable to flight type hardware.

W75-70786 **970-52-24**
Lyndon B. Johnson Space Center, Houston, Tex.
FOOD TECHNOLOGY
N. D. Heidelbaugh 713-483-5056

The objective is to develop food systems having maximum palatability and nutrition with minimum in-flight food preparation time, and minimum cost, volume, weight and power requirements. Food technology, food sciences and food engineering will be used to support research and development of food systems. Emphasis will be on food systems, preservation techniques, packaging and storage. 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 analyses, optimization of space food preservation techniques, optimization of packaging, and development of efficient in-flight food storage, preparation, and delivery systems, and subsystems hardware. Food will be developed to meet mission needs prior to development of food system hardware design specifications. System components will be to mission requirements rather than compromised to fit commercially available foods.

W75-70787 **970-52-30**
Lyndon B. Johnson Space Center, Houston, Tex.
CREW EQUIPMENT SYSTEMS
J. V. Correale 713-483-4931

Objectives are to (1) initiate component technology design, development, fabrication, and testing of a shuttle related EVA life support system; (2) continue the testing of prototype advanced IV and EVA technology suits for application in the space shuttle program; and (3) continue development of an elastomeric polymer material that will be flame resistant in an O2 enriched environment (70/30 ration of N2 and O2). Material will also be capable of molding and extruding while maintaining resiliency and elasticity. EVA life support components to be developed include those that exhibited design deficiencies in prior life support system application or require specific modifications as a result of unique shuttle related requirements. Continued design, development, fabrication, and testing of the prototype advanced IV and EVA suits as well as the development of the flame resistant elastomeric polymer material will be conducted through an increase in scope and follow-on efforts to existing contracts.

W75-70788 **970-53-10**
Lyndon B. Johnson Space Center, Houston, Tex.
SHUTTLE MAN-MACHINE INTEGRATION TECHNOLOGY
D. C. Schultz 713-483-3094
(970-53-20)

The activity outlined involves two major tasks: (1) a study to determine the applicability of using a combination of the EVA crewman and man-rated Shuttle Attached Manipulator System (AMS) to accomplish on-orbit shuttle/payload maintenance and servicing tasks: and (2) by utilizing and expanding current studies, and documented EVA capabilities (Skylab, etc.), develop a set of detailed 'payload task' completion plans. Task 1 will include: (1) feasibility and benefits of using the AMS for transporting crew and cargo to shuttle/payload worksites; (2) identification of shuttle payload operations that would economically benefit from the EVA/AMS combination; (3) development of operational requirements for the AMS attached EVA workstations; and (4) define operational requirements of an AMS-attached EVA control panel and a plug-in AMS control panel for use at the EVA workstations. Task 2 will include: (1) a definition of the Orbiter EVA System. The EVA system and capabilities defined should provide for the complete range of possible shuttle EVA missions; (2) development of a preliminary set of task sequences and timelines that show how payload mission objectives may be satisfied by using the shuttle EVA System for specific payloads and classes of payloads.

W75-70789 **970-53-20**
Lyndon B. Johnson Space Center, Houston, Tex.
SPACE SHUTTLE ATTACHED REMOTE MANIPULATOR TECHNOLOGY AND MANNED MANEUVER

Louis E. Livingston 713-483-4966

This activity is a progressive buildup of an in-house manipulator test article more nearly duplicating the performance of the orbiter system. This simulator will be utilized to develop techniques of operation and mechanical interfaces between payloads and the manipulator system. Results of these efforts will be used to verify the Shuttle manipulator system preliminary design being performed by JSC. Another segment of investigation is the preliminary design of a manned maneuvering unit (MMU). This effort is related to MMU tasks conducted under RTOP number 975-50. The total tasks under these two RTOP's will be controlled by JSC's MUWG (maneuvering unit working group) and will contribute toward and directly support the mission modeling and hardware design for a shuttle manned maneuvering unit, which could be used as early as the first manned orbital flight to conduct thermal protection subsystem inspection and repair, if necessary.

W75-70790 **970-53-30**
Lyndon B. Johnson Space Center, Houston, Tex.
ADVANCED BIOINSTRUMENTATION
S. L. Pool, MD. 713-483-4211

The Life Sciences Directorate at the L. B. Johnson Space Center has under development several items of bioinstrumentation in support of advanced space missions. These advanced bioinstrumentation developments include the GO (Gravity-Zero) Analyses the MLM (Microbial Load Monitor), MEMS (Microbiological Ecological Measurement System), APEAS (Automated Potentiometric Electrolyte Analysis System), zero-G IV fluid administration, and others. A comprehensive program to support life sciences investigations and clinical support for advanced manned missions is being developed by NASA, but several items of advanced bioinstrumentation have already emerged as viable candidates for the program and hold great promise for use on future space missions. The objective of the advanced bioinstrumentation program being conducted at JSC is to develop and test space-applicable bioinstrumentation. The advanced bioinstrumentation program is a multi-disciplinary effort; included are efforts in microbiology, cardiology, and engineering. The programs in this area usually start as study efforts, although several have now reached the ground-based hardware production phase and/or testing phase. The overall objective of the Advanced Bioinstrumentation effort is to perform research and clinical/health care instrumentation associated with cardiovascular and circulatory function, pulmonary function, laboratory analysis, early detection of disease---

W75-70791 **970-53-40**
Lyndon B. Johnson Space Center, Houston, Tex.
INTEGRATED BIOINSTRUMENTATION SYSTEMS
N. Belasco 713-483-4211
(970-53-30)

The objective is to develop and prove a system to provide remote health care delivery to crewmen and passengers in spaceflight, and provide the instrumentation support for space medical research. This effort will include formulation of engineering requirements and medical systems design requirements and procedures, and verification/evaluation of their effectiveness in ground-based simulations and actual clinical situations. A secondary objective of this effort will be to promote NASA bioinstrumentation technology applications. This effort is directed toward development of remote health care techniques utilizing a ground-based IMELMS (STARPAHC) concept. It also includes tasks to integrate and evaluate advanced bioinstrumentation technology within the IMBLMS/STARPAHC and within shuttle/spacelab verification tests, for the purpose of applying resulting procedures and requirements to the definition and development of manned spaceflight mission payloads (including instrumentation and procedures to support inflight medical research and to provide an inflight clinical capability for shuttle, spacelab, and beyond). The following tasks are proposed: (1) Development of remote health care techniques (IMBLMS) - The assembly and test, installation and operation of a ground-based remote health care delivery system using the IMBLMS concept. The system test bed accommodates advanced bioinstrumentation developments to improve the efficiency or enhance the total capability of the system;---

W75-70792 **970-53-50**
Lyndon B. Johnson Space Center, Houston, Tex.
MAN-MACHINE SYSTEMS DESIGN
Robert L. Bond 713-483-4966

The objectives are to: (1) review data from Orbiter Maintainability Program to establish tool kit requirements; (2) utilize commercial types of tools for the basic tool kit with necessary modification for on-orbit environment, both IVA and EVA; and (3) provide design for handling and packaging of tools. Specifications and drawings necessary to produce flight hardware suitable for Orbiter and its payloads will be provided.

W75-70793 **970-62-40**
Marshall Space Flight Center, Huntsville, Ala.
FLIGHT EXPERIMENTS DEFINITION AND DEVELOPMENT
Dr. J. W. Littles 205-453-3831

One objective of this RTOP is to provide the technology required for flight test of regenerative life support systems. Experiment concepts will be established, hardware designed, built and tested with a view of eventual orbital flights. The second objective is to accomplish, in cooperation with the NASA Life Sciences elements, the engineering design and development of habitats (Common Holding Units) for Life Sciences Specimens.

W75-70794 **970-63-20**
Marshall Space Flight Center, Huntsville, Ala.
TELEOPERATOR CONTROL AND REMOTE MANIPULATION
W. G. Thornton 205-453-5530

This RTOP proposed to further develop the technology applicable to earth orbiting teleoperator such that design criteria and the requirements are available in the 1976 time frame and for subsequent applications. The principal technical areas of concern are: manipulative devices including the end effectors and their control, visual and other sensors, remote control of the mobility unit, man-machine interface and system integration, applications analysis and interfaces with shuttle, tug and payloads. Objectives are: (1) to define experimental and prototype free flying teleoperator systems and operations for applications in shuttle, tug, and earth orbiting payload applications; and (2) to establish component and integrated system technology, design criteria and requirements for free flying teleoperators in the areas of manipulative devices and end effectors, sensory systems, mobility unit control, and the control and display station. Using prior system studies as a baseline and utilizing current design efforts in shuttle, tug, payloads, system definition investigations for specific applications of free flying teleoperators will be conducted. Feasibility studies and design investigations will be conducted on remote manipulators, end effectors, visual systems, displays, and remote control; man-machine invention methodology for remote, free flying teleoperator systems will be evaluated.

W75-70795 **970-83-20**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
REMOTELY MANNED SYSTEMS: DISPLAYS AND SUPERVISORY CONTROL
Ewald Heer 213-354-3060
(970-23-20; 970-63-20; 112-30-14)

The objective is to develop technical information about Remotely Manned Systems (RMS) and teleoperator/robots so that space missions requiring the use of such systems can be planned and implemented with the required reliability, performance, and economy. Specific objectives are to identify requirements, develop conceptual designs and breadboards, and determine the machine's and man's complementary roles in the operation of RMS and teleoperator/robots, including time delay requirements with emphasis on sensor/display and supervisory control aspects. The approach is to use technical studies to identify the scientific and operational mission requirements, and to develop the resultant necessary RMS and teleoperator/robot functions. From the implied capability requirements for man and machine, the necessary technology developments for teleoperator/robot systems and subystems will be derived. Required develop-

ments 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, JSC, and MSFC.

Payloads

W75-70796 **975-50-01**
Langley Research Center, Langley Station, Va.
STS USER COMMUNITY DEVELOPMENT
E. S. Love 804-827-2893

The objective is to help identify and develop space transportation system (STS) utilization in the 1980's. Potential STS users will be identified and briefed on the capabilities of the shuttle missions using space laboratories (SL), and free flying multipurpose satellites such as the Long Duration Exposure Facility (LDEF). Potential users will be stimulated with limited financial support to identify and study experiments in their particular fields which may be compatible with shuttle. The experiments will be studied in sufficient depth to define the cost and potential return. The program will be implemented in geographical areas which have high concentrations of potential STS users. Small contracts will be awarded to individuals in each selected area to identify potential users in the area, to assemble the users for briefing on the shuttle capabilities, and to work with the users after the briefings to stimulate and help develop their ideas for SL and LDEF usage. LRC personnel will participate in these shuttle briefings.

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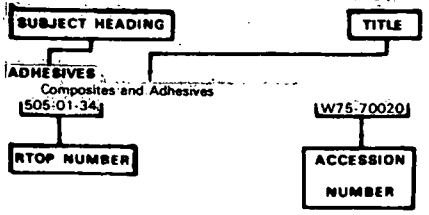

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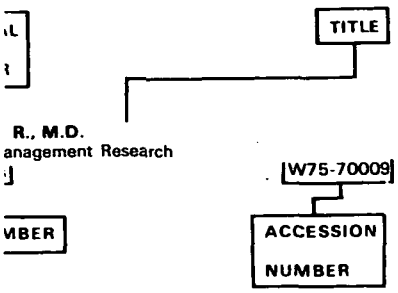

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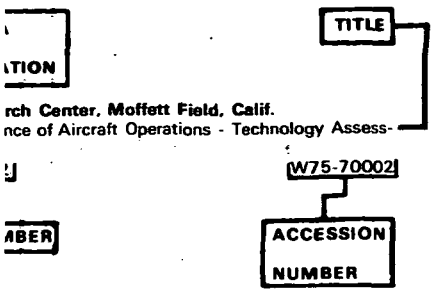

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