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NASA TM-101203

# Research and Technology Objectives and Plans Summary

## Fiscal Year 1989 Research and Technology Program

(NASA-TM-101203) RESEARCH AND TECHNOLOGY
OBJECTIVES AND PLANS SUMMARY (RTOPS)
Research and Technology Program, FY 1989
(NASA) 210 p CSCL 05A Unclas
G3/99 0019846

# INTRODUCTION

This publication represents the NASA research and technology program for FY 1989. It is a compilation of the "Summary" portions of each of the RTOPs (Research and Technology Objectives and 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 responsible NASA 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 contact which might be disruptive to ongoing 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
Washington, D.C. 20546
Attn: Edmund L. Sanchez
Director, Resources and Management Systems Office (RB)

Wm F. Ballhaus, Jr.

William F. Ballhaus, Jr.
Acting Associate Administrator for
Aeronautics and Space Technology

P-210

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RTOP ACCESSION NUMBER → W89-70174

CURRENT RTOP NUMBER → 146-66-01

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

TITLE → **METEOROLOGICAL PARAMETERS EXTRACTION**

TECHNICAL MONITOR → M. T. Chahine 818-354-6057 ← TELEPHONE NUMBER

(146-72-06) ← RELATED RTOP

TECHNICAL SUMMARY →

The overall objective of the proposed research is the development of accurate numerical analysis methods to retrieve, from satellite data, important meteorological parameters needed for weather and climate studies. To accomplish this we plan to: (1) conduct theoretical and applied studies for the development of improved numerical techniques to retrieve atmospheric and surface parameters from radiance data measured by the NOAA High-Resolution Infrared Sounder/Microwave Sounding Unit (HIRS/MSU) sounders; (2) apply the retrieval methods for simultaneous determination of several meteorological parameters such as clear-column vertical temperature and humidity profiles, sea-surface temperature, and the distribution of cloud heights and amounts; (3) verify the accuracy of the results by participation in national and international workshops dedicated to this objective; also by comparison with co-located radiosonde and sea-surface data and with cloud nephanalysis obtained independently from other sources; (4) apply the results to observe and study various air-surface interaction processes on monthly to seasonal timescales. Simultaneous determination of the atmospheric and surface thermal structure and the cloud distribution provides information on heat sources and sinks, storage rates and transport phenomena in the atmosphere. Such information is critical in determining the driving mechanisms for motions in the atmosphere and oceans and in improving numerical weather prediction.

# RESEARCH AND TECHNOLOGY OBJECTIVES AND PLANS

*a summary*

FISCAL YEAR 1989

# OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

## Aeronautics Research and Technology Base

## Fluid and Thermal Physics Research and Technology

**W89-70001** **(23) 505-60**
Langley Research Center, Hampton, Va.
**FLUID AND THERMAL PHYSICS RESEARCH AND TECHNOLOGY**
R. V. Harris 804-865-3285

The objective is to advance the computational and experimental state of the art in a broad range of fundamental technology areas and to promote the synergistic evolution of innovative, high-risk concepts, and technologies needed for the efficient design of advanced civil and military aircraft. Solution methodology will be developed for a variety of viscous and inviscid equation sets including the full Navier-Stokes equations and applied to increasingly complex configurations, as well as flow stability problems, across the speed range from subsonic to hypersonic. Detailed critical experiments will be performed to validate new computational methods and to improve the fundamental understanding of complex fluid physics and chemistry processes. This improved understanding will be applied to the development and evaluation of innovative concepts for reducing aircraft drag. Improved aircraft design methodology will be validated using data from flight tests, from numerous ground facilities, and from the high Reynolds number data base being generated in the National Transonic Facility. A change made to this RTOP is added transition and turbulent physics element. The experimental and analytical Aerodynamics effort has been shifted to 505-61.

**W89-70002** **(55) 505-60**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**FLUID AND THERMAL PHYSICS RESEARCH AND TECHNOLOGY**
L. M. Mack 818-354-2138

The part of the Drag Reduction Element of the Fluid and Thermal Physics research and technology program applied to the research area of laminar instability and transition is presented. The overall objective is an understanding of the detailed physical processes that lead to boundary-layer transition, and the application of this knowledge to the prediction and control of transition. The plan is to use experimental, analytical and numerical techniques to investigate the following four problems: (1) the mechanisms by which various external disturbance sources interact with the boundary layer and produce instability waves and other disturbances (receptivity problem), the initial conditions of the instability waves, and the relative importance of competing influences on transition; (2) the propagation through the boundary layer of the instability wave trains and wave packets produced by either receptivity or by artificial means to the point where the final breakdown to turbulence starts; (3) the development of a rational method for the prediction of transition based on stability theory and knowledge of external disturbances; and (4) passive and active methods of transition control. As knowledge of transition is important for aircraft performance in all speed ranges and for all aerodynamic surfaces, the research will encompass two- and three-dimensional incompressible, subsonic, transonic, supersonic and hypersonic boundary layers.

**W89-70003** **(21) 505-60**
Ames Research Center, Moffett Field, Calif.
**FLUID AND THERMAL PHYSICS RESEARCH AND TECHNOLOGY**
Paul Kutler 415-694-4007
(505-61-00; 505-65-00; 506-40-00)

The objective is to advance fundamental understanding of basic aerodynamic and thermodynamic processes and to develop predictive capabilities for analysis and design optimization of advanced aerospace vehicles and their propulsion systems. A combination of computer simulations and experiments will be used to study flow over individual aerospace vehicle components, as well as complete configurations. New algorithms, languages, and compilers will be constructed to realize the most effective use of advanced computer systems. Computer programs will be developed to simulate turbulence and to solve fluid dynamics problems, including the effects of viscosity and unsteady flow. Computer codes applicable to practical fluid dynamics problems will be developed to transfer advanced technology to the aerospace community. Experiments will be performed for a large Reynolds number range to document detailed turbulence properties and to provide turbulence models for use in solutions of the Reynolds-averaged Navier-Stokes equations. Both wind tunnel and flight experiments will be conducted to verify computer simulations and to validate prediction techniques.

## Applied Aerodynamics Research and Technology

**W89-70004** **(23) 505-61**
Langley Research Center, Hampton, Va.
**APPLIED AERODYNAMICS RESEARCH AND TECHNOLOGY**

R. V. Harris 804-865-3285

The objective is to develop an advanced and validated base of new aerodynamics technology for application to future generations of civil aircraft, rotorcraft, and fighter aircraft. An additional objective is to accelerate technology development in support of the hypersonic cruise/ transatmospheric vehicles. Ground-based, flight, and computational facilities are used to generate the advanced technology needed to accomplish the cited objectives. Wind-tunnel tests and consultation to DOD, industry, and other agencies are provided consistent with available resources. Changes made to this RTOP are: Added Configuration Aerodynamics and NTF Operation elements.

**W89-70005** **(21) 505-61**

Ames Research Center, Moffett Field, Calif.

**APPLIED AERODYNAMICS RESEARCH AND TECHNOLOGY**

B. A. Lampkin 415-694-6039

(505-60-00; 763-01-00; 505-68-00)

The overall objective of this activity is to provide the necessary research and technology development for an improved validated base of new aerodynamics and flight dynamics technology for application by industry to future generations of both civil and military flight vehicles. The approach will be to conduct analytical, ground based, and flight research investigations of a broad class of vehicles, which shall include subsonic transport and general aviation aircraft, rotorcraft, advanced fighter/attack aircraft, powered lift configurations (STOL, V/STOL and STOVL) and hypersonic vehicles. This RTOP will also support the development, testing, and technical studies required to properly prepare for the Unitary Plan Wind Tunnel Revitalization Project. The funding will be used for preparation in four specific areas: flow quality improvement, automation of facility control, optical flow field measurement systems, and selection and validation of modern force measurement systems.

## Propulsion and Power Research and Technology

**W89-70006** **(23) 505-62**

Langley Research Center, Hampton, Va.

**PROPULSION AND POWER RESEARCH AND TECHNOLOGY**

R. V. Harris 804-865-3285

Advanced experimental and analytical techniques are used to develop all technology areas for airbreathing hypersonic propulsion concepts, to develop the technology to significantly improve the performance potential of hypersonic flight vehicles including an understanding of and solutions to problems inherent to such vehicles, and to provide basic information on the effect of advanced propulsion concepts on the performance and interference characteristics of advanced aircraft. Analytical and experimental studies using advanced facilities and techniques are utilized by unique personnel to investigate scramjet engine components, complete subscale engines, problems inherent to such engines, engine/airframe integration and improvement of hypersonic aerodynamic performance. In addition, advanced aircraft configurations and generic models are used for investigations of thrust vectoring and reversing, 2-D nozzles and propulsion control, and nacelle/wing interactions. Computational methods and unique experimental procedures are developed to help understand the flow phenomena associated with hypersonic propulsion and inlet and nozzle integration.

**W89-70007** **(22) 505-62**

Lewis Research Center, Cleveland, Ohio.

**PROPULSION AND POWER RESEARCH AND TECHNOLOGY**

J. A. Ziemianski 216-433-3901

The broad objective is to explore and develop the technologies for the propulsion systems of advanced V/STOL, supersonic and hypersonic cruise aircraft, rotorcraft, and smaller conventional aircraft. In-house, contract, and grant research and development efforts will address various components such as inlets, engines, nozzles, ejectors, fans, and helicopter transmissions as well as unique propulsion systems and propulsion/airframe integration. Improved instrumentation and controls will be developed, and internal computational fluid mechanics capabilities will be enhanced by test and analysis.

## Materials and Structures Research and Technology

**W89-70008** **(10) 505-63**

National Aeronautics and Space Administration, Washington, D.C.

**MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY**

Samuel L. Venneri 202-453-2760

Objective is to conduct fundamental research on advanced materials concepts for Aeronautics. Advisory services to guide R and D in advanced aerospace materials are provided by the National Materials Advisory Board, a unit of the National Academies of Science and Engineering. The interdisciplinary program in airframe materials and structures includes research on advanced metallic and composite airframe materials, properties of constituent fibers and matrix system for metal matrix and carbon/carbon materials, advanced structural analysis methods, fatigue response, environmental and thermal-structures response, and modeling and processing science for light weight airframe structures. The interdisciplinary program in high temperature engine materials focuses on metal matrix composites and ceramic matrix composites. Emphasis will be placed on understanding the processing and properties of these materials. Key activities include the development of high temperature fibers, composite micromechanics at high temperature including time-dependent behavior such as fatigue and creep, and the characterization and control of the fiber/matrix interface for both metal matrix composites and ceramic matrix composites.

**W89-70009** **(22) 505-63**

Lewis Research Center, Cleveland, Ohio.

**MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY**

S. J. Grisaffe 216-433-3193

(535-00-00; 505-66-00)

The major objectives of this RTOP are: (1) to advance the level of materials and processing technologies for high-temperature metallic, polymeric, and ceramic materials in order to contribute to improving the performance, life, reliability, structural efficiency, and/or to reducing the cost of future turbine engines. The prime emphasis of the work is directed toward developing greater understanding of the interrelationships among material composition/microstructure, fabrication processes, and mechanical/physical properties; (2) develop and verify advanced analysis and synthesis methods, advanced generic structural concepts, and advanced quantitative life prediction capabilities applicable to high temperature aerospace propulsion components; (3) to develop and experimentally validate improved analytical methods to describe and predict the dynamic and aeroelastic response of aircraft turbine engine systems. Emphasis will be on high temperature applications. Material behavior constitutive relations will be developed emphasizing anisotropy of metallic/ceramic/composite materials. Generic structural concepts will be conceived to exploit the capabilities of advanced material systems.

**W89-70010** **(21) 505-63**
Ames Research Center, Moffett Field, Calif.
**MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY**
James O. Arnold 415-694-5265

The overall objective is to provide the materials, structures, and acoustics research and technology development necessary for significant improvements in the performance, durability, utility, and economy of future generation civil and military aircraft. Experimental and analytical research on advanced composites will be performed to better characterize and understand fatigue and fracture behavior in order to predict accurately the service life of structures when exposed to their environments. Computer codes for the simulation of aeroelastic effects on new vehicle configurations will be developed and their characteristics investigated, new flight load and deflection measurement techniques developed, and analysis codes evaluated through correlation with measured values. In the generic hypersonic area, efforts will be directed toward the development, fabrication, and evaluation of lightweight ceramic matrix composite structural concepts for airframe and heat shielding of hypersonic flight vehicles; development of the capability of elevated temperature mechanical testing in aggressive chemical environments; modelling and understanding the interaction zone existing between the metal-fiber contact surfaces in an advanced metal-matrix composite; and developing knowledge and skills in analyzing and testing structural concepts requiring active cooling by liquid hydrogen, liquid methane, and other cryogens.

**W89-70011** **(23) 505-63**
Langley Research Center, Hampton, Va.
**MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY**
C. P. Blankenship 804-865-2042

This research includes executing analytical and experimental programs in structures, materials, and acoustics with emphasis on: (1) thermal structures, aeroelasticity, unsteady aerodynamics, and aeroservoelasticity; (2) structural mechanics and landing dynamics; (3) polymeric materials, metallic materials, and composite materials; (4) aeroacoustics and structural acoustics; and (5) interdisciplinary analysis and optimization. Principal research objectives include providing structures and materials technologies that will enhance the performance, efficiency, and reliability of advanced commercial, military, and general aviation aircraft. Analytical, computational, and experimental approaches are included in the fundamental research that is conducted in-house, by university grant, and under contract to industry.

# Information Sciences Research and Technology

**W89-70012** **(62) 505-65**
Marshall Space Flight Center, Huntsville, Ala.
**INFORMATION SCIENCES RESEARCH AND TECHNOLOGY**
C. C. Stover 205-544-1560

The objective of this effort is to obtain a complete end-to-end high speed mainframe Computer Networking Subsystem (CNS) including its operation and maintenance utilizing the Program Support Communications Network (PSCN) as the communications medium. This subsystem is to provide for the sharing of unique mainframe computational capabilities embodied in the various large scientific computers located at NASA Centers. CNS must be adaptable to changes in the volume of traffic, number of mainframes at each site, mainframe operating systems, number of sites and rate of data transfer. The initial system will link the unique computational capabilities of the OAST Centers. The system to support this link will consist of data buffering and mainframe interface equipment, and utilize the NASA PSCN as the communications medium.

**W89-70013** **(23) 505-65**
Langley Research Center, Hampton, Va.
**INFORMATION SCIENCES RESEARCH AND TECHNOLOGY**
J. F. Creedon 804-865-4915

Advanced computer architectures offer increased performance and greater reliability. The concurrent processing research under this RTOP addresses both systems issues and distributed operating systems technology to improve performance and reliability. Disciplined approaches to software development and automated tools are needed to construct reliable software for flight crucial systems. The software engineering research aims to characterize and evaluate automated support tools for software specification, design, and code; create guidelines for developing fault-tolerant software; and measure software reliability. Concurrent processing issues to be studied include communication and synchronization, programming languages and environments, problem decomposition and algorithm development, and comparison of prototype architectures for real-time computing. Promising distributed operating system concepts will be installed in a laboratory network environment for proof of concept tests. Analysis of fault-tolerant software techniques applied to a realistic flight software problem will be conducted and automatic generation of selected programming constructs studied. Much of the parallel computing systems research will be done at the Institute for Computer Applications in Science and Engineering. A block grant in computer science at the University of Illinois Computing Laboratory for Aerospace Systems and Software supports related research tasks.

**W89-70014** **(21) 505-65**
Ames Research Center, Moffett Field, Calif.
**INFORMATION SCIENCES RESEARCH AND TECHNOLOGY**
Marcelline C. Smith 415-694-5188
(506-44-00)

The objective is to support computational fluid dynamics, computational chemistry, and other disciplines of Agency interest by developing an understanding of the relationships and tradeoffs between algorithms and computer architectures for these applications. Approaches, techniques, and tools are needed to apply this insight to the development of optimal hardware/software systems for this class of problems. The research will permit better utilization of emerging concurrent processors, and will influence the design of systems crucial to NASA in the 1990s. This RTOP is a response to OSTP's Research and Development Strategy for High Performance Computing. The approach involves collaboration between Ames, universities, and Ames' Research Institute for Advanced Computer Science (RIACS). This collaboration will bring together computer science and computational physics expertise to analyze the requirements, evaluate extant concepts and products, and conduct the necessary research and development. The steps involved include: the development of requirements and evaluation of promising systems concepts; the development of simulation, emulation, or modeling techniques to validate system concepts; and the building of prototypes to serve as proof of concept.

# Controls and Guidance Research and Technology

**W89-70015** **(21) 505-66**
Ames Research Center, Moffett Field, Calif.
**CONTROLS AND GUIDANCE RESEARCH AND TECHNOLOGY**
G. W. Condon 415-694-5567
(505-61-00; 533-02-00; 505-67-00)

The objective of this research is to develop a guidance and control technology base for the design of safe, efficient civil and military aircraft. Research will be conducted on: advanced, robust flight/propulsion control systems for superaugmented aircraft; advanced guidance and display systems which fully utilize new computational capabilities evolving within the fields of artificial intelligence and decision making theory to achieve effective tactical path planning and to permit more efficient operations in the Air Traffic Control (ATC) environment; control concepts for hypersonic vehicles; advanced analysis techniques to enhance our knowledge of atmospheric processes and other causes of aircraft accidents by analyzing data from accidents in conjunction with the National Transportation Safety Board (NTSB); application of expert system, computer vision, and advanced guidance technology to enable automated rotorcraft flight in the nap-of-the-earth; and application of expert system techniques to develop automation in maneuvering flight for fighter/attack aircraft. The approach will be to conduct analytic studies, evaluate concepts on flight simulators, and validate the more promising concepts in flight.

**W89-70016** **(51) 505-66**
Goddard Space Flight Center, Greenbelt, Md.
**CONTROL AND GUIDANCE RESEARCH AND TECHNOLOGY**
David G. Roberts 804-824-1541

The overall objective of this RTOP is to provide for operational support to approved OAST projects utilizing the Goddard Space Flight Center/Wallops Flight Facility (GSFC/WFF) research airport. Operational support includes: project coordination; program aircraft fuel and ground servicing; control tower management of the GSFC/WFF research airport control area; airport maintenance; shop support; ADP operations; SAR, chase, and other aircraft flight services; crash, fire, and rescue services; specialized instrumentation; and miscellaneous equipment.

**W89-70017** **(23) 505-66**
Langley Research Center, Hampton, Va.
**CONTROLS AND GUIDANCE RESEARCH AND TECHNOLOGY**
J. F. Creedon 804-865-4915

The overall objective of this work is to provide for the necessary research and technology development leading to improved civil and military aircraft operations under all weather conditions and for the exploitation of new controls and guidance concepts and hardware to increase the efficiency, effectiveness, and safety of new military and civil aircraft. Research activities under this RTOP will be directed toward establishment of a technology base for multidisciplinary control law analysis and synthesis techniques, improved display design concepts, flight crucial systems, super-maneuverability controls and pilot interface technology, detection, and avoidance of wind shears, and system concepts and procedures enabling safe and efficient operations in the evolving National Airspace System. Analytical and experimental techniques will be developed to exploit advanced electronic and computer based flight systems concepts for improving efficiency and performance of future civil and military aircraft. Emphasis will be placed on increasing levels of integration and on exploiting multi-disciplinary interactions.

## Human Factors Research and Technology

**W89-70018** **(10) 505-67**
National Aeronautics and Space Administration, Washington, D.C.
**HUMAN FACTORS RESEARCH AND TECHNOLOGY**
Lee B. Holcomb 202-453-2747

This RTOP provides support for the National Academy of Sciences (NAS) Commission on Behavorial and Social Science (CBASS) Committee on Human Factors. The NAS and its committees provide advice to governmental agencies in solving advanced technology problems. The Committee on Human Factors was established to provide advice on determining the most important theoretical and methodological issues in Human Factors.

**W89-70019** **(23) 505-67**
Langley Research Center, Hampton, Va.
**HUMAN FACTORS RESEARCH AND TECHNOLOGY**
J. F. Creedon 804-865-4915
(505-66-00)

The overall objective of this RTOP is to provide a research and technology data base from which solutions to human problems impeding the growth and safety of air transportation may be derived. Specific objectives include: the exploration and development of concepts for integrated display and information transfer between crew and aircraft; the application of artificial intelligence concepts to cockpit aids such as system status monitoring and diagnosis to facilitate safe and efficient flight operations; the exploration and development of innovative control/display operational concepts involving cockpit displays of flight management information that will insure the efficient and safe use of ATC system technology; the development and validation of human response measurement technologies for the assessment of aerospace crew mental state; the establishment of a quantitative and qualitative data base for display format/arrangement factors; and the development of a technology base that will allow reliable substitution of simulators for research applications involving atmospheric environment factors.

**W89-70020** **(21) 505-67**
Ames Research Center, Moffett Field, Calif.
**HUMAN FACTORS RESEARCH AND TECHNOLOGY**
M. G. Shafto 415-694-6170
(506-47-00; 505-66-00)

The objectives are to understand the pilot's task in terms of the demands it places on human sensory, perceptual, cognitive, and communicative abilities; to apply this understanding to the development of tools for the specification, design, prototyping, and evaluation of crew/cockpit interfaces; to develop the crew/cockpit/air traffic control (ATC) interaction technology base required to increase the safety, efficiency, and effectiveness of civil and military aviation; to develop human-centered automation principles and designs to monitor flight crew performance, assist flight crews in contingency operations, and improve aviation system reliability and precision; and to develop advanced crew/vehicle interfaces and operational concepts that will improve aviation safety by reducing the frequency and impact of human error. The approach emphasizes mathematical and computational modeling of human sensory, perceptual, cognitive, and communicative abilities. Models are developed and tested against quantitative human performance data collected in actual flight and in high-fidelity simulation. Validated models are used to formulate design principles for cockpit information systems and displays.

## Flight Systems Research and Technology

**W89-70021** **(23) 505-68**
Langley Research Center, Hampton, Va.
**FLIGHT SYSTEMS RESEARCH AND TECHNOLOGY**
R. V. Harris 804-865-3285
(533-02-00)

The objective of this RTOP is to improve the knowledge of severe storm atmospheric processes as they affect the design and safe and efficient operation of aircraft and aircraft systems. Existing experimental programs will be continued to provide additional data for improving the detection and avoidance of severe storm hazards, and for the development of design and operating criteria for those hazards which cannot be avoided. Specific hazards include precipitation, wind shear, turbulence, and in-flight lightning. Advanced methods and vehicle concepts needed to significantly increase fighter maneuverability considering such effects of high angle of attack, separated flow conditions, vortex flows, and thrust vectoring will be developed; and flight experiments to validate key elements are utilized.

**W89-70022** **(22) 505-68**
Lewis Research Center, Cleveland, Ohio.
**FLIGHT SYSTEMS RESEARCH AND TECHNOLOGY**
J. A. Ziemianski 216-433-3901

The overall objective of this effort is to provide for the necessary research and technology development of advanced flight systems concepts for application to future military and civil aircraft. This part of the flight systems R and T program is focused on advancing critical technology needed to solve propulsion and icing problems associated with operation of military and civil rotorcraft and propulsion and control problems associated with operation of military high performance V/STOL aircraft. The current plans for this research area are to develop analytical and experimental simulation techniques to study aircraft icing problems and to develop advanced ice protection system concepts to improve aircraft productivity, operational capability and safety, and to identify and develop propulsion technology for supersonic V/STOL aircraft.

**W89-70023** **(21) 505-68**
Ames Research Center, Moffett Field, Calif.
**FLIGHT SYSTEMS RESEARCH AND TECHNOLOGY**
D. H. Gatlin 805-258-3166
(533-02-00)

The overall objective is to provide for the necessary research and technology development of advanced flight systems for application to future military and civil aircraft. Research will be conducted in conjunction with high angle-of-attack flight experiments utilizing the High Alpha Research Vehicle (HARV). Near-term emphasis will involve forebody flows by correlating flow visualization and surface pressures measured in flight and in wind/water tunnels with results generated by computational fluid dynamic (CFD) analysis. The long-term goal is development of flight validated predictive techniques. Research activities supporting evaluation of unconventional controls, including thrust vectoring for high alpha control and maneuvering, will also be conducted. In support of the NASA supersonic Short Take-off and Vertical Landing (STOVL) program, contracted efforts are being conducted to evaluate supersonic single engine concepts featuring different propulsive lift systems. Following a U.S./U.K. downselect process, a concept-specific technology program will be conducted, including piloted simulation using the Vertical Motion Simulator.

## Systems Analysis Research and Technology

**W89-70024** **(23) 505-69**
Langley Research Center, Hampton, Va.
**SYSTEMS ANALYSIS**
R. V. Harris 804-864-3285

The overall objective of this work is to provide long term guidance and direction to aeronautics research and technology programs performed by NASA and the Nation's aviation industry. In-house and contract multidisciplinary systems studies identify high-payoff, emerging technology needs and opportunities that can lead to significant advancements or improvements in future civil or military aircraft, creation of new markets, and economic benefits. Studies assess the feasibility and potential benefits of highly integrated configurations incorporating improvements in aerodynamics, propulsion, propulsion-airframe integration, avionics and controls, and structures and materials. Tradeoff analyses are conducted to optimize parameters and to determine the sensitivity of the configuration concepts to the required technology developments. Although research addresses vehicles for both civil and military applications across the speed range, current emphasis is focused on high speed transportation needs and identification of the most promising future vehicle concepts based on an evaluation of the technical, economic, and timing issues.

**W89-70025** **(22) 505-69**
Lewis Research Center, Cleveland, Ohio.
**SYSTEMS ANALYSIS**
D. C. Mikkelson 216-433-5637

To perform studies of the feasibility and potential benefits of advanced subsonic, supersonic, and hypersonic propulsion concepts, to identify technology research requirements and define opportunities for capitalizing on technology advances. Studies will be performed on a wide variety of engine cycles, propulsion systems, and engine/airframe combinations in aircraft missions. Near term and long range aeropropulsion planning will be conducted to assist in the development of future NASA aeronautics programs.

**W89-70026** **(21) 505-69**
Ames Research Center, Moffett Field, Calif.
**SYSTEMS ANALYSIS**
James A. Albers 415-694-5070

The overall objective of this activity is to provide an information data base for advanced planning of rotorcraft research programs. This information will lead to the development of technology which will advance the state-of-the-art of rotorcraft. Emphasis will be on promising technologies which will enable new or greatly increased capabilities of rotorcraft vehicles, innovative and/or beneficial uses of rotorcraft, and the application of emerging technologies to rotorcraft. The feasibility, potential benefits, and critical technologies of advanced, high speed rotorcraft concepts will also be assessed.

**W89-70027** **(10) 505-69**
National Aeronautics and Space Administration, Washington, D.C.
**SYSTEMS ANALYSIS**
Cecil Rosen 202-453-2789

The objective of this effort is to provide for various activities in support of the Aeronautics Studies program. These activities include a studies contract in support of OAST aeronautics technology program requirements, assessments, planning and advocacy, as well as a continuation of support of the Radio Technical Commission for Aeronautics (RTCA), and a university advanced aeronautical design studies program.

## NASP Hypersonics Research and Technology-Aero

**W89-70028** **(23) 505-80**
Langley Research Center, Hampton, Va.
**NASP HYPERSONICS RESEARCH AND TECHNOLOGY - AERO**
Roy V. Harris 804-865-3285
(506-80-00; 763-01-00)

The objective is to provide advanced technologies on a schedule consistent with the needs and requirements of the NASA/DOD National Aero-Space Plane (NASP) Program. Key research and technology efforts are required in the following areas: (1) propulsion, to provide mature high-speed propulsion technologies in areas such as scramjets, engine components, and complete engines; (2) aerodynamics (including computational fluid dynamics), to provide insight into the stability and control of vehicle concepts, the aerothermodynamic environment to which the airframe will be exposed, the complicated flow fields about the vehicle and at crucial locations such as the inlet of engines and vehicle afterbodies, and integration of the high-speed propulsion system with the airframe itself; (3) structures and materials, to provide characterization of a select group of advanced high-temperature/high-strength materials and verification of their applicability to hypersonic structures concepts, and cryogenic tankage concepts; (4) flight systems, to establish flying quality requirements and to develop guidance, navigation, and control methodologies required to meet NASP performance objectives and mission goals; and (5) systems integration which provides the methodology for and the assessment of the performance levels of particular subsystems or components on overall vehicle performance.

**W89-70029** **(22) 505-80**
Lewis Research Center, Cleveland, Ohio.
**NASP HYPERSONICS RESEARCH AND TECHNOLOGY - AERO**
J. A. Ziemianski 216-433-3901
(506-80-00; 763-01-00)

Key research and technology efforts for the NASA/DOD National Aerospace Plane (NASP) Program are required in the following areas: (1) propulsion, to provide mature high speed propulsion technologies in areas such as scramjets, engine components, and complete engines; (2) aerodynamics (including computational fluid dynamics), to provide insight into the stability and control of vehicle concepts, the aerothermodynamic environment to which the airframe will be exposed, the complicated flow fields about the vehicle and at crucial locations such as the inlet of engines and vehicle afterbodies, and integration of the high-speed propulsion system with the airframe itself; (3) structures and high-temperature/high-strength materials and verification of their applicability to hypersonic structures concepts, and cryogenic tankage concepts; (4) flight systems, to establish flying quality requirements and to develop concepts, and cryogenic tankage concepts; and (5) systems integration which provides the methodology for and the assessment of the performance levels of particular subsystems or components on overall vehicle performance.

**W89-70030** **(21) 505-80**
Ames Research Center, Moffett Field, Calif.
**NASP HYPERSONICS RESEARCH AND TECHNOLOGY - AERO**
James O. Arnold 415-694-5265
(763-01-00)

The objective is to provide advanced technologies on a schedule consistent with the needs and requirements of the NASA/DOD National Aero-Space Plane (NASP) Program. Key research and technology efforts are required in the following areas: (1) obtain new and retrieve existing experimental ground test and flight data over a range of conditions applicable to the aero-space plane configuration and trajectory; (2) perform ballistic range tests to obtain drag, shock shapes and shock layer density profiles to achieve real-gas simulation; (3) document expansion tube data taken some years ago at real-gas enthalpies equivalent to Mach 7 (together these new and existing data will be used to validate real-gas modeling in computer codes); (4) test aero-space plane generic models in the Langley hypersonic wind tunnels; (5) test a 3-D boundary layer model at Mach 18 to verify development of new complex viscous codes; (6) obtain a data base and develop improved turbulence models for complex hypersonic flows such as shock interaction and adverse pressure gradient; (7) define pertinent fluid dynamics parameters to aid in selection of CFD codes and in CFD code verification; and (8) evaluate existing and developmental computer codes for suitability in aero-space plane design process and apply verified codes to design of the flight vehicle.

# Interdisciplinary Technology

**W89-70031** **(23) 505-90**
Langley Research Center, Hampton, Va.
**INTERDISCIPLINARY TECHNOLOGY**
R. W. Barnwell 804-865-2664

The objective of this work is to originate, support, promote, and maintain innovative, high-risk, long-term university-based research through research and training grants, cooperative research efforts, and joint research institutes. This is accomplished through three program elements: (1) The Fund for Independent Research (FIR), (2) The Graduate Program in Aeronautics (GPA), and (3) Joint University Institutes (JUI), which includes the Joint Institute for Advancement of Flight Sciences (JIAFS) and the Institute for Computer Applications in Science and Engineering (ICASE). The approach is as follows: The FIR funds novel, long-range, high-risk, basic research investigations in engineering and physical sciences related to aeronautics through the support of unsolicited proposals from the university community; GPA sponsors graduate training and research that is relevant and acceptable to both NASA and the university in the field of aeronautics and encourages a greater number of newly graduating U.S. citizen engineers to pursue graduate training. A significant portion of the training will be through student research conducted with faculty support at an NASA Center using NASA facilities. The JUI provides a core level of funding for the promotion of an active NASA/university interchange in order to maintain cooperative, innovative, venture research at the edge of the latest technology and techniques in science, engineering, mathematics, and computers.

**W89-70032** **(22) 505-90**
Lewis Research Center, Cleveland, Ohio.
**INTERDISCIPLINARY TECHNOLOGY**
M. J. Hartmann 216-433-2954

The overall objective is to originate, support, promote, and maintain innovative, high-risk, long-term university-based research through research and training grants, cooperative research efforts, and joint research institutes. The program is carried out primarily through grants which are selected by the Chief Scientist with the aid of the Research Advisory Board. It allows OAST to initiate fundamental studies in areas not presently included in a specific discipline program and to sponsor graduate training in aeronautics. The funds are also used to bring speakers and visiting university scientists to the Center and to hold workshops and seminars.

**W89-70033** **(21) 505-90**
Ames Research Center, Moffett Field, Calif.
**INTERDISCIPLINARY TECHNOLOGY**
Masayuki Omura 415-694-5113

The objective of this RTOP is to promote and maintain innovative, high-risk, university-based basic research in aeronautics through research and training grants, cooperative research efforts, and a joint research institute. The objective is accomplished through three elements within the RTOP: Funds for Independent Research; Aeronautics Graduate Research Program; and a Joint University Institute. The Aeronautics Graduate Research Program provides grants to support graduate training and research in aeronautics. A significant portion of the training will be through student research conducted at Ames Research Center. The Joint University Institute element provides core funding for the Ames/Stanford Joint Institute for Aeronautics and Acoustics. The Institute promotes an active NASA/Stanford interchange to maintain cooperative, innovative advanced research in the disciplines of aeronautics and acoustics.

**W89-70034** **(10) 505-90**
National Aeronautics and Space Administration, Washington, D.C.
**INTERDISCIPLINARY TECHNOLOGY**
Edmund L. Sanchez 202-453-2790

The objective of this effort is to provide for various support activities for the Aeronautics Research and Technology program. These activities include the Resident Research Associateship (RRA) program; the conduct of reviews, studies, and assessments of the ongoing and planned programs by the Aeronautics and Space Engineering Board (ASEB); the large-scale scientific computing program; and hypersonic training and research. The RRA program and the ASEB activities are contracted efforts, and the large-scale scientific computing program and hypersonic training and research will include university grants.

# Aeronautics Systems Technology Programs

## Materials and Structures Systems Technology

**W89-70035** **(22) 510-01**
Lewis Research Center, Cleveland, Ohio.
**ADVANCED HIGH-TEMPERATURE ENGINE MATERIALS**
J. R. Stephens 216-433-3195
(505-66-00)

The major objective of this RTOP is to develop the technology for revloutionary advances in materials to enable the development of 21st century transport aircraft propulsion systems having greatly decreased specific fuel consumption, reduced direct operating costs, improved reliability, and extended life. To accomplish this objective, very high temperature, lightweight material systems and the associated processing technologies will be developed. This includes the development of advanced metals, fibers, and intermetallic matrix composites; advanced ceramic fibers and ceramic matrix composites. Advanced analysis design methods and life prediction methodologies will also be developed to support the use of these materials in advanced turbine engines. Generic propulsion system structural concepts will be used to evaluate the advanced materials and determine the validity of structural analysis methodologies developed under the program.

**W89-70036** **(23) 510-02**
Langley Research Center, Hampton, Va.
**ADVANCED COMPOSITE STRUCTURES TECHNOLOGY PROGRAM**
C. P. Blankenship 804-865-2042

The research includes advanced concept development, analysis, fabrication, testing, and demonstration programs in structures and materials with emphasis on primary structure for aircraft applications. The benefits of advanced composites will be exploited to develop enabling technology and required scientific basis for verified innovative lightweight, structurally efficient, damage tolerant, and the cost effective materials and structural concepts. Innovative concepts will be developed and demonstrated for use in future primary aircraft structures. A multidisciplinary approach will be utilized involving advanced organic matrix materials, cost effective fabrication techniques, innovative structural concepts, damage tolerant designs, and fatigue/fracture characterization to promote new materials concepts that are integrated with structures technology. Structural mechanics technologies will be developed including analysis, design, and test methods for wing and fuselage components and subcomponents subjected to realistic loadings.

## Rotorcraft Systems Technology

**W89-70037** **(21) 532-06**
Ames Research Center, Moffett Field, Calif.
**ADVANCED ROTORCRAFT TECHNOLOGY**
William G. Warmbrodt 415-694-5642

The objective of this program is to advance rotorcraft systems technology for reduced noise and for high subsonic speeds to enable advances in military and civil rotorcraft vehicles. Rotorcraft noise methodology will be improved by the acquisition of a modern airloads data base and the refinement of predictive methods. Semi-empirical design methods will be improved and analytical and Computational Fluid Dynamics (CFD) codes will be validated. Scaling laws will be investigated by comparison of small- and large-scale model data with flight test data. Analytical capabilities, ground based facilities and flight research vehicles will be used to advance technology for high-speed rotorcraft. CFD techniques will be developed to accelerate high-speed designs. Technology requirements for civil applications of the tilt rotor will be assessed. Advanced high speed rotorcraft concepts will be investigated for potential development and future technology needs will be identified.

**W89-70038** **(23) 532-06**
Langley Research Center, Hampton, Va.
**ADVANCED ROTORCRAFT TECHNOLOGY**
C. P. Blankenship 804-865-2042
(505-61-00)

The objective is to develop the technology for improving rotor noise prediction methodology and noise design criteria for both military and civil rotorcraft and advanced rotorcraft. The approach is to acquire acoustic data from tests of a variety of rotor and rotor system configurations and to utilize these data to develop and verify advanced noise prediction methods as well as innovative noise reduction concepts. This research is performed through contracts with major U.S. manufacturers of helicopters and is coordinated with in-house aeroacoustic research at Ames and Langley and with company independent research.

## High-Performance Aircraft Systems Technology

**W89-70039** **(21) 533-02**
Ames Research Center, Moffett Field, Calif.
**HIGH-PERFORMANCE FLIGHT RESEARCH**
Calvin R. Jarvis 805-258-3177
(505-68-00)

The overall objective is to provide the flight-validated data base required for military and potential civil application of advanced technologies. Program objectives are accomplished by analysis, ground-based simulations, wind tunnel experimental research and flight research tests. Generic high angle-of-attack research will be continued with an F-18 test aircraft. Under joint NASA/USAF Advanced Fighter Technology Integration (AFTI) Program, the F-16 will continue Close Air Support/Battle Area Interdiction (CAS/BAI) technology development, and the F-111 manual and automatically-controlled Mission Adaptive Wing flight research will be completed. The F-15 Performance Seeking Control (PSC) program will continue with design and development effort to optimize the total integrated propulsion and flight control system, with subsequent flight test of key systems and modes. Development of technologies necessary to permit V/STOL aircraft to effectively operate in all mission phases and their validation will continue with the YAV-8B Harrier. The X-29 Forward Swept Wing follow-on research phase will continue with data base development and performance assessment for the high angle-of-attack envelope. A Supersonic Laminar Flow flight experiment program will be initiated using an F-16 XL aircraft as a testbed.

**W89-70040** **(23) 533-02**
Langley Research Center, Hampton, Va.
**HIGH-PERFORMANCE FLIGHT RESEARCH**
R. V. Harris 805-865-3285
(505-68-00)

The objective of this RTOP is to provide improved design methods for highly maneuverable aircraft in the areas of aerodynamic performance, stability, and control with emphasis on moderate and high angles of attack. More specifically, work will be focused on validating design methods for the vortex flap concept and validation/demonstration of high angle-of-attack aerodynamic technology applicable to fighter airplanes. The approach to be used will combine full scale flight and wind tunnel testing in both areas of emphasis. The LaRC F-106 will be equipped with a ground adjustable vortex flap which was designed by computational methods and wind tunnel tests. This flap, instrumented for pressures and loads, will be flight tested through transonic flight conditions to validate the design procedure by correlation of physical flow characteristics observed in flight versus design predictions. The focus for high angle-of-attack technology validation will be the NASA F-18 High-Alpha Research Vehicle (HARV) being instrumented and prepared for flight tests at NASA-Dryden. This program, involving Ames, Dryden, and LaRC, is concentrating initially on the analysis and prediction of the separated vortex flows generated by the fuselage forebody and wing-body strakes at high angles of attack.

## Advanced Propulsion Systems Technology

**W89-70041** **(22) 535-03**
Lewis Research Center, Cleveland, Ohio.
**ADVANCED TURBOPROP SYSTEMS**
J. A. Ziemianski 216-433-3901

The objective of the Advanced Turboprop Systems effort is to develop and evaluate propeller and related drive system and aircraft technologies critical to the efficient, reliable, and acceptable operation of future advanced, high-speed, turboprop-powered aircraft. Both single- and counter-rotating propeller technologies are being evaluated. Propfan technologies will be evaluated in ground and flight test of scale model and large scale hardware. Aerodynamic, accoustic and mechanical performance will be evaluated.

**W89-70042** **(23) 535-03**
Langley Research Center, Hampton, Va.
**ADVANCED TURBOPROP SYSTEMS**
C. P. Blankenship 804-865-2042

The objective of the program is to develop both aerodynamic and acoustic technology necessary for the design of future advanced turboprop-powered aircraft. Configurations of interest are powered by highly loaded, multi-bladed, single-rotating and counter-rotating propeller systems. Emphasis is on prediction and control of propeller aerodynamic interactions and cabin interior noise environments. The approach is to develop improved analytical and experimental methods for predicting aerodynamic flow field interactions, aircraft stability and control characteristics, propeller noise (both in the near-field and far-field), and airborne and structure-borne noise transmission through the cabin sidewall. The prediction methods are validated using wind-tunnel data and results from a joint NASA/industry flight demonstration program. The improved prediction methods and criteria will be used to guide the design of advanced turboprop propellers and aircraft configurations.

**W89-70043** **(21) 535-03**
Ames Research Center, Moffett Field, Calif.
**ADVANCED TURBOPROP SYSTEMS**
Daniel P. Bencze 415-694-6618

The work covered by this RTOP is the development of the technology to demonstrate the feasibility of advanced turboprop transport aircraft capable of cruise speeds up to 0.8 Mach number and altitudes above 35,000 feet. Theoretical and experimental studies will be conducted to define the aerodynamic technology required to integrate advanced turboprop propulsion systems with supercritical wings and fuselages. Detailed flow interactions among the propeller slipstream, nacelle, pylon and wing surface or fuselage will be examined and methods to optimize the installation identified. Theoretical analyses will include linear and non-linear methods capable of handling the transonic slipstream nacelle-wing or nacelle-pylon-fuselage interactions. Experimentally, the flow interactions will be measured with powered full- or semi-span wind tunnel models and flight vehicles that provide accurate simulation of the actual flow conditions. Detailed flow experiments will be conducted to acquire accurate and consistent force, pressure, and flow field data to help verify advanced computational fluid dynamics techniques.

**W89-70044** **(22) 535-05**
Lewis Research Center, Cleveland, Ohio.
**GENERAL AVIATION/COMMUTER ENGINE TECHNOLOGY**
J. A. Ziemianski 216-433-2901

The objective of this effort is to provide the advanced technology base needed to insure the technical advantage of U.S. manufacturers in the future small turbine engine marketplace. The approach is to evolve, evaluate, and verify critical advanced technology applicable to gas turbine engines of 250 to 5,000 shp suitable for general aviation, commuter, rotorcraft, and cruise missile applications. Analytical and experimental studies will emphasize revolutionary powerplant improvements in the 250 to 1,500+ shp range. Program subelements are: (1) system studies; (2) discipline research and technology; and (3) component research and technology. This overall approach will provide industry with the capability to design and build small engines with performance, mantainability, and durability approaching that of large engines. The technology envolved, while primarily applicable to small engines, is also applicable to higher thrust engines. This is especially true for very high pressure ratio engines (to 100 atm) which will approach the smaller engines in geometrical size.

## Numerical Aerodynamic Simulation

**W89-70045** **(21) 536-01**
Ames Research Center, Moffett Field, Calif.
**NUMERICAL AERODYNAMIC SIMULATION (NAS)**
F. R. Bailey 415-694-4500
(536-02-00)

The objectives of the NAS program are threefold: to act as the pathfinder in advanced, large-scale computer system capability through systematic incorporation of state-of-the-art improvements in computer hardware and software technologies and through creation of an applied computer science research effort; to provide a national computational capability to NASA, DOD, other government agencies, universities and industry in order to ensure continuing U.S. leadership in computational fluid dynamics and related disciplines; and to provide a powerful research tool for the NASA Office of Aeronautics and Space Technology. The NAS Program is composed of three elements--the computer processing system (the NAS Processing System Network or NPSN), the facility to house the associated machines and people, and the operation of the NPSN. This RTOP covers the overall management of the program, the facility and development of the processing system. It does not cover the operations elements which are covered in related RTOP 536-02. The NPSN technical approach is one of phased and evolutionary development incorporating the latest advancements in scientific supercomputers, graphics devices, storage media and other computer system technologies.

**W89-70046** **(21) 536-02**
Ames Research Center, Moffett Field, Calif.
**NUMERICAL AERODYNAMIC SIMULATION (NAS) OPERATIONS**
F. R. Bailey 415-694-4500
(536-01-00)
The objectives of the NAS program are threefold: to act as the pathfinder in advanced, large-scale computer system capability through systematic incorporation of state-of-the-art improvements in computer hardware and software technologies; to provide a national computational capability to NASA, DOD, other Government agencies, universities and industry in order to ensure continuing U.S. leadership in computational fluid dynamics and related disciplines; and to provide a powerful research tool for the NASA Office of Aeronautics and Space Technology. The NAS Program is composed of three elements--the computer processing system (the NAS Processing System Network or NPSN), the facility to house the associated machines and people, and the operation of the NPSN. This RTOP covers the operations elements of the NAS Program. It does not cover the overall management of the Program, the facility and development of the processing system which is covered in related RTOP 536-01.

**W89-70048** **(21) 506-40**
Ames Research Center, Moffett Field, Calif.
**AEROTHERMODYNAMICS RESEARCH AND TECHNOLOGY**
J. O. Arnold 415-694-5265
(505-60-00; 506-43-00; 763-01-00)
The objective is to advance the fundamental understanding of aerodynamic flow phenomena in hypersonic flight regimes and to develop the predictive capability to permit performance optimization of advanced aerospace vehicles. Advanced computation methods and computer codes will be developed and validated for numerically simulating vehicle flow fields. The results will then be used to predict thermal loads to, and aerodynamic performance of the vehicle. The codes will yield solutions for the full Navier-Stokes equations for a chemically reacting and radiating gas. The real gas properties-reaction rate constants, radiative transition probabilities and high-temperature transport properties will be determined from computational chemistry methods. Such developments depend on results of both numerical simulations and experiments for improving and/or validating these complex codes. In addition, engineering models are being developed that will give reasonable approximations of the benchmark results. Experimental research will be performed leading to nonintrusive instrumentation for use in hypersonic wind tunnels, to measure local density, temperature, pressure, and their fluctuations anywhere in the flow field having optical access. This extended measurement capability will be developed for application to code-validation and flow-modeling experiments.

# Space Research and Technology Base

## Aerothermodynamics Research and Technology

**W89-70047** **(23) 506-40**
Langley Research Center, Hampton, Va.
**AEROTHERMODYNAMICS RESEARCH AND TECHNOLOGY**
W. R. Hook 804-865-2893
(506-48-00; 506-49-00; 591-42-00)
This research is to improve the fundamental understanding of aerodynamic and aerothermodynamic flow phenomena over ascent and entry vehicles and to develop the predictive capability to permit performance optimization of advanced aerospace vehicles. Emphasis is on providing flow-field computational techniques; providing real-gas chemistry models; utilizing Shuttle wind-tunnel, flight, and analytical prediction data to validate techniques for the design of future vehicles; providing the design and performance parameters on advanced vehicles to identify and analyze high payoff technologies; scoping heating problems on advanced concepts and developing prediction techniques; providing the experimental and analytical data base to improve understanding of real-gas chemistry and Mach number on current and advanced vehicles; and improving wind-tunnel technology, test techniques, and instrumentation for fundamental research. Results will enhance the capabilities, reliability, versatility, and efficiency of future aerospace vehicles. Analytical, computational, and experimental techniques are included in the fundamental research conducted in-house, by university grants, and under contract to industry. The experimental portion of the program emphasizes the unique capabilities of the Langley Hypersonic Facilities Complex and the 8-Foot High Temperature Tunnel.

## Space Energy Conversion Research and Technology

**W89-70049** **(10) 506-41**
National Aeronautics and Space Administration, Washington, D.C.
**SPACE ENERGY CONVERSION RESEARCH AND TECHNOLOGY**
Gregory M. Reck 202-453-2847
The objective of this RTOP is to provide support to the Headquarters operation of the OAST Space Energy Conversion Program. This will include operation of the multi-agency-supported power information center of the Interagency Advanced Power Group.

**W89-70050** **(22) 506-41**
Lewis Research Center, Cleveland, Ohio.
**SPACE ENERGY CONVERSION RESEARCH AND TECHNOLOGY**
H. W. Brandhorst 216-433-6149
The objective of this work is to provide a research and technology development base leading to a spectrum of advanced space power systems and subsystems. Areas include photovoltaics, electrochemical energy storage, fault tolerant power management and distribution components and subsystems, spacecraft environmental interactions, integrated spacecraft bus technology, thermal and solar dynamic systems, advanced radiator concepts, two-phase flow in zero-G, and supporting technology for the SP-100 nuclear power system focusing on free-piston Stirling engines. Major thrusts are to improve performance, reliability and tolerance to the plasma and radiation environment, while reducing cost and mass for systems operating in the LEO, GEO and planetary environments. The research generally aims at providing the technological base for emerging ten-to-hundred kilowatt and ultimately to megawatt level power system needs, while also recognizing and addressing agency and other needs up to the ten kilowatt level.

**W89-70051** **(21) 506-41**
Ames Research Center, Moffett Field, Calif.
**SPACE ENERGY CONVERSION RESEARCH AND TECHNOLOGY**
J. G. Lawless 415-694-5900

The objective of the Environmental Control and Life Support portion of the Space Energy research and technology program is to guide and facilitate the development of new processes for water, waste, and air recycling, as well as the development of new sensor and control devices. The approach chosen for meeting this objective is to use modeling of new technology concepts as a preliminary step in the selection and development of new life support technologies. Environmental control and life support activities will focus on providing the process modeling required to expedite the development of new chemical processes, subsystems, and system designs. These computerized models will provide for the first time the ability to fully simulate and evaluate basic performance interactions. Sensor and control technologies for water and air contamination will be developed in support of these activities so that the integrated life support subsystems and systems may operate as required.

**W89-70052** **(51) 506-41**
Goddard Space Flight Center, Greenbelt, Md.
**SPACE ENERGY RESEARCH AND TECHNOLOGY**
T. D. Swanson 301-286-6952

The principal objective of this research is to develop, analyze, and test advanced thermal energy management concepts and components for application to future spacecraft and space facilities. Focus is on the thermal control of power systems, instrumentation, and other heat dissipating equipment. Midtemperature and long life applications will be stressed. This work will be accomplished through: (1) research into basic thermo-fluid phenomena under micro and partial gravity; (2) development and test of various two-phase components and test verification; and (3) small flight experiments.

**W89-70053** **(55) 506-41**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**SPACE ENERGY CONVERSION RESEARCH AND TECHNOLOGY**
Kenneth L. Atkins 818-354-6293

The objective is to develop and demonstrate advanced technologies in the areas of power switching and control; chemical energy conversion; photovoltaic energy conversion; and thermal energy conversion -- for applications/spacecraft power systems up to 25 kW. The overarching theme of the program is HIGH DENSITY POWER technology to keep the volume-percentage of the power subsystem within the bounds of 20 percent total space system volume. Current SOA -- is about 1 W/cu. in. The eventual objective is 10 W/cu. in. by the year 2000 -- a factor of 10 improvement. Without such progress, typical power subsystems could require over 60 percent of the total system volume. To enable this achievement will require: steady progress in power switching and control functions from discrete to hybrid monolithic technologies; continuing the drive toward long-lived (10 year), high energy-density (200 to 400 W-hr/kg) primary batteries, and toward 10 yr, 100 W-hr/kg rechargeables; developing and demonstrating photovoltaic array technology at 300 W/kg and/or 300 W/sq.m. (for near sun and selected electric propulsion missions); and thermal conversion technology thrusts along both solid-state and liquid metal (AMTEC) avenues to reach conversion efficiencies in the 15 to 20 percent range without moving parts. Approaches will include industrial and university co-op tasks to achieve prototypes and demonstration elements, with solid analytical support.

**W89-70054** **(23) 506-41**
Langley Research Center, Hampton, Va.
**SPACE ENERGY CONVERSION RESEARCH AND TECHNOLOGY**
W. R. Hook 804-865-2893

Three research areas: laser space power transmission, advanced power management, and advanced power/propulsion (P/P) concept analysis are studied. The goal of the laser area is to assess the scientific and technical feasibility of in-space power transmission for propulsion and for electric power. Direct and indirect solar-pumped lasers are conceived, tested, and modeled. Near-term objectives are to define efficient solar-pumped lasers and to establish scaling laws for estimating high average power operation. In conjunction with laser energy generation, laser-to-electric conversion is a major aspect of laser transmission for electric power distribution. A potentially high-efficiency concept, laser photovoltaic conversion, is under experimental and theoretical investigation. To assess the advantages of space power transmission and to guide the laser and converter research, limited trade studies are performed. Advanced power management is primarily focused on three integratable thermal energy control technologies, liquid droplet (L.D.) radiators, L.D. heat exchangers, and phase-change storage media offering lightweight, efficient space systems. The research involves device modeling and performance measurement both in the laboratory and at zero gravity. Potential applications for these technologies include advanced space stations, lunar bases, and deep-space missions. Advanced P/P concept analysis couples selected advanced P/P concepts to specific performance goals by developing system designs and requirements.

**W89-70055** **(72) 506-41**
Lyndon B. Johnson Space Center, Houston, Tex.
**SPACE ENERGY CONVERSION RESEARCH AND TECHNOLOGY**
W. W. Guy 713-483-4931

The objectives of this RTOP effort are to develop thermal management and environmental control and life support technologies, emphasizing physicochemical regenerative and closed-loop life support systems technologies, which will enable an orderly growth in both system size and capability for future long-duration manned missions in space beyond Shuttle and Space Station. Development of systems and subsystems analytical models also are to be emphasized. The tasks included for thermal management will consist of basic analysis and experimental investigations to provide critical and enabling thermal technologies for future long-duration human missions in space. Emphasis will be directed at development of critical technologies in the heat collection, transport, and rejection areas for both transit vehicle and planetary base applications. The tasks included for regenerative and closed-loop life support are directed at improving process efficiencies and operational reliability, reducing expendables and attaining a higher degree of system closure. Particular emphasis will be placed on the technology development and analytical modeling of advanced processes to accomplish the life support functions of air revitalization, water recovery, and waste management.

# Propulsion Research and Technology

**W89-70056** **(62) 506-42**
Marshall Space Flight Center, Huntsville, Ala.
**PROPULSION RESEARCH AND TECHNOLOGY**
J. F. Macpherson 205-544-5936

The objective of this RTOP is to expand fundamental knowledge and understanding of rocket engine process, and to define advanced design concepts leading to more efficient and effective component and engine system designs that will provide enhanced payload delivery capability for future space transportation vehicles at greatly reduced cost. The technology task elements described herein for Advancement Transportation Propulsion include: investigation of high area ratio nozzle concepts with extendible nozzle made of lightweight materials employing radiation cooling techniques. Other areas of investigation are the development of analytical techniques/methods for evaluating combustion chamber and nozzle boundary layer, and liquid/liquid jet interaction-atomization characteristics. Work will continue in the investigation of very high-mixture-ratio combustion processes with the conclusion of the materials compatibility effort and the initiation of an oxygen-rich burner development and test activity.

**W89-70057** **(22) 506-42**
Lewis Research Center, Cleveland, Ohio.
**PROPULSION RESEARCH AND TECHNOLOGY**
L. A. Diehl 216-433-2438
(582-01-00; 594-10-00)

The objective is to provide the technology for advanced chemical and electric propulsion systems that will allow the development of advanced propulsion for future space transportation systems, Earth orbiting platforms, orbital transfer vehicles, and lunar/planetary descent/ascent vehicles. Advanced propulsion will provide the capability to perform a variety of challenging space missions through major improvements in performance, reliability, operational flexibility, and economy. High energy density propulsion systems will greatly reduce the size, mass, and cost of Earth-to-orbit orbital vehicles, orbital transfer vehicles, and lunar/planetary landers. Lunar and planetary ascent vehicles utilizing propulsion designed to operate with in-situ produced propellants will greatly reduce Earth launch requirements for both piloted and cargo delivery missions to the moon and to Mars. Dependable, long-life, low-thrust primary and auxiliary propulsion systems, both chemical and electric, will provide the high performance and reliability needed for the extended in-space operation of Earth-orbiting platforms and satellites and for planetary transfer vehicles and spacecraft.

**W89-70058** **(10) 506-42**
National Aeronautics and Space Administration, Washington, D.C.
**PROPULSION RESEARCH AND TECHNOLOGY**
Gregory M. Reck 202-453-2847

The primary objective of this activity is to maintain a continuous up-to-date information gathering capability on the nation's total chemical propulsion technology efforts as an aid in planning and implementing the NASA program. In addition, joint interagency tasks are undertaken when appropriate, such as publishing handbooks, manuals or computer models, that will be beneficial to the propulsion community as well as other potential users. The approach is to share support of the Chemical Propulsion Information Agency (CPIA), which supplies information gathering and dissemination services, with DOD agencies through the Joint Army, Navy, NASA, Air Force (JANNAF) Interagency Propulsion Committee. For special interagency tasks, funding is transferred to the agency designated as responsible for the procurement action and contract monitoring.

**W89-70059** **(55) 506-42**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**PROPULSION RESEARCH AND TECHNOLOGY**
John F. Stocky 818-354-3575

The objective is to study electric and advanced propulsion system concepts in order to identify critical technology development requirements, and also to develop and demonstrate feasibility for the most promising concepts so they may be ready for mission application in the 1990's. The feasibility of both ion and magnetoplasmadynamic (MPD) propulsion systems has been shown by previous analyses and experiments. Work in FY89 will emphasize fundamental research to model the basic physics of ion and MPD thruster operation and to develop critical components, such as high-current electrodes. For the ambitious missions of the 21st century, studies will be carried out to identify propulsion concepts which offer substantial performance increases over today's propulsion systems. Study candidates include multi-megawatt electric propulsion, nuclear fission or fusion, beamed microwave or laser energy, solar sails, and antiproton annihilation. These studies will examine feasibility issues, define critical technology development requirements, and identify proof-of-concept experiments that are required both to evaluate these advanced concepts, and to guide future technology development programs.

## Materials and Structures Research and Technology

**W89-70060** **(10) 506-43**
National Aeronautics and Space Administration, Washington, D.C.
**MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY**
Samuel L. Venneri 202-453-2760

The objective of this research is to develop a wide range of analytical tools and experimental techniques for use in the design, development, and analysis of the structures and structural dynamics of complex spacecraft and space structures. The program will be structured to foster innovative engineering solutions and design concepts for such vehicles. A number of key structural integrity issues will be addressed in order to develop the understanding and tools needed for the next generation of space structural design concepts.

**W89-70061** **(22) 506-43**
Lewis Research Center, Cleveland, Ohio.
**MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY**
S. J. Grisaffe 216-433-3193

The objectives of this research are to develop greater understanding of materials with aerospace propulsion and power potential and to develop guidelines for improving their physical/mechanical properties and reliability. Fundamental studies are aimed at investigating mechanical and other factors that limit material reliability, performance, and useful life. Fundamental studies are also aimed at identifying scientific concepts that might be applied to substantially improve aerospace materials. The research includes: (1) material properties/performance enhancement via innovative application of nondestructive evaluation concepts/models for characterization of microstructure and mechanical properties; (2) understanding the basics of friction, wear, adhesion, thin film liquid lubrication, and the chemistry and morphology of solid lubricants; (3) work to develop ceramic matrix composites for aerospace applications; and (4) development of materials for heat storage and space power applications. The analytical and experimental results of this research will have far reaching practical applications for a wide range of aerospace materials, structures, and components.

**W89-70062** **(55) 506-43**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY**
Jovan M. Moacanin 818-354-3178

The objective is to develop advanced materials and structures technology for use in future space systems. Analytical and experimental research will be conducted to investigate new methods for predicting the chemical, physical and mechanical properties and reactions of spacecraft materials such as polymers, composite matrices, and alloys. Greater understanding of the correlation between molecular parameters and observed mechanical properties will lead to a capability for producing very specific mechanical characteristics by utilizing innovative molecular designs. Analytic capability which includes design optimization, fabrication, testing and performance prediction of advanced structural composite materials such as carbon-carbon composites will also be developed. In the area of space environmental effects, beams of energetic oxygen atoms, charged particles and short wavelength UV light, will be used along with spectroscopic and analytical techniques, to characterize the degradation processes of polymers in a simulated space environment. These experiments will determine the long term effects of the space environment. Research on flexible structure dynamics will develop new methods, and improve existing methods for the analysis and synthesis of large complex structural systems. Ground testing to validate existing model of predicting dynamic behavior of large flexible structures will also be carried out.

**W89-70063** **(23) 506-43**
Langley Research Center, Hampton, Va.
**MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY**
C. P. Blankenship 804-865-2042

The research includes executing analytical and experimental programs in structures and materials with emphasis on: (1) thermal structures and aerothermal effects; (2) structural concepts; (3) polymeric materials, metallic materials, and composite materials; and (4) interdisciplinary analysis and optimization. The objective is to develop structures and materials technologies that will enhance the performance, efficiency, and reliability of spacecraft and space transportation systems. Analytical, computation, and experimental approaches are included in the fundamental research that is conducted in-house, by university grant, and under contract to industry.

**W89-70064** **(72) 506-43**
Lyndon B. Johnson Space Center, Houston, Tex.
**MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY**
J. T. Visentine 713-483-8923
(506-44-33; 506-44-33)

This RTOP will provide funds to develop a high-intensity AO beam facility at Los Alamos National Laboratory and evaluate the effects of atomic oxygen exposure on materials proposed for the design and construction of Space Station. The database generated by the studies will be used to select materials and protective coatings that do not degrade in the LEO flight environment. These selections will, in turn, lead to increased design confidence for Space Station and will reduce requirements for Shuttle-tended, on-orbit maintenance later during the program. This RTOP will also provide funds to examine the effects of hypervelocity impacts on non-metallic materials and investigate new concepts for shielding against hypervelocity impacts. The examination of the hypervelocity impact resistance of non-metallic materials and of new shielding concepts will be conducted in the JSC Hypervelocity Impact Research Laboratory. The emphasis of this study will be to develop a method of modeling the debris plume from the hypervelocity impact of thin sheets of non-metallic materials.

**W89-70065** **(51) 506-43**
Goddard Space Flight Center, Greenbelt, Md.
**MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY**
Jack J. Triolo 301-286-8651

The overall objective of this program is to develop and verify contamination models leading to improved prediction capability, new materials and protective methods. The current plans for this research are to develop and fly instrumentation to characterize induced on-orbit environments, develop ground based facilities for material characterization, develop data bases, improve, develop and verify models, advance material development, and develop protective and collective devices. Some aspects of these efforts will be accomplished with joint programs between NASA and ESA by combining capabilities and technical strengths of both agencies.

**W89-70066** **(21) 506-43**
Ames Research Center, Moffett Field, Calif.
**MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY**
J. O. Arnold 415-694-5265
(506-40-00; 506-48-00)

The objective is to provide advanced materials technology for the development of future space systems with significant improvements in performance, durability and economy. Emphasis is given to computational materials science and thermal protection materials development. In computational chemistry, the physical and chemical properties of molecules, small atomic clusters and gas-surface interactions are calculated from first principles. These and extrapolations to larger systems are being studied to compare with experiment and to obtain surface and bulk properties. These results are used to study chemisorption, catalysis, corrosion and the physical properties of polymers. Ames' unique arc-plasma test facilities, ceramic materials laboratory, and analytical and computational capabilities are used to develop materials and optimized systems for advanced space transportation vehicles, enhanced Space Shuttle vehicles, aeroassisted orbital transfer vehicles (AOTV), transatmospheric vehicles (TAV), planetary and solar probes, and safe earth reentry of radioactive power sources. Candidate thermal protection system (TPS) concepts and materials are selected and subjected to systematic analysis and testing to qualify for defined end use.

# Space Data and Communications Research and Technology

**W89-70067** **(22) 506-44**
Lewis Research Center, Cleveland, Ohio.
**SPACE DATA AND COMMUNICATIONS RESEARCH AND TECHNOLOGY**
Denis J. Connolly 216-433-3503
(584-00-00)

The overall objective of this RTOP is to provide through research, design and experimental tests, the components, subsystems and enabling technology required to support NASA satellite communications systems. To achieve this objective, advanced research and development programs will be conducted to identify, produce and demonstrate critical components, techniques and subsystems required for complete communications systems. Principal emphasis will be directed toward spacecraft microwave electron beam amplifiers with increased power output, linearity, efficiency, high frequency capability and long life; multi-frequency, multi-beam antennas providing increased frequency reuse at higher frequencies; and solid state materials and component technology for high frequency spacecraft applications, such as switching, power amplification and beam forming.

**W89-70068** **(51) 506-44**
Goddard Space Flight Center, Greenbelt, Md.
**SPACE DATA AND COMMUNICATIONS RESEARCH AND TECHNOLOGY**
John T. Dalton 301-286-8623

This RTOP will: (1) develop and demonstrate the advanced transmitter and receiver technology required for high performance space-borne laser communication systems, and (2) develop a software management environment consisting of an integrated set of tools, software measures, and a knowledge base of software management expertise to improve the management and development of large, complex software systems. The approach includes the development of semiconductor transmitter modules suitable to use in high data rate communication systems in parallel with advancing receiver technology, and the performance of research into key areas of software management leading to the development of an operational software system with the concentration in software management tools and software measures for specifications and design, as well as the development of a software management envirornment consisting of an integrated set of tools, software measures, and a knowledge base of software management expertise to improve the management and development of large, complex software systems.

**W89-70069** **(72) 506-44**
Lyndon B. Johnson Space Center, Houston, Tex.
**SPACE DATA AND COMMUNICATIONS RESEARCH AND TECHNOLOGY**
S. A. Gorman 713-483-5272

This Proposal continues support of the NASA sponsored Software Engineering Research Center at the High Technologies Laboratory of the University of Houston Clear Lake (UHCL). The Center provides a means of focusing NASA research into software engineering issues and also provides a formal liason with other similar centers of research such as the Defense Department's Software Engineering Institute (SEI) at Carnegie Mellon University and the Microelectronics and Computer Technology Corporation (MCC). Areas of research will include: New models, methodologies, and paradigms to advance the life-cycle engineering of software; Productivity tools for software development and maintenance; Development and maintenance of distributed information systems, especially nonstop embedded systems; NASA software engineering training requirements; Advancements in operating systems and network operating systems; Advancements in computer networks; Software fault tolerance; Multi-level computer security; Use of the Ada language and associated environments on NASA projects; Application of Expert Systems and Artificial Intelligence techniques to life-cycle software management; and others as directed by NASA.

**W89-70070** **(21) 506-44**
Ames Research Center, Moffett Field, Calif.
**SPACE DATA COMMUNICATIONS RESEARCH AND TECHNOLOGY**
Marcelline C. Smith 415-694-5188
(505-65-00)

The objective is to develop systems architectures for spaceborne applications which significantly enhance onboard computational capability and improve reliability. Of particular interest is the development of novel memory and sensory encoding architectures which permit learning and image recognition. The approach involves collaboration between the Computer Systems Laboratory (CSL) at Stanford University and Ames' Research Institute for Advanced Computer Science (RIACS). This collaboration will bring together the hardware design and fabrication capability of CSL, the architecture design and systems software development capability of RIACS, and the space requirements which are well known by the space scientists within NASA. Currently a prototype of a Sparse Distributed Memory architecture developed by Kanerva is being tested to determine its applicability to several space science applications.

**W89-70071** **(55) 506-44**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**SPACE DATA AND COMMUNICATIONS RESEARCH AND TECHNOLOGY**
John F. Stocky 818-354-5095
(506-45-00; 584-02-00)

Neural network research, which will significantly expand our ability to do intelligent information processing, will lead to the development of devices for hardware implementations of non-volatile, reversible, variable-resistance synaptic arrays, and architectures for inclusion of these arrays in smart memory systems. The software engineering research element is targeted towards building a sound basis for new software development methodologies and tools which can provide the most cost-effective means for producing complex and reliable systems for NASA. In the context of space data systems applications, this work focuses on software component reuse and associated development environments and tools while also branches out to experiment with non-standard development paradigms such as rapid prototyping. The goal of the communications activity is to develop and test, at the component and subsystem levels, suitable laser modules for free-space optical applications, both near- and deep-space. This will be achieved by developing high-efficiency and high power laser transmitter components and modules. These will then be evaluated on an integrated optical test-bench at the component level, then at the module level, in-conjunction with other optical subsystems as they become available.

**W89-70072** **(23) 506-44**
Langley Research Center, Hampton, Va.
**SPACE DATA AND COMMUNICATIONS RESEARCH AND TECHNOLOGY**
J. F. Creedon 804-865-4915
(506-45-00)

The objective is to research new component and system concepts in space data and communications systems. This research and concept development will result in planning, development, and delivery of technology elements through research and development studies, system models to establish feasibility, proof of concept, or engineering validation hardware and software builds as appropriate to demonstrate technology readiness in support of planned missions. The mission set includes advanced transportation vehicles, Space Station, earth observing systems, lunar colonies, and Mars rovers in the area of embeddable data systems and communications. The approach is to use mission-identified system level needs, together with new device and system-level technologies in high-speed space qualifiable processors, large capacity electro-optical memories with no moving mechanical parts, light-based interconnect structures to encompass both optical channel switched and bussed interconnection of subsystem elements, antenna components and analyses, and optical communications subsystems components, each to give enabling and enhanced system level performance. Particular elements will be developed through proof of concept, and this technology will be delivered to mission projects by appropriate jointly funded developmental proof of performance test vehicles. Individual tasks included are semiconductor lasers, multibeam feeds for spaceborne antennas, and millimeter wave technology.

## Information Sciences Research and Technology

**W89-70073** **(10) 506-45**
National Aeronautics and Space Administration, Washington, D.C.
**INFORMATION SCIENCES RESEARCH AND TECHNOLOGY**
Lee B. Holcomb 202-453-2747
(505-37-10)

The objective of the aerospace computer science university research is to develop a university-based center for aerospace computing technology, focusing on concurrent processing, highly reliable computing, and scientific and engineering information management. It also fosters cooperative, coordinated research coupling computer science with aeronautics, astronautics, and space sciences. The objective of the Advisory Group on Electron Devices 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 (AGED) and its constituent working groups, NASA program managers receive expert advice on the feasibility, currency and soundness of planned research and development procurement activities, long ranging research and development requirement, complementary work in other government agencies, and forecasts of new technical developments.

**W89-70074** **(55) 506-45**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**INFORMATION SCIENCES RESEARCH AND TECHNOLOGY**
Virendra Sarohia 818-354-6758
(505-55-01)

This task develops technologies which will enhance sensing and management of space-derived information, and advance information science and photonics technology in space. For passive and remote sensing, advanced research in material development and semiconductor lasers for injection seeding of high-power solid state laser are being developed. Research on software engineering of large complex systems, and artificial intelligence applied to problems of space information management is being conducted. This task will also develop real time optical signal processing techniques and NASA unique spatial light modulator concepts for optical on-board computing.

**W89-70075** **(23) 506-45**
Langley Research Center, Hampton, Va.
**INFORMATION SCIENCES RESEARCH AND TECHNOLOGY**
W. D. Mace 804-865-3745

The objective of this program is to develop solid-state IR and far-IR detectors for active remote sensors supporting high-flying aircraft and space-based earth science investigations in atmospheric dynamics and chemistry. This research and technology program has been structured to approach these challenges in the areas of laser materials research, laser transmitter design and development, lifetime and efficiency improvement as well as detector research and development. This work addresses the improvement of IR and far-IR sensors and sensor system components through theoretical studies and single crystal materials development.

**W89-70076** **(21) 506-45**
Ames Research Center, Moffett Field, Calif.
**INFORMATION SCIENCES RESEARCH AND TECHNOLOGY**
Craig R. McCreight 415-694-6549
(584-01-11; 584-01-41; 549-03-61)

One objective is to develop advanced infrared detector array technology for future astronomical applications. The array technology is applicable to low- and moderate-background astronomical applications throughout the infrared (IR) spectrum (2 to 200 micrometers) and will directly benefit programs such as the Space Infrared Telescope Facility (SIRTF) and the Large Deployable Reflector (LDR). These activities blend analysis with component development, and include extensive in-house characterization and selected technology demonstrations. A second objective is to develop real-time photonics-based technologies and systems architectures for spaceborne applications. The research is centered around two major subtasks: real-time on-board science and engineering data processing; and incorporation of photonic processors in higher-level expert systems for image understanding and control of intelligent systems. These objectives will be accomplished by coordinating and integrating the efforts at Ames with user organizations and applicable research groups within academia, industry, and other Government agencies and laboratories.

**W89-70077** **(51) 506-45**
Goddard Space Flight Center, Greenbelt, Md.
**INFORMATION SCIENCES RESEARCH AND TECHNOLOGY**
John T. Dalton 301-286-8623

The objectives of the research in Computer Science are: (1) to study, design, and implement systems to handle very large multi-source data bases managed at distributed locations; (2) experiment with and apply expert system front ends to aid in extracting relationships from correlative information in complex scientific data bases; (3) develop concurrent processing algorithms critical to space research and data analysis; (4) perform fundamental research in object oriented data management; and (5) establish a consortium of university, industry, and government scientists as a Center of Excellence in Space Data and Information Sciences. The Sensor Technology program aims toward dramatic advances in X-ray, gamma-ray, and cosmic-ray observational capabilities. Imaging arrays of silicon drift detectors are being developed for soft X-rays, having very high spectral resolution at energies below 30 KeV. Similar silicon drift detectors are being developed for high energy cosmic ray particle detectors such as required for trajectory analysis in Astromag. Mercuric iodide spectrometer detectors are being developed for X-rays and gamma-rays which provide good energy resolution at room temperature for planetary missions. The Quantum X-ray microcalorimeter will be improved by optimizing thermalization efficiency, low heat capacity, and thermal conductance.

# Controls and Guidance Research and Technology

**W89-70078** **(62) 506-46**
Marshall Space Flight Center, Huntsville, Ala.
**CONTROLS AND GUIDANCE RESEARCH AND TECHNOLOGY**
R. W. Schock 205-544-4060

The overall objective of this research is to define, develop, and demonstrate advanced control concepts for the stabilization and control of future spacecraft, payload pointing systems, and advanced transportation vehicles. The work is focused in two primary areas: the stabilization and control of large flexible structures in space and advanced control techniques for the next generation of space transportation vehicles. In the first area, the effort will be a continuation of the ongoing analytical and experimental investigation of flexible body control techniques. Here, the principal end product will be new control techniques for pointing, slewing, and actively rigidizing large systems in space. The second area represents an expansion in scope to address improvements in vehicle control design practice which will result in reduced transportation system operational cost and at the same time enhance system reliability and utility.

**W89-70079** **(51) 506-46**
Goddard Space Flight Center, Greenbelt, Md.
**CONTROLS AND GUIDANCE RESEARCH AND TECHNOLOGY**
Harry P. Frisch 301-286-8730

The objective of this RTOP in computational controls is to achieve a 2 to 4 orders-of-magnitude improvement in spacecraft control design, modeling and simulation tools. These computational analysis tools are to be generic in nature and designed to satisfy both immediate, mid- and far- range NASA mission needs. The two prime areas of work concentration will be in multibody dynamics simulation and control system design and analysis. Multibody dynamics theory and associated software eliminates the need to derive, code and debug complex equations of motion. Any dynamic system which can be modeled as a system of rigid and flexible bodies subject to both active and passive control can be modeled as a multibody system. Demonstration problems will be defined and solved via emerging 5th generation software to insure that their capabilities will satisfy NASA flexible structure analysis needs. Interactive control system design and analysis tools have increased the productivity of project support engineers by orders-of-magnitude over the past several years. It is essential that multivariable, nonlinear, optimal control and other related methods be made accessible to project support engineers. An automated compensation design capability will be developed and implemented within INCA.

**W89-70080** **(72) 506-46**
Lyndon B. Johnson Space Center, Houston, Tex.
**CONTROLS AND GUIDANCE RESEARCH AND TECHNOLOGY**
K. J. Cox 713-483-8224

The objective is to develop and assess guidance, navigation, and control concepts, techniques and design methodologies to provide needed capabilities for full and cost-effective utilization of current and future space systems. Methodologies for cost-effective development, implementation and verification of control capabilities will also be evaluated. Technology needs will be addressed across interacting space fleet elements, including the Shuttle, OMV, OTV, MMU, free-flyers, aeromaneuvering planetary and earth return vehicles, and Space Station. Studies will be directed toward technology developments which have the broadest application to these fleet elements and which integrate the requirements and constraints associated with the interactions of these elements. Emphasis will be placed on the development of control technologies supporting integrated orbital operations and services. This activity will also involve the development and demonstration of a system architecture and associated design and evaluation methodologies which will effectively serve the need for advanced information processing across a broad spectrum of future NASA missions. The approach used will be to conduct studies, analyses, and trade-off studies to define hardware and software requirements.

**W89-70081** **(23) 506-46**
Langley Research Center, Hampton, Va.
**CONTROLS AND GUIDANCE RESEARCH AND TECHNOLOGY**
J. F. Creedon 804-865-4915
(585-01-00)

The goal is to provide fundamental and applied guidance, navigation, and control (GN and C) research and technology for advanced spacecraft, space platforms, and transportation vehicles. Major activities are to advance the state of the art in control of large flexible space structures through the development of advanced modern control theories and attendant analytical and design tools. Advanced, autonomous GN and C concepts are under study for future space transportation system elements, as well as orbital return and planetary entry vehicles using aerodynamic deceleration. Advanced control modeling techniques and on-line identification will be utilized with dynamic models of such spacecraft as a manned space station, Shuttle-attached experiments, large diameter antennae, advanced space transportation system concepts, and reentry vehicles. Resulting GN and C system implementations will be thoroughly evaluated via high fidelity computer simulations, and where applicable in conjunction with complementary ground and flight test programs.

**W89-70082** **(55) 506-46**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**CONTROLS AND GUIDANCE RESEARCH AND TECHNOLOGY**
A. F. Tolivar 818-354-6215
(505-55-01)

The objectives are to develop and evaluate advanced control and guidance concepts, designs, algorithms, computational tools, and components required for the autonomous control, pointing, guidance, and stabilization of future space systems including large space antennas and platforms, the evolutionary space station, orbit transfer vehicles, and advanced earth orbiters and planetary spacecraft. The approach is to: (1) develop and validate system identification techniques and software for automated monitoring of system performance, adaptive control designs for autonomous compensation of dynamic uncertainties and/or configuration change; (2) develop two advanced guidance and control components: FORS a long-life all-solid-state integrated optics fiber gyro, and SHAPES, a 3-dimensional position optical sensor for static and dynamic figure measurement and dynamic identification of flexible spacecraft and large antennas; (3) develop and evaluate sub-micron accuracy control sensor concepts suitable for future large optical space interferometers and segmented systems; (4) develop and validate controls and guidance concepts for future aeromaneuvering spacecraft; and (5) initiate the development of next-generation computational control design and simulation tools.

## Human Factors Research and Technology

**W89-70083** **(55) 506-47**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**HUMAN FACTORS RESEARCH AND TECHNOLOGY**
A. K. Bejczy 818-354-4568
(906-00-00)

The general objective is to develop the technology base for man-equivalent capabilities in remote material handling, construction, servicing and other manipulative operations which require mechanical dexterity together with the fusion of a variety of sensor information conveyed to the operator during task performance. The basic man-equivalent capability for manipulative dexterity resides in the dexterous capabilities of end effectors attached to remote manipulators. The technical approach to providing man-equivalent capabilities for remote manipulation with rich information feedback to the operator will utilize the design, development and evaluation of a dexterous and anthropomorphic arm-hand system in master-slave hybrid position and force feedback mode of control, which functionally can be operated from a crew-station. The development will start with a single master-slave arm-hand system, followed by the development of a dual master-slave arm-hand system configuration. The system evaluation and demonstration will start with no time delay in the control communication, followed with short (less than 1 sec) time delays and with longer (3 to 5 sec) time delays between operator and remote work site. Some of the evaluation and demonstration effort will be conducted jointly with NASA ARC.

**W89-70084** **(72) 506-47**
Lyndon B. Johnson Space Center, Houston, Tex.
**HUMAN FACTORS RESEARCH AND TECHNOLOGY**
B. J. Woolford 713-483-3701

The objectives of this RTOP are to develop technologies for increasing the productivity, efficiency, effectiveness, and safety of man-systems interactions in spaceflight, and to advance the fundamental understanding of human interaction with increasingly complex and automated systems. The major tasks within this RTOP include development of guidelines for man-machine interfaces, development of models and developing sophisticated means for data collection, developing a technology base of human interfaces with artificial intelligence, and development of new technology crew interface and performance aids for the extravehicular astronaut. To complement the basic research performed under this RTOP, the approach emphasizes the transfer of technologies developed from the research activities to a state that permits applications to ongoing programs. The tasks for Crew Station Human Factors cover a range of activities, from examining display formats and procedures to collecting and analyzing the operational experience of humans in space. The emphasis is on analysis of the results leading to models and guidelines that can be generally applied. A computer model describing human motion in 0-g is being developed, and tested with experimental data. Display formats for EVA are being tested on helmet-mounted display prototypes.

**W89-70085** **(21) 506-47**
Ames Research Center, Moffett Field, Calif.
**HUMAN FACTORS RESEARCH AND TECHNOLOGY**
M. G. Shafto 415-694-6170
(505-67-00; 591-32-00; 506-41-00)

Relative to previous space missions, the Space Station Freedom and other manned missions now being planned will involve more autonomous operation to reduce the costs of ground support. They will also incorporate more automated on-board systems to increase productivity. Freedom will house and support a more heterogeneous crew, and will use extravehicular activity (EVA) on a routine operational basis. To ensure high levels of safety and productivity for future space missions, research will be conducted in two areas: crew-station design and EVA. The objectives are to develop a technology base for intelligent operator interfaces, especially interfaces to autonomous subsystems, and to develop a new generation of high-performance space suits, gloves, and end effectors that meet the requirements of advanced space missions. Research will be conducted in laboratories and simulators. Demonstrations of interface technology will be conducted in engineering testbeds at Ames and other NASA Centers. Advanced suits, gloves, and portable life-support concepts will be developed, prototyped, and tested to provide proofs of concept.

## Space Flight Research and Technology

**W89-70086** **(22) 506-48**
Lewis Research Center, Cleveland, Ohio.
**SPACE FLIGHT RESEARCH AND TECHNOLOGY**
E. P. Symons 216-433-2853
(591-23-00)

The objective of the Space Flight R and T program is to provide for the flight verification and evaluation of advanced technolgies for future space systems. The program elements contained in this submittal include Cryogenic Fluid Management, Experimental Outreach Studies, and In-Space Research. The Cryogenic Fluid Management element of the Space Flight R&T program is focused on developing the technology required to effectively and efficiently manage subcritical cryogenic fluids in the low gravity space environment including the storage, acquisition and transfer of cryogenic fluids. The Experimental Outreach Studies element provides a mechanism for: (1) the definition and development of advanced in-space technology experiments with the aerospace industries and universities, and (2) the validation and verification of these technologies using the nations space facilities. The In-Space Research element is aimed at providing the evaluation and demonstration of technologies for advanced space vehicles and systems through in-space experiments to obtain data which can be used to verify anlalytical models or provide demonstrations of technology readiness.

**W89-70087** **(21) 506-48**
Ames Research Center, Moffett Field, Calif.
**SPACE FLIGHT RESEARCH AND TECHNOLOGY**
J. O. Arnold 415-464-5265
(506-40-00; 506-43-00)

The objective is to utilize the Space Shuttle as a flight research facility to obtain data to support and augment the research and technology base for advanced space transportation systems. A better understanding of thermal protection system (TPS) performance during Orbiter entry will allow creation of options for TPS cost and weight reductions and improved TPS temperature and durability capabilities for the current Space Shuttle and advanced aerospace/hypersonic vehicles. Three separate experiments will be flown as test panels or tiles replacing baseline TPS on the Orbiter during operational flights. These experiments take advantage of the actual entry heating environment that cannot be fully simulated in ground facilities. The experiments will investigate TPS convective heating effects and will demonstrate advanced TPS materials for possible Orbiter retrofit and for application to advanced vehicles. Baseline TPS procedures and instrumentation will be used to the maximum extent practical. There will be no impact on Orbiter operations. These experiments will be designed, developed, and fabricated through both in-house and contract efforts. This RTOP will also provide technical management support for the In-Space Technology Experiments Program.

**W89-70088** **(72) 506-48**
Lyndon B. Johnson Space Center, Houston, Tex.
**SPACE FLIGHT RESEARCH AND TECHNOLOGY**
R. L. Spann 713-282-1831

The objective of the Orbiter Experiment (OEX) Program is to collect data in the technology disciplines that will augment the research and technology base for future spacecraft design. Flight data relative to these disciplines will be collected by the development of unique experiments compatible with the flight operational capabilities of the Orbiter. Studies will be conducted to determine the optimum method of utilizing the Shuttle System to conduct research and technology. This RTOP includes the effort associated with overall project management, project support, experiment development initiation, experiment compatibility assessments, experiment integration activities, and integration hardware development for OEX and In-Space technology experiments.

**W89-70089** **(51) 506-48**
Goddard Space Flight Center, Greenbelt, Md.
**SPACE FLIGHT RESEARCH AND TECHNOLOGY**
Jack J. Triolo 301-286-8651

The objective of this RTOP is to develop a flight experiment to study effects of the shuttle and surrounding ambient on return mechanisms of outgassing from payloads. This data will support analytical prediction model development and verification. The approach is to develop, fabricate, test and fly a simple source and sensor package mounted on an extendable tube mast. The mast can be supplied by ESA. The experiment will be activated, so that measurements can be taken in the shuttle bay and at various distances from the shuttle bay. This RTOP will also provide technical management and payload integration support to the In-Space Technology Experiments program.

**W89-70090** **(55) 506-48**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**SPACE FLIGHT RESEARCH AND TECHNOLOGY**
A. K. Bejczy 818-354-8581
(906-00-00)

The objective is to conduct a flight experiment to demonstrate, space telerobot control, and to generate basic science data on human operators in performing various microgravity telerobotic operations. The experiment will evaluate the effect of different types of sensory feedback information on performance of both ground-based and space-based operators. The efficacy of predictive displays as a means of performance improvement will also be investigated. The approach to implementing this experiment is to take advantage of the German Robot Technology Experiment (ROTEX) being flown on the Spacelab D-2 mission. An advanced Force Reflecting Hand Controller (FRHC), force-torque display will be integrated with the German robot arm, and will be operated sequentially with the German isometric controller. This RTOP will also provide technical management support for the In-Space Technology Program.

**W89-70091** **(23) 506-48**
Langley Research Center, Hampton, Va.
**SPACE FLIGHT RESEARCH AND TECHNOLOGY**
W. R. Hook 804-865-2893
(506-40-00)

The objective of this research is the development of advanced space systems technologies through a broad-based program of in-flight experimental research. This program provides for data measurement and systems evaluation and verification in the true space flight environment, when such research cannot be adequately accomplished in ground-based simulations or facilities. The approach is to: (1) develop and fly instruments which make use of the Space Shuttle Orbiter as a research vehicle to obtain data to be used to improve our ability to extrapolate ground-based data and predictions to the actual entry environment for advanced space transportation systems; (2) develop and fly instruments which use the orbiter as an in-orbit test platform on which to conduct experiments to improve our understanding of the orbital environment, the performance of space structures in that environment, and the atmospheric environment; and (3) develop requirements and instrumentation concepts that could be used in extracting in-flight data from a space station.

## Systems Analysis

**W89-70092** **(62) 506-49**
Marshall Space Flight Center, Huntsville, Ala.
**SYSTEMS ANALYSIS**
J. F. Macpherson 205-544-5936

Two second generation space transportation systems (i.e., the Shuttle II and the Full Evolved Shuttle) are being studied and traded with emphasis on reducing the total Life-Cycle-Cost (LCC) of delivering payloads to earth orbit. Propulsion is a key area where the cost elements are high and may therefore provide a fertile area for cost reduction. Therefore, it is the intent of this study to address new and innovative chemical propulsion concepts not now being considered in the current propulsion studies, to compare them with those now being studied, and to define the technologies to implement these new concepts. The study will concentrate on hydrogen oxygen, pump-fed engine systems that show promise for significant reductions in cost and improvements in vehicle performance. System design, development, manufacture, and operations features will be addressed. Engine system reliability, maintainability, and low cost will be merits of comparison. The study will be done in concert with two vehicle system inhouse NASA studies for Shuttle II and the Fully Evolved Shuttle on-going. Study results will include engine system and technology definitions. Technology definition shall include selection, description, and benefits/rationale. The benefits will show the effect on performance, weight, and cost.

**W89-70093** **(22) 506-49**
Lewis Research Center, Cleveland, Ohio.
**SYSTEMS ANALYSIS**
H. W. Brandhorst 216-433-6149

Element 1 is to survey, identify and define advanced space propulsion system concepts and evaluate the performance of the resulting systems for missions ranging from near-term unmanned applications to far-term manned planetary exploration of Mars and the Moon. This task will result in the identification of the non-chemical space propulsion concepts and component technologies with the greatest promise of meeting both near- and far-term space transportation needs. Element 2 is to identify, assess, and prioritize high leverage spacecraft technologies. SPACECRAFT 2000 Program is targeting those technologies that have a large payoff in large numbers of diverse missions. The approach calls for liaison with industry, and both in-house and contracted studies. Early results from the contracted Technology Impact Study will be used in planning the global change technology initiative. Element 3 is to define and develop system level technology requirements for advanced power, propulsion and communications systems and to evaluate their impact on the evolutionary space station elements including: fuel depots; assembly nodes; science, commercial and communications platforms; and supporting vehicles. The results of these studies will be used to develop evolutionary systems requirements data bases and to identify high payoff technologies.

**W89-70094** **(55) 506-49**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**SYSTEMS ANALYSIS**
A. K. Bejczy 818-354-9330
(906-00-00)

The objectives are to identify critical technology needs for future high priority NASA missions and to assist in the formulation of the necessary supporting technology development programs. Studies will contribute to planning for the Global Change Technology Initiative and will evaluate the technology needs of Solar Probe, Comet Nuclear Sample Return, optical interferometry and extra-solar planetary system detection missions. Studies will also address the potential contribution to future missions of micro-spacecraft technologies and the requirements for development of advanced propulsion concepts. To ensure the achievement of greatest scientific return and maximum cost effectiveness, technological approaches will be carefully evaluated in terms of capability, performance, risk, and cost. Resulting information on the benefits, costs, and development plans/schedules for each of the technologies considered will be presented to NASA program managers.

**W89-70095** **(51) 506-49**
Goddard Space Flight Center, Greenbelt, Md.
**SYSTEMS ANALYSIS**
G. E. Rodriguez 301-286-6202

The objective of this program is to identify the high leverage enabling and enhancing technologies unique to future NASA Earth Observing Science Missions, including the Earth Observing System and the Global Change Program. The approach will be to perform system studies identifying the science and mission parameters, analyze and develop engineering requirements for mission sets, and map these against updated technology trends and forecasts to determine areas which require technology development.

**W89-70096** **(23) 506-49**
Langley Research Center, Hampton, Va.
**SYSTEMS ANALYSIS**
W. R. Hook 804-865-2893

The technical objectives of this research are to identify technology requirements for advanced space systems and to synthesize these requirements into comprehensive and timely technology development plans; to advocate research and technology development programs which satisfy these requirements; and to support conceptual design and development of future spacecraft, advanced Earth- and space-based transportation vehicles, lunar and planetary transportation systems and large space antennas, platforms, and space stations via system-level analyses and supporting flight research. In-house and contracted analytical capabilities and computational and experimental facilities will be utilized to accomplish these objectives. Computer-aided engineering, design, and simulation capabilities will be expanded to meet the analysis and technology assessment needs.

**W89-70097** **(10) 506-49**
National Aeronautics and Space Administration, Washington, D.C.
**SYSTEMS ANALYSIS**
Fred P. Povinelli 202-453-2733

The objective of this RTOP is to provide space program studies in support of OAST space technology program requirements, assessments, planning, and advocacy. The studies are intended to provide an analytical basis for planning activities in space R and T. Areas of work will include: technology status and trends assessments; mission concepts and systems; long-range planning activities; program technology needs, requirements, and opportunities. Activity will also include other study contracts, and consulting services in support of advanced system concepts and policy analysis issues such as those relating to CSTI, Pathfinder, and potential new or changing roles for OAST in Space R and T.

**W89-70098** **(72) 506-49**
Lyndon B. Johnson Space Center, Houston, Tex.
**SYSTEMS ANALYSIS**
K. Fairchild 713-282-1880

The objective of this RTOP is to assess the technology requirements that are associated with the evolution of the U.S. civil space transportation system. A structure is being developed to study options and make recommendations as to how Earth-to-Orbit civil space assets, an technological capabilities that currently exist in NASA, DOD, and the private sector, can evolve to regain space leadership through the 1990's and beyond. Emphasis will be on a crew optimize capability, cargo optimized capability, demonstrations and precursors. Primary evaluation criteria will be safety and reliability, performance increases, and cost effectiveness. A number of task teams were established to investigate specific areas of spaceflight evolution. These areas include architectures operations, costing, etc. Representatives from these areas will form the technology team, to capture the technology requirement and opportunities uncovered in each of the teams. In addition, number of workshops will be held to further understand these requirements and opportunities. A support contract will be negotiated to provide logistical and documentation assistance.

**W89-70099** **(21) 506-49**
Ames Research Center, Moffett Field, Calif.
**SYSTEMS ANALYSIS**
M. G. Shafto 415-694-6170

The first objective is to define a program plan for research and development of planetary systems detection technologies for OAST to meet OSSA's program goals for Origins and Evolution. Initially, the state-of-the-art of planetary detection techniques will be characterized. Opportunities to advance these techniques will then be investigated and prioritized. The approach will be to conduct a study and a preliminary workshop to determine planetary detection technology status and needs. A final set of needs will be selected, categorized and prioritized at a subsequent workshop, based on feasibility and utility. An OAST research and development program plan for the orderly development of planetary systems detection technologies will be assembled. The second objective is to assess the potential of bionics, that is, the derivation of engineering design principles from nature, to contribute technologies and applications of significant benefit to NASA, and to identify opportunities for accelerated research. The approach will be to conduct a study to survey bionics research and accomplishments to date and their applicability to advanced aerospace systems of interest to NASA. The study will produce a report which documents the survey, identifies opportunities for accelerated research, and provides an overview for management and a guide for researchers.

## University Space Research

**W89-70100** **(10) 506-50**
National Aeronautics and Space Administration, Washington, D.C.
**UNIVERSITY SPACE ENGINEERING RESEARCH**
Frederick P. Povinelli 202-453-2733

The objective of the university space engineering research is to enhance and broaden the capabilities of the nation's engineering community to participate more effectively in the U.S. civil space program. The program responds to remedy the decline in the availability of qualified space engineers by making a long-term commitment to universities. The program is managed from the Office of Aeronautics and Space Technology at NASA Headquarters, utilizing technical monitors at NASA centers to foster collaborative arrangements, exchange of personnel, and the sharing of facilities between NASA and the universities. The program elements include the university space engineering research program, that supports interdisciplinary research centers; the university investigators research program, providing grants to individuals with outstanding credentials; and the university advanced space design program, which funds advanced systems study courses at the senior and graduate levels.

## NASP Hypersonics Research and Technology-Space

**W89-70101** **(23) 506-80**
Langley Research Center, Hampton, Va.
**NASP HYPERSONICS RESEARCH AND TECHNOLOGY - SPACE**
Roy V. Harris 804-865-3285
(505-80-00; 763-01-00)

The objective is to provide advanced technologies on a schedule consistent with the needs and requirements of the NASA/DOD National Aero-Space Plane (NASP) Program. Key research and technology efforts are required in the following areas: (1) propulsion, to provide mature high-speed propulsion technologies in areas such as scramjets, engine components, and complete engines; (2) aerodynamics (including computational fluid dynamics), to provide insight into the stability and control of vehicle concepts, the aerothermodynamic environment to which the airframe will be exposed, the complicated flow fields about the vehicle and at crucial locations such as the inlet of engines and vehicle afterbodies, and integration of the high-speed propulsion system with the airframe itself; (3) structures and materials, to provide characterization of a select group of advanced high-temperature/high-strength materials and verification of their applicability to hypersonic structures concepts, and cryogenic tankage concepts; (4) flight systems, to establish flying quality requirements and to develop guidance, navigation, and control methodologies required to meet NASP performance objectives and mission goals; and (5) systems integration which provides the methodology for and the assessment of the performance levels of particular subsystems or components on overall vehicle performance.

**W89-70102** **(22) 506-80**
Lewis Research Center, Cleveland, Ohio.
**NASP HYPERSONICS RESEARCH AND TECHNOLOGY - SPACE**
L. A. Diehl 216-433-2438
(505-80-00; 763-01-00)

The objective is to provide advanced technologies on a schedule consistent with the needs and requirements of the NASA/DOD National Aero-Space Plane (NASP) Program. Key research and technology efforts are required in fuel system thermal management, to provide mature technology in areas such as para-to-ortho conversion of hydrogen, thermal properties code, vehicle thermal management code, subsystem thermal management codes, componenet codes, and enhanced heat transfer technologies. The research and technology efforts will be accomplished using both experiments and analysis.

## Interdisciplinary Technology

**W89-70103** **(10) 506-90**
National Aeronautics and Space Administration, Washington, D.C.
**INTERDISCIPLINARY TECHNOLOGY**
Edmund L. Sanchez 202-453-2790

The objective of this effort is to provide for the Resident Research Associateship (RRA) program. The RRA program is administered by the National Research Council of the National Academy of Sciences under contract to NASA.

# Civil-Space Technology Initiative (CSTI) Program

## CSTI-Automation and Robotics

**W89-70104** **(72) 549-02**
Lyndon B. Johnson Space Center, Houston, Tex.
**ROBOTICS**
G. J. Reuter 713-483-1520
The objective of this RTOP is to demonstrate advanced closed loop control by application of OAST developed force/torque sensor and control algorithms to the Shuttle Remote Manipulator System (RMS) in order to influence future RMS upgrades. In this demonstration, a force/torque sensor will be integrated into a full-scale hydraulic (low fidelity dynamics) simulator at JSC (the Manipulator Development Facility) to demonstrate the utility of force/torque feedback for teleoperation (shared control) and for telerobotics (traded control). The use of the force/torque sensor will also be incorporated into the Systems Engineering Simulator (high fidelity dynamics including RMS bending modes) to provide a high correlation between simulated and on-orbit manipulator dynamics. Series of established on-orbit procedures will be modified to utilize the force/torque feedback and then will be executed in each of these facilities by engineers and astronauts experienced in the use of the RMS to quantify the capability enhancement.

**W89-70105** **(10) 549-02**
National Aeronautics and Space Administration, Washington, D.C.
**CSTI-ROBOTICS**
Lee B. Holcomb 202-453-2747
The purpose of this RTOP is to conduct space operations research with particular emphasis on human capabilities assisted by various levels of automation. The research will be conducted by developing and testing a beam assembly teleoperator (BAT) for use in neutral buoyancy tests. Also tests will be conducted of closed cabin free flyers, head up displays for control of maneuvering units, simulation of telepresence technology, investigation of the human function in supervisory control and the investigation of expert system for task assignment and housekeeping aboard a space station. This work will be carried out under a grant to MIT.

**W89-70106** **(21) 549-02**
Ames Research Center, Moffett Field, Calif.
**ROBOTICS**
Henry Lum 415-694-6544
(549-03-00)
The objective is to develop and test integrated knowledge-based systems, control, and human interface strategies for free-flying, autonomous intelligent robots which will obtain the maximum level of productivity from an astronaut team. Through the development and use of intelligent robots, a single human will be able to accomplish a larger set of complex tasks rather than concentrate on and execute repetitive, labor-intensive tasks. Current emphasis is on the real-time control of mobile, intelligent two-arm Satellite Robot Simulator Vehicles (SRSV) and on the development of intelligent work stations for integration with the Telerobotics Test Bed/Demonstration at NASA/JPL. The basic SRSV systems research is being conducted at the Stanford University Aerospace Robotics Laboratory in collaboration with DARPA and NSF. Current research elements include: autonomous navigation and task level control of satellite robots, real-time control of cooperating arms, and object manipulation strategies. A research effort has also been initiated at Stanford University (Departments of Computer Science and Aeronautics and Astronautics) to integrate the Artificial Intelligence research with the robotics research focusing towards the development of an intelligent robot within five years.

**W89-70107** **(76) 549-02**
John F. Kennedy Space Center, Cocoa Beach, Fla.
**ROBOTICS**
R. M. Davis 407-867-2780
The objective of this effort is to demonstrate the use of advanced robotics technologies to perform the connecting and disconnection of the STS External Tank GH2 umbilical. This project was initiated as a seven year effort commencing with a first year goal of procuring a Robotic Prototype Development System to provide the electromechanical tools necessary to perform advanced robotic development. Year two incorporated a Robotics Application Development Laboratory (RADL) at the Launch Equipment Test Facility (LETF). Year three involved fabrication/testing of several work cells to evaluate compliance techniques and end-effectors, development of 3-DOF tracking algorithms (both visual and force-torque) and the development of compliance techniques. This RTOP addresses years four thru six of this project. In year four, 3-DOF tracking and preliminary prototyping of a robotically operated umbilical will be demonstrated. Year five involves testing of the prototype and refinement of tracking algoritýms and mating mechanisms. Year six entails the upgrade of a tracking simulator from 3-DOF to 6-DOF using an additional robot as a real-time simulator. Year six cumulates in a realistic high-fidelity applications demonstration of a 6-DOF remote umbilical mate/demate.

**W89-70108** **(51) 549-02**
Goddard Space Flight Center, Greenbelt, Md.
**ROBOTICS**
Henry H. Plotkin 301-286-6185
The GFSC program in robotics research and technology is directed at creating the ability for autonomous robots to generate their own plans for disassemble, assembly, and servicing of complex assemblies, using Computer Aided Design (CAD) derived geometric knowledge-bases and spatial reasoning. Laboratory robots execute plans and use sensor feedback to accommodate real-world errors and uncertainties.

**W89-70109** **(62) 549-02**
Marshall Space Flight Center, Huntsville, Ala.
**ROBOTICS**
J. B. Haussler 205-544-1762
The overall objective of this research is to provide development of the highly experimental technology of telerobotics for orbital assembly and servicing of a space station, platforms, and satellites. This research is focused on developing methodology for evaluation and selection of telerobot systems and demonstrations using scaled test tasks and quantitative measurements. The effort has developed sensored task simulator with graduated difficulty and quantitative measurements which can be used in a test methodology for evaluation of telerobotic demonstrations and systems. Manipulator position and attitude, and operator inputs during a task will also be recorded.

**W89-70110** **(23) 549-02**
Langley Research Center, Hampton, Va.
**ROBOTICS**
J. F. Creedon 804-865-4915
The objective of the activity is to provide automated manipulator, mobility, sensing, and actuation technology needed for future NASA teleoperation and robotics applications such as satellite servicing, maintenance and repair, structural assembly, and space manufacturing. The development and evaluation of optical sensing/processing are additional objectives of this research. The approach is to conceputalize, evaluate, and verify algorithms, sensors, actuators, software, and system architecture required for remote space operations. The research will be conducted through simulation and laboratory hardware

experimental tests. The current plan is to investigate cooperative human/machine control of manipulator systems and to augment the human teleoperator control through the application of advanced control technology to automate the system, elevating the operator to higher levels of supervisory control.

**W89-70111** **(55) 549-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**ROBOTICS**
Wayne R. Schober 818-354-8581
(506-47-00; 549-03-00; 506-48-00; 591-11-00; 591-12-00)

The general objective is to develop the technology base required in teleoperators, teleoperator human factors, artificial intelligence, and robotics. This will include automated manipulation, sensing, control and actuation technology required for future NASA telerobotics applications. Example applications are space assembly, space construction, satellite servicing, space exploration, and platform maintenance and repair. The areas of technology will span from operator interface to the end effectors (hands) of the robot and will include: (1) sensing and perception; (2) planning and reasoning; (3) control execution; (4) operator interface; and (5) system architecture and integration. The general approach has two parts: (1) develop core technology which has multiple applications in automation and robotics; and (2) focus the technology in a Telerobotics System Integration Testbed to integrate and accelerate transfer of the diverse technologies through ground-based system proof-of-concept. The telerobotics testbed will integrate core technologies to provide system level, ground based, proof-of-concept demonstrations of telerobotics capability.

**W89-70112** **(62) 549-03**
Marshall Space Flight Center, Huntsville, Ala.
**AUTONOMOUS SYSTEMS**
J. B. Haussler 205-544-1762

The primary goal of the HSTDEK Project is to enable major NASA projects to capture the design/engineering expertise they have acquired during the development of their systems in a knowledge base capable of supporting multiple applications. In order to accomplish this, current knowledge engineering technology must be extended in several areas, the new technology must be validated, and a mechanism established for transferring it to users within NASA. Several specific objectives have been identified for the project: (1) To develop a methodology for constructing multi-application, large-scale knowledge bases; (2) To develop a methodology for acquiring knowledge from multiple domain experts representing different technical disciplines, and integrating it into a single knowledge base; (3) To develop an approach for integrating knowledge engineering into the traditional engineering activities which comprise a system development effort; and (4) To validate this new technology in the context of a major NASA Program: construction of a deep, comprehensive knowledge base for the Hubble Space Telescope; (5) Develop an in-house knowledge engineering capability for NASA to apply this new technology and support its validation; (6) Establish a program for making this new technology available to major new NASA projects, beginning with Space Station and AXAF. The basic technical approach taken in HSTDEK is to start the development of a comprehensive design/engineering knowledge base for the HST using currently available knowledge engineering tools.

**W89-70113** **(22) 549-03**
Lewis Research Center, Cleveland, Ohio.
**AUTONOMOUS SYSTEMS**
H. W. Brandhorst 216-433-6149

The objective of Element 1 is to provide program support to the Systems Autonomy Demonstration Program (SADP) by carrying out the Power Systems Autonomy Demonstration (PSAD), which is an element of the 1990 System Autonomy Demonstration. This is the second in the SADP series of demonstrations that apply advanced automation technologies to Space Station Systems. This program is suballoted from Ames Research Center and focused to highlight benefits of applying advanced automation technologies and core technologies, such as planning and scheduling, energy/power resource allocation, fault diagnosis for anticipated failures, rule based simulation, coordination control of the Electrical Power System (EPS) and the Thermal Control System (TCS). Also included will be the Core Module (CM).

**W89-70114** **(76) 549-03**
John F. Kennedy Space Center, Cocoa Beach, Fla.
**AUTONOMOUS SYSTEMS**
J. E. Galliher 407-867-3224

The objective of this work is to provide the systems autonomy development program with the development of diagnostics and control software that will be demonstrated on actual shuttle launch processing ground systems hardware that are similar to electromechanical systems that will be used for space station. Development of core technology diagnostics and control software has been underway at Kennedy Space Center (KSC) for four years. There have been two parallel software developments underway at KSC. The knowledge-based autonomous test engineer (KATE) control and monitor shell, which uses a frame-based, source/path/sink structure; and the generic model-based diagnostic system (GMODS) software which uses an object-based structure. During late 1989, the lessons learned from the GMODS project will be incorporated into more comprehensive (from a functionality viewpoint) KATE shell, and the KATE shell will be used and improved for future demonstrations and operational systems. The objectives of the KSC project are to improve efficiency of the existing KSC launch processing system, to reduce the manpower required to process the shuttle, and to increase the reliability of the system and the process so the proposed heavy launch rates can be better accommodated, as well as developing diagnostics and control concepts for the space station ground processing system and future launch vehicle ground systems.

**W89-70115** **(55) 549-03**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**AUTONOMOUS SYSTEMS**
Wayne R. Schober 818-354-2555

The objective of this task is to develop and demonstrate technologies which enable and enhance the multi-mission capabilities of ground data systems for spacecraft. This task will develop automated tools commonly applicable to spacecraft telemetry and operations ground data systems. Techniques will be developed for automated real-time monitoring and diagnosis functions. A long term objective is to develop technology which enables integration of uplink and downlink operations. The long-term task is divided into two steps: the development of automated telemetry monitoring functions, and the application of these functions to spacecraft subsystems in a demonstration parallel to operations. A series of demonstrations of increasing automated capability are planned. With the objective of a demonstration during the Voyager encounter of Neptune, on-going work will focus on automated monitoring of spacecraft telemetry with subsequent extension to ground data systems. The products of the task will be software demonstrations of automated monitoring and diagnosis capability which are ready for transition to operational use. One specific goal of the demonstrations is to show the potential for productivity enhancement in mission operations.

**W89-70116** **(72) 549-03**
Lyndon B. Johnson Space Center, Houston, Tex.
**AUTONOMOUS SYSTEMS**
J. F. Muratore 713-483-0796

Almost every NASA space and aeronautical mission involves the use of mission control facilities to monitor telemetry from aerospace vehicles. Among the most famous of these is the Space Shuttle Mission Control Center (MCC) at the Lyndon B. Johnson Space Center. The MCC utilizes mainframe based processing with limited automation to monitor Space Shuttle flights. The objective of this RTOP has been to introduce expert system and workstation technology into the MCC, place it in the hands of the operational users, and demonstrate the value of this technology in a real NASA space operations environment. The approach in this RTOP has been to develop a workstation based real time rule based expert system to monitor the Space Shuttle Integrated Communications Systems (INCO), and to place this system in the MCC for evaluation during simulations and Space Shuttle missions. The system runs in parallel with the mainframe system to allow side by side comparisons of the two technologies. This effort started in August 1987 and the system was moved into the MCC in April 1988. The system will be used to support STS-26.

**W89-70117** **(23) 549-03**
Langley Research Center, Hampton, Va.
**AUTONOMOUS SYSTEMS**
J. F. Creedon 804-865-4915

The objective of this activity is to increase the technology of planning and reasoning automation needed for future NASA space and ground-based operations. In particular, this activity will examine new approaches to planning and scheduling problems, and will develop the methodology required to build validatable knowledge-based systems. The approach is to examine the planning and scheduling requirements of NASA, to evaluate available planning/scheduling software in light of these requirements, and to examine the use of competition-based connectionist systems as a domain-independent framework for planning/scheduling solutions. Additionally, quantitative parameters will be defined to characterize the effects of an embedded knowledge-based system on the total system reliability. Analytical error models and/or simulative techniques will be developed for measuring these parameters. Guidelines will be developed for designing validatable knowledge-based systems. A methodology and tools for quantifying the reliability of these systems will be developed.

**W89-70118** **(51) 549-03**
Goddard Space Flight Center, Greenbelt, Md.
**AUTONOMOUS SYSTEMS**
Walter F. Truszkowski 301-286-8821

The overall objective is to research and develop the basic technologies of knowledge-based systems required to achieve successfully higher levels of autonomous activity in command and control systems both on the ground and in space. The immediate testbed for these technology developments will be near-earth spacecraft control ground/space systems. The general approach will be to develop advanced system architectures incorporating multiple knowledge-based systems which operate in a coordinated and cooperative fashion to achieve operational system objectives.

**W89-70119** **(21) 549-03**
Ames Research Center, Moffett Field, Calif.
**AUTONOMOUS SYSTEMS**
Henry Lum 415-694-6544
(506-45-00; 506-47-00)

The objective is to develop technologies in artificial intelligence and information sciences leading to advanced automation for spaceborne and ground-based applications. Emphasis is in the areas of spaceborne symbolic multiprocessing architectures, machine learning, advanced planning and scheduling, cooperating knowledge-based systems, operator interface, validation of knowledge-based systems and knowledge from design through operations. A cooperative Ames-academia-industry team consisting of leading researchers has been established. Through a memorandum of understanding with project centers, such as NASA/JSC and NASA/GSFC, technologies will be transferred to project applications such as Space Station and Space Shuttle. In addition, the Systems Autonomy Demonstration Program (SADP) will transfer the basic research technologies to real-time mission operations environments. The SADP will increase user confidence/acceptance of new technologies and provide a focus for the research efforts to assure their relevance to NASA problems. Program objectives are: decrease of manpower intensive tasks by at least 50 percent; decrease of documentation for failure diagnostics by at least 80 percent; and, increase in productivity by at least 20 percent.

## CSTI-Propulsion

**W89-70120** **(62) 582-01**
Marshall Space Flight Center, Huntsville, Ala.
**EARTH TO ORBIT**
J. L. Moses 205-544-1747

The earth-to-orbit propulsion technology base in support of current and future space transportation systems is to be extended and further developed. The technology described herein encompasses both oxygen/hydrogen and oxygen/hydrocarbon propulsion and is directed at enhancing engine life, performance and operability. The activity is divided into two categories, technology acquisition and technology validation. Technology acquisition activities include analytical model development, performance improvement, cold flow testing, combustor cooling, turbine drive gas generation, control system analysis, materials and process synthesis, and advanced instrumentation development. The technology verification effort is subdivided into three areas: large scale combustor components, large scale turbomachinery components, controls and monitoring subsystems. The technology advancements emanating from the technology acquisition activity will receive a final degree of verification by testing on a large scale component, control and monitoring subsystem or on the oxygen/hydrogen engine system testbed.

**W89-70121** **(22) 582-01**
Lewis Research Center, Cleveland, Ohio.
**EARTH-TO-ORBIT**
L. A. Diehl 216-433-2438

The objective is to provide the knowledge, understanding, and design methodology that will enable the development of advanced high-performance, reusable earth-to-orbit propulsion systems with high design margins for extended component service life, and with autonomous ground and flight operations. High-density propellant systems, such as the LOX/hydrocarbons will receive special emphasis in order to provide an advanced engine technology base that will enable significant reductions in future earth-to-orbit vehicle size, mass, and cost. Specific goals include engine service life of at least 100 missions between major overhauls, up to a 20-percent increase in effective engine specific impulse, turnaround times measured in hours instead of weeks, and man-rated reliability.

**W89-70122** **(62) 582-02**
Marshall Space Flight Center, Huntsville, Ala.
**BOOSTER TECHNOLOGY**
J. E. Clark 205-544-6728

The effort described herein is directed toward developing/enhancing those technologies that will provide propulsion alternatives to the Shuttle solid rocket booster. These alternatives must have an emergency shut-down capability and an increased total safety. Technology for two concepts is being pursued, pressure-fed oxygen-hydrocarbon propulsion and hybrid propulsion. The technology for pressure-fed propulsion is focused on developing a technology data base on combustion stability of a LOX/RP-1 engine and how it is affected by a pressure-fed delivery system. The specific activities include combustion modeling for both performance and stability, combustion chamber and nozzle cooling, regenerative and ablative, expendible versus recoverable thrust chambers and demonstration of the technology in 750K lb. thrust (S.L.) engines. The hybrid propulsion effort is focused on identifying and planning and acquiring hybrid motor technology data base and demonstrating it in a large subscale motor. The specific activities include fundamentals of the liquid oxidizer-solid fuel grain reaction, recession rates, grain tailoring, grain structure, port sizing and design, ignition, oxidizer injection and distribution, thrust vector control and thrust scaling law formulation and verification.

## CSTI-Vehicle

**W89-70123** **(23) 582-02**
Langley Research Center, Hampton, Va.
**BOOSTER TECHNOLOGY**
W. R. Hook 804-865-2893

The technical objective of this research is to assess the technologies for alternate propulsion concepts for the Space Shuttle solid rocket boosters having a safe abort option and the potential for enough additional impulse to avoid the need to operate the SSME engines at over 100 percent thrust. In this activity, the existing systems analysis capability at Langley will be used to assess the performance improvements/penalties of these candidate systems.

**W89-70124** **(23) 583-01**
Langley Research Center, Hampton, Va.
**AEROASSIST FLIGHT EXPERIMENT**
W. R. Hook 804-865-2893

The objective of this project is to develop an in-space flight experiment that will provide validated technology for the design of future Aeroassisted Space Transfer Vehicles. Instrumentation is being defined and developed to obtain measurements at actual flight conditions, which cannot be simulated by ground-based facilities, and to obtain flow field information which cannot be determined by validated analysis. The instrumentation will be integrated into the AFE spacecraft and the flight will be conducted to maximize the science return such that technology needs for Computational Fluid Dynamics code validation (radiative heating, wall catalysis, alternate thermal protection material, and base flow) can be satisfied and the aerodynamic and control phenomena of this generic shape can be assessed.

**W89-70125** **(62) 583-01**
Marshall Space Flight Center, Huntsville, Ala.
**AEROASSIST FLIGHT EXPERIMENT**
L. B. Allen 205-544-1917

The overall objective of this effort is to provide for the necessary research and technology developments for the aeroassist flight experiment (AFE) to permit investigations of critical vehicle design and environmental technologies applicable to the design of an aeroassisted orbital transfer vehicle (AOTV). Aeroassist technology significantly enhances the orbital transfer vehicle (OTV) mission performance. Because aerodynamic braking maneuver will only penetrate the upper regions of the earth's atmosphere at or near geosynchronous return velocities, the AFE will provide design environments that cannot be simulated in ground facilities or determined through analysis. It is necessary, therefore, to obtain critical aerodynamic and aerothermodynamic environments for adequate flight control and thermal protection systems designs for the AOTV. These environments are subject to atmospheric variations that also influence guidance logic for successful rendezvous in low-earth orbit. Four NASA centers are involved in the project, with Marshall responsible for overall project management, carrier vehicle development, and spacecraft integration. Johnson Space Center is responsible for the aerobrake design and fabrication, as well as experiment development with Langley Research Center, and Ames Research Center is responsible for development of other major experiments.

## CSTI-Information

**W89-70126** **(22) 584-01**
Lewis Research Center, Cleveland, Ohio.
**SCIENCE SENSOR TECHNOLOGY**
Denis J. Connolly 216-433-3503
(506-44-00)

The objective of this RTOP is to provide through research, design data and developments of materials and methods, the technology base for the development of voltage tunable local oscillator sources, capable of approximately 1 milliwatt output in the frequency range between 600 to 2000 GHz. The approach taken pursues the development of voltage tunable, electron beam excited Backward Wave Oscillators (BWOs), with an expected frequency tuning range (by voltage tuning) of approximately plus or minus 10 percent above and below a center frequency. Because of the extreme smallness of slow wave structures dimensions (less than 50 microns), new methods of fabricating BWO circuits must be explored. These include reactive ion etching, laser cutting and metallization techniques. In addition, skin effect losses and direct interception will necessitate novel approaches for heat rejection.

**W89-70127** **(62) 584-01**
Marshall Space Flight Center, Huntsville, Ala.
**SCIENCE SENSOR TECHNOLOGY**
J. B. Haussler 205-544-1762

The objectives of this effort are two fold: (1) to conduct CO2 laser research for space-based lidar application; and (2) to perform investigations into cryogenic coolers and superconducting array detectors. The planned approach incorporates both in-house and contractual efforts to arrive at the desired objectives.

**W89-70128** **(55) 584-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**SCIENCE SENSOR TECHNOLOGY**
Wayne R. Schober 818-354-6758
(505-55-45)

This task develops new technologies for sensors for future NASA mission needs. Specifically the emphasis is on infrared direct detection (3 to 300 micrometers), submm heterodyne detection (100 to 1000 micrometers) and on sensor coolers. Three detector subelements are: (1) improved quantum efficiency and response of Schottky barrier IR detectors, (2) identify LWIR technologies in the range of 8 to 17 micrometers consistent with coolers and, (3) far-infrared (FIR) focal plane arrays in the 30 to 300 microns range using extrinsic Ge Blocked Impurity Band (BIB) detectors with silicon MOSFET-switch readouts for 10X32 arrays. The goal of the submillimeter heterodyne task is to develop space qualifiable receivers for the range of 300 to 3000 GHz including local oscillators (LO), mixers and antennas. The LO development is to demonstrate a solid state multiplier source with 100 microW at greater than 400 GHz. The mixer subelement is directed towards Superconductor-Insulator-Superconductor (SIS) tunnel junctions for use in submm wave heterodyne receiver arrays. The antenna array element is to develop mixers for use with NbN SIS junctions. Coolers suitable for cooling detectors in the range from sub-Kelvin to 140K would be developed. One subelement is to develop low-vibration, low-EMI sorption refrigerators for 65 to 140K. A second is directed at experiments on unique, high-leverage coolers in the sub-Kelvin to 20K range. The third is to develop generic cooler vibration and EMI test facilities.

**W89-70129** **(23) 584-01**
Langley Research Center, Hampton, Va.
**SCIENCE SENSOR TECHNOLOGY**
W. D. Mace 804-865-3745

The objective of this program is to develop all solid-state components for versatile active remote sensors supporting high-flying aircraft and space-based earth science investigations in atmospheric dynamics and chemistry. The most important of these sensors are Light Detection And Ranging (LIDAR), Differential Absorption Lidar (DIAL), and Doppler heterodyne systems. This Research and Technology Program has been structured to approach these challenges in the areas of laser materials research, laser transmitter design and development, lifetime and efficiency improvement through in-house, university grant, and industrial contract efforts.

**W89-70130** **(21) 584-01**
Ames Research Center, Moffett Field, Calif.
**SCIENCE SENSOR TECHNOLOGY**
Craig R. McCreight 415-694-6549
(506-45-00)

Advanced infrared (IR) detector array technology, and advanced detection concepts which promise to provide future IR arrays, will be developed and characterized. These arrays will be applicable in low- and moderate-background missions such as the Space Infrared Telescope Facility (SIRTF) and the Large Deployable Reflector (LDR). The goal is to achieve enhanced IR spectral response (to and beyond 200 micrometers) and improved sensitivity in anticipated orbital environments. Advanced low-noise multiplexer, impurity band conduction, and improved 30 micrometer array technology will be pursued. A second objective is to develop and demonstrate advanced cryogenic systems for future space applications. These coolers are required to have a high efficiency, low cost, an extended life, and good temperature stability. In some applications the coolers must allow the instruments to be serviced and/or replaced on orbit. Elements of this objective include pulse tube refrigerators, a 2 to 15 kelvin cooler, and advanced coolers for less than 1 kelvin operation. These activities blend analysis with component development, and include extensive in-house characterization, development, and technology demonstrations.

**W89-70131** **(51) 584-01**
Goddard Space Flight Center, Greenbelt, Md.
**SCIENCE SENSOR TECHNOLOGY**
Henry H. Plotkin 301-286-6185

In order to develop and validate sensor technology for planned future space science and application missions, research is being conducted in three areas. Components for spaceborne heterodyne spectrometers at infrared and sub-mm wavelengths from 30 to 200 micrometers are being developed. They include sensitive, wide band, efficient, interdigitated HgCdTe photoconductive mixers, and a family of new MBE fabricated PbSnSe diode laser local oscillators. Components for spaceborne laser ranging and lidar applications are being developed. Long-life flashlamps are being developed and tested. Tunable, stable, and efficient alexandrite lasers are being developed, with diode laser pumping and novel resonators to provide efficient sources for atmospheric lidar missions. Picosecond-pulse lasers and picosecond-resolution time interval receivers are being developed for the Geodynamic Laser Ranging System (GLRS) on the EOS platform. A laser source based upon Raman Scattering will provide radiation continuously tunable from 2 to 25 micrometers. Long-life spaceborne cryogenic cooler subsystems are being developed to meet requirements of sensing instruments which must operate at temperatures ranging as low as 2K. Tasks include flexure and magnetic bearings, multistage coolers, and comparisons of alternative regenerative cycles.

**W89-70132** **(23) 584-02**
Langley Research Center, Hampton, Va.
**DATA: HIGH RATE/CAPACITY**
W. D. Mace 804-865-3745

The objective is to research new concepts in space data processing and storage. This concept development will result in planning, development, and delivery of technology research and development studies, system feasibility models, and prototype proof of concept hardware in support of NASA's mission, including Advanced Aerospace Transportation Vehicles, Space Station, Co-orbiting Platforms, Polar-orbiting Platforms, and Deep Space Payloads, in the areas of Data Systems. The approach is to use mission identified needs, together with new device and systems technologies in high-speed, space qualified processors, and high rate/capacity optical storage systems, and analyses to provide an enabling and enhanced system level performance. In particular, elements will be researched and developed through the proof of concept phase, and this technology will be delivered for mission projects where appropriate. Individual tasks included are VHSIC Processor Technology, Erasable Optical Media, Laser Diode Arrays, Multichannel Controller, Optical Disk Drive, Fiber Optic Integrated Circuit transceivers, and Distributed Computing Strategies.

**W89-70133** **(51) 584-02**
Goddard Space Flight Center, Greenbelt, Md.
**DATA: HIGH RATE/CAPACITY**
John T. Dalton 301-286-8623

The objective is the development of an onboard high rate/high capacity data system called the Configurable High Rate Processing (CHRP) system, suitable for onboard spacecraft processing of space and Earth sciences sensor data. CHRP capabilities will be adaptable to the needs of different instruments and missions by reconfiguring in real time to adapt to changes in the operating environment. The architecture will adapt to support a range of high data rate imaging missions and will support evaluation of higher levels of onboard data compression, analysis and instrument control through development of onboard processor and storage technology. CHRP will be coordinated with the definition of the next generation of high rate imaging missions and will provide the total onboard data management support required for scientific operations from interface to communication link transmitters and receivers. This includes formatting, coding, editing, buffering, processing, storage, and multiplexing required by complex heterogeneous payloads operating from ten to hundreds of megabits per second. The integration of technology components from other centers in the CSTI Data Systems Program into a test bed demonstration focused on compression and management of data from EOS high rate sensors will be part of this RTOP.

**W89-70134** **(55) 584-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**DATA: HIGH RATE/CAPACITY**
David A. Nichols 818-354-8912
(506-44-00; 506-45-00)

The objective and approach of this RTOP is to provide research and technology development for specific high rate and high capacity space flight data system components. Many of the space science missions being planned for the mid-1990s and beyond will have payloads capable of producing extremely high data rates - well beyond the projected downlink communications capacity. Data system technology development included in this RTOP will both enhance the ability to make more productive scientific use of collected data and enable the deployment of instruments to make new and unique observations. Specific tasks include the development and demonstration of: (1) a next-generation flight multi-computer, capable of greater than an order-of-magnitude increase in throughput over current practice; (2) a SAR processor suitable for use on an EOS-type platform, capable of near real-time image generation and data compression; (3) a spaceborne processor capable of radiometric calibration, compression, and simple information extraction as applied to imaging spectrometer data; and (4) an autocorrelation spectrometer suitable for use in spaceborne mm-wave and submm-wave radiometers. In each task the goal will be the development of a flight qualifiable prototype which could form the basis of an actual operational or experimental unit in the EOS program or in other missions.

## CSTI-Large Structures and Control

**W89-70135** **(62) 585-01**
Marshall Space Flight Center, Huntsville, Ala.

**CONTROL OF FLEXIBLE STRUCTURES**
R. W. Schock 205-554-4060

The objective of this technology program is to develop a Ground Test Facility (GTF) to perform the advanced development studies for the Control and Structures Experiment in Space (CASES) program. The CASES flight experiment will demonstrate the flight readiness of several key Control Structure Interactions (CSI) methodologies in the early 1990's, thereby enabling future NASA science missions which will require CSI technology to proceed on course. The approach towards CASES will be to develop a prototype GTF under this RTOP in support of the CASES definition, design, and development phases. To minimize technical and cost risks, the flight proven OAST-1 test structure will be utilized in CASES. The definition phase (Phase B) is scheduled to begin in FY89 under a subsequent RTOP. The decision to proceed with CASES design and development phases will be made at the conclusion of the phase B. During the CASES design, development, and operational phases, the GTF will also support the CSI Guest Investigator program.

**W89-70136** (55) 585-01
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**CONTROL OF FLEXIBLE STRUCTURES**
W. E. Layman 818-354-3023
(506-44-00; 506-45-00)

The long range objective of this program is to identify, develop and validate the Control/Structure Interaction (CSI) technology for integrated control/structure spacecraft design that is necessary to achieve future mission goals. This research program will be part of a comprehensive NASA-wide CSI research program which will concentrate in the areas of: new integrated control/structure concepts, integrated control/structure analysis and design methodology, ground testing, and on-orbit testing. A unified team of researchers from the structures and controls disciplines will participate in the development of a multi-discipline approach in these areas. Research performed at JPL will be coordinated with the other participating NASA centers and will focus on the CSI problem area of precision controlled structures. Focus missions will be identified and the advantages of the application of CSI technology in terms of reduced development costs and improved operational performance will be demonstrated. A combination of ground and flight testing will be used to validate design methods, models and system concepts.

**W89-70137** (23) 585-01
Langley Research Center, Hampton, Va.
**CONTROL OF FLEXIBLE STRUCTURES**
J. F. Creedon 804-865-4915

The overall objective of the Control/Structures Interaction (CSI) Program is to develop and validate the technology needed to design, verify, and operate spacecraft in which the structure and the control interact beneficially to meet the requirements of future NASA missions. This research program is part of a comprehensive NASA-wide CSI program which will concentrate in the areas of: integrated control/structure concepts, integrated control/structure analysis and design methodology, ground testing, and in-space flight experiments. A team of researchers from the structures and controls disciplines will participate jointly in the development of a multi-discipline approach in these areas. Long-term goals of the effort are as follows: (1) to provide spacecraft dynamic response amplitude reductions of 90 percent; (2) to predict the on-orbit performance of CSI systems based on the results of integrated analyses verified by ground test data; and (3) to develop unified controls-structures modeling, analysis, and design methods.

**W89-70138** (23) 585-02
Langley Research Center, Hampton, Va.
**PRECISION SEGMENTED REFLECTORS**
C. P. Blankenship 804-865-2042

The research includes development, fabrication, and testing programs in structures and materials with emphasis on: (1) advanced composite materials and coating, and (2) deployable and erectable structural concepts. The objective is to develop advanced composite materials and coatings that are durable and have stable thermal and mechanical properties and low thermal coefficient of expansion, and to develop deployable and erectable primary structural concepts for applications to precision segmented reflector technology development. Analytical, computation, and experimental approaches are included in the fundamental research that is conducted in-house, by university grant, and under contract to industry.

**W89-70139** (55) 585-02
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**PRECISION SEGMENTED REFLECTORS**
W. E. Layman 818-354-4263
(159-41-00)

The objective is to develop the technology needed for the large lightweight precision reflectors for space applications. This is the JPL portion of a joint effort with LaRC to support the development of Precision Segmented Reflectors technology as part of the Civil Space Technology Initiative. This program will initially be directed toward providing reflecting surfaces with the precision required for the Far Infrared Region (wavelengths greater than 75 microns) and then progress toward shorter wavelengths. The long term goal of this program is to develop a technology base that will enable future missions that are expected to use large, lightweight, low-cost reflectors. The program will develop baseline graphite/epoxy composite 1-meter panels, the panel control/sensing system necessary to maintain figure control, and test these panels on a representative structure. Technology will be integrated into a test bed demonstration of an actively controlled, segmented reflector that will be operated in three years (1991). It will provide a means of validating the technology and providing a test bed for future technology developments. Alternate panel construction materials will be researched in order to identify promising approaches for advanced composite materials to improve surface precision and fabrication methods will be investigated to extend the panel size. Active and passive vibration damping techniques will be developed for the panel support structure.

## CSTI-Power

**W89-70140** (22) 586-01
Lewis Research Center, Cleveland, Ohio.
**HIGH CAPACITY POWER**
H. W. Brandhorst 216-433-6149

The NASA CSTI High Capacity Power Program is intended to advance engineering development and ground testing of major subsystems being conducted by DOE and is structured to enhance the chances of success for the overall SP-100 nuclear power system development. The program goals are focused on providing significant component and subsystems options for increased efficiency, survivability, growth at reduced weights, and higher reliabilities. These goals will be attained by conducting the broad based research and technology program which include the following elements: systems analysis to guide the research and technology efforts and to identify the pay-offs; conversion systems for nuclear applications; thermal management; power management; systems diagnostics; and environmental interactions.

**W89-70141** (55) 586-01
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**HIGH CAPACITY POWER**
W. E. Layman 818-354-0988
(159-41-00)

The objective is to develop and demonstrate solid-state thermal-to-electric power conversion technology meeting the demanding requirements of high-density power conversion with lifetimes (10 yr +) and high efficiencies (10 to 20 percent) - for spacecraft power systems. This will support the overarching HIGH DENSITY power theme to keep the volume-percentage of the power subsystem within the bounds of 20 percent of total space system volume. Current state-of-the art (SOA) is about 1 W/cu. in. The eventual objective is 10 W/cu. in. by the year 2000 - a factor of 10 improvement. Without progress in high-efficiency converters, typical power subsystems would require over 60 percent of total system volume. To enable this achievement will require steady progress in solid state thermal conversion technology avenues to reach conversion efficiencies in the 15 to 20 percent range without moving parts. Approaches will include industrial and university co-op tasks to achieve demonstration elements, with solid analytical support. The major activities will focus on: (1) nearer term doping techniques with silicon-germanium semi-conductor materials, and (2) alternative rare-earth semi-conductor materials. Basic materials research and theoretical analysis will be the primary tools.

## Pathfinder Program

## Surface Exploration

**W89-70142** **(10) 591-11**
National Aeronautics and Space Administration, Washington, D.C.
**PLANETARY ROVER**
Lee B. Holcomb 202-453-2747

The purpose of this RTOP is to conduct space operations research with particular emphasis on integration of automated robotic capabilities into a planetary rover. The research on the second objective will be carried out by developing and testing a one-G model of a planetary rover. This work will be carried out under a grant to Carnegie Mellon University.

**W89-70143** **(55) 591-11**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**PLANETARY ROVER**
W. E. Layman 818-354-4238
(591-12-00)

The overall goal of the Pathfinder Planetary Rover (PPR) Program is to develop and validate technology to enable the automated and piloted exploration of extensive areas of lunar and planetary surfaces. The initial focus is on unmanned rover technology for exploration and science. The key technologies for unmanned rovers are navigation, mobility, power, operations/autonomy, computation, architecture, thermal control and communications. Development and integration of these technologies will allow orders of magnitude increase in the effectiveness of remote surface operations. Later technology needs are for robust rover systems for automated construction and mining, and for exploration with human-driven rovers. The generic technology requirements for manned and unmanned rovers are strongly related; the manned rover program element will be built upon the technology base developed in the earlier unmanned rover program elements.

**W89-70144** **(21) 591-11**
Ames Research Center, Moffett Field, Calif.
**PLANETARY ROVER**
D. R. Cox 415-694-4759
(591-12-00)

The technical problem of light-speed signal delays will preclude the use of total teleoperation for future, highly capable, planetary rovers which must be able to sustain real-time exploration over the period of one or more years. The objective of this work is to develop the technology for increasingly more autonomous rovers capable of subsystem operation, diagnosis, and repair as well as efficient science operations with only high-level commands from Earth. In addition, future rovers should be able to plan to take maximal advantage of unpredicted, yet scientifically interesting observations during the course of a lengthy traverse. The approach will involve the development of prototypes for autonomous subsystems and system executives, jointly with other members of the Planetary Rover effort at JPL and the validation of these prototypes in the integrated rover testbed at JPL (and eventually in a copy of the testbed at ARC).

**W89-70145** **(72) 591-12**
Lyndon B. Johnson Space Center, Houston, Tex.
**SAMPLE ACQUISITION, ANALYSIS AND PRESERVATION**
Douglas P. Blanchard 713-483-5151

This is a technology program that supports a wide range of future robotic and piloted missions to planets and other solar system bodies to recover and return extraterrestrial samples for research. The particular focus is Mars (Mars Rover/Sample Return (MRSR) Mission). This year's task will assemble the characteristics of drilling tools applicable to the Mars environment and anticipated Mars samples. Benchtop testing will establish the nominal range of performance factor for a variety of designs. The functions of a sample preparation system will be analyzed based on the scientific objectives of the mission (as described by the Science Working Group) and the constraints imposed by the sampling system that supplies the sample and the containerization system that receives the prepared sample. An initial concept will be generated for the preparation system. Concepts for the preservation system will be assembled and evaluated. The integrity and leak tightness of selected candidate containers will be tested on a limited basis. Other operational factors will be evaluated and documented. An initial concept will be generated for the containerization and preservation system. The state of technology for planetary surface instruments will be evaluated by a panel of instrumentation experts in a workshop.

**W89-70146** **(55) 591-12**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**SAMPLE ACQUISITION, ANALYSIS AND PRESERVATION**
Brian K. Muirhead 818-354-8179
(591-11-00)

The Sample Acquisition, Analysis and Preservation (SAAP) element of Pathfinder will develop the technologies required to return to earth scientifically valuable specimens from a planet's surface and near-subsurface. The SAAP element will concentrate on enabling technologies in the following areas: (1) site and sample recognition and selection, (2) acquisition, (3) preparation/processing, (4) analysis, and (5) storage and preservation. The program will produce a technology base that can be applied to a variety of mission scenarios. This will lead to the development of hardware systems that are adaptive, compact and rugged and software systems that are intelligent and robust. An overall SAAP system concept design will be developed. This activity will be performed in close cooperation with the Planetary Rover element of Pathfinder. SAAP technologies will ultimately be integrated into a testbed to demonstrate a fully operational technology base. The following technical approach is being followed for SAAP: (1) determine the technology to be developed in each area, (2) evaluate the technology readiness/criticality, (3) select critical technology areas, (4) define concepts for developing technology, (5) develop and test concepts analytically and experimentally, and (6) integrate technology disciplines into a SAAP testbed.

**W89-70147** **(21) 591-12**
Ames Research Center, Moffett Field, Calif.
**SAMPLE ACQUISITION, ANALYSIS AND PRESERVATION**
G. W. Condon 415-694-4759
(591-11-00)

The first objective is to develop a Sample Acquisition Analysis and Preservation (SAAP) system-level executive which uses pre-set goals and high-level commands to coordinate and carry out SAAP functions. Algorithms and code requirements and concepts for a science executive will be developed. A rudimentary prototype will also be developed early in the program to demonstrate feasibility and then be expanded to encompass the full range of science executive needs. A fully operational science executive is planned for the Phase 1 testbed in Fiscal Years 1992 to 1994. A second objective is to develop algorithms for the autonomous detection of geologically interesting formations and samples. The effort will concentrate on the use of visible wavelength imaging data, but may also involve images in other bands. The eventual goal is to enable the coordination of science and mobility on the platforms used for autonomous space science.

**W89-70148** **(55) 591-13**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**AUTONOMOUS LANDING**
Allan R. Klumpp 818-354-3892
(591-11-00)

The objective of the system integration and planetary terrain modeling is to develop technology to enable modeling planetary terrain in preparation for soft landing. It must be possible to construct the terrain model using statistics regarding the distribution landings to test hazards, and use the terrain model in simulated landings to test hazard detection and avoidance. The approach to precision landing and terrain following navigation is to develop practical concepts and techniques for terrain following, enabling a planetary lander to be navigated and guided from descent orbit insertion to a preselected landing.

**W89-70149** **(21) 591-13**
Ames Research Center, Moffett Field, Calif.
**AUTONOMOUS LANDER**
G. W. Condon 415-694-5567

The goal is to develop and demonstrate technology required to land a planetary spacecraft safely in the face of potential surface hazards while landing close to the intended target site. The specific objectives are: (1) establish mission requirements and constraints on the landing process for future planetary exploration initiatives; (2) develop and demonstrate the technology required to enable precision landing at a preselected site; and (3) develop and demonstrate the technology required to enable real-time hazard detection and avoidance during the terminal phase of landing. JSC has the overall responsibility for the Autonomous Lander. The project will follow a general strategy of systems analysis and evaluation using simulation, followed by instrument and algorithm development, followed by demonstrations. The demonstrations will be performed first using a ground based testbed and then via simple 1-gravity atmospheric flight tests. The objective of this specific RTOP is to conduct basic research leading to improved computer vision methods for hazard detection and avoidance in support of JSC.

**W89-70150** **(72) 591-13**
Lyndon B. Johnson Space Center, Houston, Tex.
**AUTONOMOUS LANDER**
Kenneth Baker 713-483-2041

The objective of this work is to develop, for use in the Mars Rover Sample Return (MRSR), Manned Mars Exploration and Lunar Base Initiatives, the technology that is required to land a spacecraft safely and accurately on Mars or the Moon in areas chosen to meet mission requirements without regard to the general roughness of the terrain. Terrain features of principal concern are large rocks and locally steep slopes. In MRSR, for example, this means landing with a probability of safe landing a three sigma landing error ellipse radius of less than or equal to 5.0 km. and surviving rocks up to 1.0 m in size and slopes up to 15 degrees over a baseline of 10 m. Approaches to this problem divide into two categories: Precision Landing and Hazard Detection and Avoidance. Precision Landing consists of picking, prior to de-orbit, a specific landing site, of a prespecified size, and landing within it. Hazard Detection and Avoidance consists of selecting, prior to deorbit, a landing target such that at terminal engine start there will (with high probability) be a small safe touchdown site within the maneuver range of the lander. During this phase of the descent, the lander must detect such a site and maneuver to land there. The work under this RTOP will be to develop the sensors and algorithms to: (1) make the navigation measurements, and (2) detect the surface hazards that will make these approaches work and can be achieved with practical spacecraft.

**W89-70151** **(22) 591-14**
Lewis Research Center, Cleveland, Ohio.
**SURFACE POWER**
H. W. Brandhorst 216-433-6149

The objective of the program is to develop solar-based technology to a level of readiness sufficient to enable or enhance extraterrestrial surface missions. Toward that end, verification of key component technologies will be followed by ground-based system verification tests of integrated power generation and energy storage technologies. The program will include system analysis of mission scenarios for both Mars and Lunar surface applications in order to define technology requirements and guide technology pursuits, address energy storage technology using hydrogen/oxygen regenerative fuel cells with increased life and reliability, develop amorphous silicon photovoltaic technology with increased efficiency, reduced mass and improved lifetime and reliability, address solar dynamics technology issues unique to the Lunar or Mars environments and evaluate impacts of electrical power management architectures. The goal is to develop a technology base sufficient for subsequent system demonstration of power systems capable of delivering tens of kilowatts of user power at a substantially reduced mass.

## In-Space Operations

**W89-70152** **(62) 591-21**
Marshall Space Flight Center, Huntsville, Ala.
**AUTONOMOUS RENDEZVOUS AND DOCKING**
J. B. Haussler 205-544-1762

The overall objective of this RTOP is the development, validation, and demonstration of autonomous rendezvous and docking capability to support manned and unmanned vehicle operations in lunar and planetary orbits. The tasks are broken into four areas: sensor and mechanism research and development; development of guidance, navigation, and control algorithms; intelligent systems; and systems integration. Systems integration controls the overall coordination of the effort and defines the system, trajectory control, and GN and C system requirements for the development of the AR and D capability and vehicle configuration will be defined and performance requirements for the AR and D hardware and software established. Hardware and software technologies that satisfy these requirements will be identified and current technologies assessed for applicability. These capabilities will be divided into near-term and far-term phases depending upon the readiness of the technology. Different GN and C algorithms will be developed to implement these AR and D capabilities. Detailed software simulations will be used for performance, sensitivity analyses, and trade studies. Prototype sensors and docking mechanism hardware and software will be developed and incorporated into integrated ground testing and simulation in Marshall's Flight Robotic test facility.

**W89-70153** **(55) 591-21**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**AUTONOMOUS RENDEZVOUS AND DOCKING**
Allan R. Klumpp 818-354-3892
(591-11-00)

The objective of the RTOP is to develop technology, based on the Battin-Vaughan Lambert algorithm, applicable to rendezvous in planetary orbit and with the Space Station upon return to earth.

**W89-70154** **(72) 591-21**
Lyndon B. Johnson Space Center, Houston, Tex.
**AUTONOMOUS RENDEZVOUS AND DOCKING**
S. L. Lamkin 713-483-8264

This RTOP will develop, validate, and demonstrate autonomous rendezvous and docking (AR and D) capability to support manned and unmanned vehicle operations in lunar and planetary orbits. The tasks in this RTOP are broken into three areas: system integration, guidance and control, and sensors and mechanisms. System integration controls the overall coordination of the effort and defines the system, trajectory control, and GN and C system requirements for the development of the AR and D capability. Scenarios necessary to evaluate the AR and D capability and vehicle configuration will be defined and performance requirements for the AR and D hardware and software established. Hardware and software technologies that satisfy these requirements will be identified and current technologies assessed for applicability. These capabilities will be divided into near-term and far-term phases depending upon the technology readiness of the technology. Different GN and C algorithms will be developed to implement these AR and D capabilities. Six and twelve DOF simulations will used for performance, sensitivity analyses, and trade studies. Evaluation results will lead to prototype sensor specifications. Prototype sensors and docking mechanism hardware and software will be developed and incorporated into proof-of-concept demonstrations. Integrated ground demonstrations will be used for final docking operations.

**W89-70155** **(62) 591-22**
Marshall Space Flight Center, Huntsville, Ala.
**IN-SPACE ASSEMBLY AND CONSTRUCTION**
R. W. Schock 205-544-4060

The objective of this technology program are: (1) To develop the mechanisms and techniques to remotely and, as near as possible, autonomously manipulate, align and temporarily hold structural components while performing permanent joining operations. Both the temporary alignment and holding, and the permanent joining, whether mechanical or welding, bonding, or brazing, will be designed for maximum autonomy to minimize manned interaction. Weld integrity will also be determined autonomously; and (2) To develop berthing and docking mechanisms for supporting components during permanent joining and/or final major assembly docking. These mechanisms will likewise be designed for self alignment to minimize precise handling requirements. The approach to accomplish this program will be to: (1) Define the joining requirements based on mission scenarios defined by the Office of Exploration; (2) Evaluate concepts to best satisfy the design requirements; (3) Develop early prototype demonstrations of autonomous welding and mechanical joining; (4) Optimize the designs through development testing; and (5) Design, fabricate, and test the final configuration selections. The selected techniques will then be system demonstrated at the LaRC Test Bed.

**W89-70156** **(72) 591-22**
Lyndon B. Johnson Space Center, Houston, Tex.
**IN-SPACE ASSEMBLY AND CONSTRUCTION**
R. B. Berka 713-483-8808

The goal is to develop methods for assemblying large aerobrakes in earth orbit. The aerobrake assembly will include thermal protection systems, integrated utility systems, and primary structure. The development of the assembly methods will include definition of associated assembly equipment and techniques.

**W89-70157** **(55) 591-22**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**IN-SPACE ASSEMBLY AND CONSTRUCTION**
Brian K. Muirhead 818-354-8581
(591-11-00)

The long range objective of this program is to identify, develop and validate in-space assembly and construction technologies of large systems required for future NASA missions such as Manned Lunar Outpost and Manned Mars Missions. This research program will be part of a comprehensive NASA-wide In-Space Assembly and Construction effort. The initial activity for JPL is to participate as part of the NASA-wide team headed by LaRC to help plan and focus the effort and to participate with LaRC to develop construction concepts to move large and/or massive subsystems for assembly or precisely locate smaller subsystems for construction. The construction concept to perform the above functions is referred to as a space crane. JPL will initially focus on the space crane structures/controls concepts necessary to meet the requirements established by the NASA-wide team and to validate the concepts through analysis and tests. Subsequently with the growth in the program, the JPL role will include developments in ground test methods, deployable utilities, and other aspects of the total program.

**W89-70158** **(23) 591-22**
Langley Research Center, Hampton, Va.
**IN-SPACE ASSEMBLY AND CONSTRUCTION**
C. P. Blankenship 804-965-2042

The research includes technology development for in-space assembly and construction of space vehicles envisioned for future space missions. The vehicles required for future space missions will be too large and massive to be placed in orbit by single launch vehicles such as Shuttle or Heavy Lift Launch Vehicles. The focus of this technology program will be the development of in-space construction systems that combine efficiency and autonomy with reliability, economy, and ease of operation and maintenance. Research will be conducted to develop concepts and methodologies for constructing large vehicles in space with emphasis on design-for-construction; to develop infrastructures and hardware concepts; and to demonstrate the technology with a ground based testbed.

**W89-70159** **(22) 591-23**
Lewis Research Center, Cleveland, Ohio.
**CRYOGENIC FLUID DEPOT**
E. P. Symons 216-433-2853
(506-48-00)

The objective of the Cryogenic Fluid Depot program is to develop the technology base required to develop a Cryogenic Fluid Depot which will perform safe and efficient storage, supply and transfer of subcritical cryogenic liquids in the low-gravity environment of space. The long-term goal of this technology program is to enable the space fueling/resupply operations for future spacecraft and space transportation vehicles.

## Space Transfer

**W89-70160** **(22) 591-41**
Lewis Research Center, Cleveland, Ohio.
**CHEMICAL TRANSFER PROPULSION**
L. A. Diehl 216-433-2438
(506-44-11)

The goal is to provide a technology base in Chemical Transfer Propulsion to support the future exploration of the Solar System including the resumption of manned missions to the Moon and both unmanned and manned missions to Mars. The technology base will concentrate on mission-focused components and engine systems, design and analysis codes, Integrated Control and Health

Monitoring (ICHM), fault tolerant operational capabilities and reuseability.

**W89-70161** **(23) 591-42**
Langley Research Center, Hampton, Va.
**HIGH ENERGY AEROBRAKING**
W. R. Hook 804-865-2893
(506-40-00)

This research is to develop the technology base required for the successful application of aerobraking to the high energy missions with special emphasis on Manned Mars missions and the Mars Rover Sample Return Mission. Primary thrusts are in the areas of Mission and Vehicle Concept Studies; Aerothermo-dynamics; and Guidance, Navigation, and Control. Studies to define overall missions, entry velocities, and candidate aerobraking vehicle concepts will be carried out. Computational techniques will be developed, verified, and applied to predict the aerothermodynamics environment over the entry vehicles during aerobraking (or direct entry) maneuvers at Mars and during Earth return from Mars or lunar missions. Convective and radiative heating rates, aerodynamics, and flow field parameters will be defined for real-gas flow conditions, including continuum and rarefied flows, at Mars and Earth for the complete forebody and aftbody configurations. Experimental investigations will be carried out to provide a timely, parametric aerodynamic/aerothermodynamic assessment of candidate configurations required for aerobraking performance optimization. Studies of onboard, autonomous, optimal guidance systems will be carried out, and candidate aerobraking guidance laws will be developed and demonstrated.

**W89-70162** **(55) 591-42**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**HIGH ENERGY AEROBRAKING**
Lincoln J. Wood 818-354-3137
(506-46-00)

Mission and vehicle concept studies in support of high-energy aerobraking are carried out. Techniques are developed for designing nominal atmospheric aerobraking trajectories that satisfy specified end conditions, minimize propellant consumption, and meet heating rate and other constraints. Atmospheric navigation approaches are developed and compared for aerobraking applications employing alternative estimation algorithms and measurement types. The performance of various closed-loop, fault-tolerant, onboard atmospheric guidance schemes are developed and compared. Planetary approach guidance and navigation accuracies are assessed in aerobraking applications for various navigational data types, data processing scenarios, and maneuver strategies.

**W89-70163** **(21) 591-42**
Ames Research Center, Moffett Field, Calif.
**HIGH ENERGY AEROBRAKING**
J. O. Arnold 415-694-5265
(506-40-00; 506-43-00)

The overall objective of this activity is to support the Pathfinder High Energy Aerobraking Program for OAST. Research areas include system analysis, aerothermodynamics and materials and structures. In systems analysis the major effort will be directed at the Manned Mars Mission, but some studies of the Mars Sample Return Mission will also be considered. This activity will focus Ames' research and development technology. In aerothermodynamics, the ultimate objective will be to develop validated codes which properly account for real-gas effects and which can reliably predict the convective/radiative heating, forces, moments and trim angles of attack for candidate vehicles. Important flow phenomena will be defined and computational chemistry techniques will be used to obtain the real-gas properties. In materials and structures, efforts will be initiated to develop minimum weight thermal protection systems (TPS) for all vehicles, by improving or by developing and arc-jet testing new ablative, insulative and hot structural materials, heat shield concepts, and new structure/TPS systems.

**W89-70164** **(72) 591-42**
Lyndon B. Johnson Space Center, Houston, Tex.
**HIGH ENERGY AEROBRAKING**
R. C. Ried 713-483-6606

Consistent with the Project Pathfinder, High Energy Aerobraking Program Plan, the objectives of this RTOP are to develop the technology to enable and enhance aerobraking into planetary atmospheres and upon return to Earth at velocities exceeding Earth escape. This effort is in support of future exploration missions now under definition as well as precursors of such missions (e.g., piloted missions to Mars and unpiloted precursors. The technology development includes: Mission and System definition from the specialized vantage of aerobraking, aerothermodynamics analysis development and testing, computational fluid dynamics, guidance navigation and control, atmospheric flight mechanics, aerodynamics, thermal protection systems and associated structures, aerothermodynamic configuration investigations as well as ground facility diagnostics and flight test development planning and analysis. The approach is based on bringing the unique expertise and experience at JSC (predominately based on Apollo), in concert with synergistic research center efforts, to bear on developing the required high energy aerobraking technology. The tasks included in this RTOP are directed at the aerothermodynamics, guidance, navigation and control, and materials and structures tech. as required for Mars missions.

# Aero-Space Plane Technology

## Research and Technology

**W89-70165** **(23) 763-01**
Langley Research Center, Hampton, Va.
**AERO-SPACE PLANE TECHNOLOGY**
R. V. Harris 804-865-3285
(505-80-00; 506-80-00)

The objective is to provide advanced technologies on a schedule consistent with the needs and requirements of the NASA/DOD National Aero-Space Plane (NASP) Program. Key research and technology efforts are required in the following areas: (1) propulsion, to provide mature high-speed propulsion technologies in areas such as scramjets, engine components, and complete engines; (2) aerodynamics (including computational fluid dynamics), to provide insight into the stability and control of vehicle concepts, the aerothermodynamic environment to which the airframe will be exposed, the complicated flow fields about the vehicle and at crucial locations such as the inlet of engines and vehicle afterbodies, and integration of the high-speed propulsion system with the airframe itself; (3) structures and materials, to provide characterization of a select group of advanced high-temperature/high-strength materials and verification of their applicability to hypersonic structures concepts, and cryogenic tankage concepts; (4) flight systems, to establish flying quality requirements and to develop guidance, navigation, and control methodologies required to meet NASP performance objectives and mission goals; and (5) systems integration which provides the methodology for and the assessment of the performance levels of particular subsystems or components on overall vehicle performance.

**W89-70166** (22) 763-01

Lewis Research Center, Cleveland, Ohio.

**AERO-SPACE PLANE TECHNOLOGY**

J. A. Ziemianski 216-433-3901

The objective of this program is to advance those critical technology areas required to support, in a timely manner, the joint DOD/NASA National Aerospace Plane (NASP) Program. The NASP Program represents a major national effort in defining and maturing the array of advanced technologies including possible flight validation. This RTOP focuses on advancing critical technology needed to solve low speed propulsion, rocket propulsion, slush hydrogen, engine structures and materials problems associated with NASP. The current plans for this research area are to develop aerodynamic analytical codes to evaluate candidate propulsion concepts and components for further refinement and testing; screen various experimental configurations; provide technology information for future experiments; develop thermal models for conducting vehicle and engine heat balances, research on cryogenic propellants, like slush hydrogen; perform thermal management studies; develop dynamic models for engine controls; and develop analytical codes for metal matrix composites and develop selected structural concepts and technologies for lightweight and durable propulsion systems.

**W89-70167** (21) 763-01

Ames Research Center, Moffett Field, Calif.

**AERO-SPACE PLANE RESEARCH AND TECHNOLOGY**

J. O. Arnold 415-694-5265

(505-80-00; 506-43-00; 505-61-00)

The objective is to mature technologies required for the National Aerospace Plane (NASP) Program. This work is highly focused and will complement the ongoing research and technology programs (R and T base). Emphasis will be placed in the areas of Propulsion Technology, Aerodynamics, Structures and Materials, and Flight Systems. In Propulsion Technology research includes chemical kinetics, inlet/forebody aerodynamics, direct connect combustor/nozzle experiments, shock tunnel nozzle tests, and the development of a CFD code to study the effects of cowl lip bluntness. In Aerodynamics, computational chemistry will provide the basic atomic and molecular database required by the CFD codes, and the chemistry will be coupled to flow codes. In Materials and Structures, research includes temperature control coatings, materials hydrogen compatibility tests, and instrumentation. In Flight Systems, research includes simulation model development and flight research test planning.

# OFFICE OF SPACE SCIENCE AND APPLICATIONS

## Global Scale Atmospheric Processes

**W89-70168** 146-00-00

Langley Research Center, Hampton, Va.

**GLOBAL ATMOSPHERIC PROCESSES**

M. P. McCormick 804-865-2065

This RTOP is to cover several studies of atmospheric processes related to the improvement of global weather prediction. These studies include the development of lidar techniques for airborne/spaceborne remote sensing of atmospheric constituents, such as water vapor, and other meteorological parameters, such as winds. Also included are studies of global atmospheric aerosols and the basic physics required to develop and utilize a Doppler laser wind sounder.

**W89-70169** 146-60-00

Goddard Space Flight Center, Greenbelt, Md.

**METEOROLOGICAL SATELLITE DATA APPLICATIONS**

Robert Atlas 301-286-3604

(146-64-00; 145-65-00)

The objectives of this RTOP are to: utilize satellite observations of the atmosphere to initialize, verify and improve models; diagnose atmospheric processes; assess the impact of satellite data on forecast accuracy; and increase our understanding of atmospheric behavior. The approach is to develop advanced general circulation models and analysis methods and utilize satellite data for a comprehensive 4-dimensional analysis of the atmosphere. The results will be used to perform data impact studies and to diagnose and understand the dynamics of the atmosphere. The studies are expected to result in: (1) the utilization of the new global fields by the academic community; (2) improved general circulation models and analysis methods which can be used for prognostic and diagnostic studies; and (3) theoretical and numerical studies that improve our understanding of global scale atmospheric processes.

**W89-70170** 146-61-00

Goddard Space Flight Center, Greenbelt, Md.

**PRECIPITATION REMOTE SENSING RESEARCH**

Otto W. Thiele 301-286-9006

The objective of this RTOP is to conduct precipitation remote sensing research which involves: (1) physical processes associated with precipitation; (2) remote sensing techniques; (3) the statistical properties of rainfall; (4) techniques for validating space based precipitation measurements; (5) field experiments; (6) the application of space acquired precipitation data to weather and climate problems; and (7) conduct planning studies for precipitation measurements from space. The approach is to: (1) investigate the physical processes and distribution characteristics associated with precipitation including understanding associated cloud regimes; (2) develop techniques for remote sensing of precipitation from aircraft and satellites, (e.g., radar, microwave and visible/IR radiometers) also including related science for algorithm development; (3) investigate the statistical properties of rainfall to define sampling strategies in time and space; (4) investigate ways to improve and interpret in-situ rainfall measurement techniques for developing methods to validate (ground truth) space remote sensing measurements of precipitation; (5) conduct field experiments associated with physical processes studies and the development of algorithms, instrumentation, and ground truth schemes; (6) conduct science investigations, including modeling and simulation studies, relating to the application of space and aircraft acquired simulation studies, relating to the application of space and aircraft acquired precipitation data to weather problems, the hydrological cycle and to climate diagnostics and predictability research; and (7) develop science strategy and mission concepts for rainfall measurements from space. Expected results are to lay the scientific and technical foundation for making, understanding and applying space based measurements of tropical and eventually global precipitation to a host of weather, climate and hydrological problems.

**W89-70171** 146-61-07

Marshall Space Flight Center, Huntsville, Ala.

**SATELLITE DATA RESEARCH**

F. W. Leslie 205-544-1633

The objectives of this RTOP are: (1) to contribute to the NASA Global Scale Processes Research Program objectives performing diagnostic and theoretical studies of global-scale atmospheric systems to develop new and improved spaceborne atmospheric sensing techniques; (2) develop new techniques to extract information from and more fully utilize existing and planned spaceborne atmospheric sensing systems; and (3) contribute to the development of our understanding of global scale atmospheric processes. Approaches will be to conduct detailed analyses with space and ground-based data sets, guided by theoretical studies, to understand the role of latent heat release in the dynamics of cyclones; examine global atmospheric processes to gain improved understanding of the scales of motion; develop techniques for including satellite data in diagnostic procedures; and develop strategies and mission concepts to measure global scale processes from space platforms.

**W89-70172** **146-64-06**
Goddard Space Flight Center, Greenbelt, Md.
**DATA ASSIMILATION AND APPLICATIONS TO MODELING GLOBAL SCALE ATMOSPHERIC PROCESSES**
Robert Atlas 301-286-3604
(146-60-00; 146-65-00)

The objectives of this RTOP are to investigate new methods for assimilating satellite data and conventional data into general circulation models to improve our understanding of global scale atmospheric processes. These methods will be applied to various modeling efforts and the results used to study predictability of large-scale atmospheric flows, maritime cyclogenesis, global cloud distributions, long-term tropical variability, and the global hydrological cycle.

**W89-70173** **146-65-00**
Goddard Space Flight Center, Greenbelt, Md.
**METEOROLOGICAL PARAMETER EXTRACTION**
Robert Atlas 301-286-3604
(146-64-00; 146-60-00)

The objectives of this RTOP are to develop new and improved techniques for retrieving useful parameters from satellite-measured radiances and to interpret these retrievals to provide information on the state of the atmosphere. The approach is the development of advanced methods for satellite temperature retrievals; research in methods to determine temperature, moisture, and precipitation from measurements of various portions of the electromagnetic spectrum. Expected results are techniques to determine atmospheric temperature and moisture profiles, cloud parameters, surface parameters; validation of the retrieved products. Analyses of these data should improve our understanding and prediction of global scale atmospheric processes.

**W89-70174** **146-66-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**METEOROLOGICAL PARAMETERS EXTRACTION**
M. T. Chahine 818-354-6057
(146-72-06)

The overall objective of the proposed research is the development of accurate numerical analysis methods to retrieve, from satellite data, important meteorological parameters needed for weather and climate studies. To accomplish this we plan to: (1) conduct theoretical and applied studies for the development of improved numerical techniques to retrieve atmospheric and surface parameters from radiance data measured by the NOAA High-Resolution Infrared Sounder/Microwave Sounding Unit (HIRS/MSU) sounders; (2) apply the retrieval methods for simultaneous determination of several meteorological parameters such as clear-column vertical temperature and humidity profiles, sea-surface temperature, and the distribution of cloud heights and amounts; (3) verify the accuracy of the results by participation in national and international workshops dedicated to this objective; also by comparison with co-located radiosonde and sea-surface data and with cloud nephanalysis obtained independently from other sources; (4) apply the results to observe and study various air-surface interaction processes on monthly to seasonal timescales. Simultaneous determination of the atmospheric and surface thermal structure and the cloud distribution provides information on heat sources and sinks, storage rates and transport phenomena in the atmosphere. Such information is critical in determining the driving mechanisms for motions in the atmosphere and oceans and in improving numerical weather prediction.

**W89-70175** **146-66-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**GLOBAL SEASAT WIND ANALYSIS AND STUDIES**
P. M. Woiceshyn 818-354-5416

Our research is directed towards the exploitation of high-resolution scatterometer marine wind and wind stress measurements in global meteorological research, applications and prediction, and towards the development of techniques for dealiasing and assimilating scatterometer wind data into atmospheric and into coupled atmosphere-ocean models. The major objectives are: (1) to perform global and regional meteorological research using the dealiased SEASAT-A Satellite Scatterometer (SASS) marine wind fields; (2) continue to pursue methods for assimilating SASS data into numerical weather prediction models for application to short-range forecasts and to characterize the quality of the SASS retrieval system; (3) to process SEASAT SASS data augmenting and enhancing the 15-day data record provided to NASA in Sept., 1983, using algorithms developed by the project; in particular to process SASS windfields for one additional week in September, 1978, and for special cases. SEASAT data will be analyzed globally to perform the following tasks: (1) case studies of special interest: intense storms, unusual structures, small-scale marine phenomena, etc., that are poorly analyzed and forecast by standard models; (2) wind fields (SASS and ECMWF) described in terms of principal components (EOF's) for potential application to statistical and/or dynamical forecasting; (3) application and impact studies of SASS marine wind data in: (1) equatorial ocean-atmosphere interaction dynamics; (2) global-ocean rainfall estimation; (3) frontal instability; (4) diabatic marine boundary layer studies; (5) high-resolution numerical assimilation/forecast schemes; and (6) generation of synoptic pressure fields consistent with scatterometer wind data, and incorporation of these fields in a numerical forecast scheme, for 6 to 12 hour forecast periods, using only scatterometer data; and (4) collaboration with ECMWF, CNR-Venice, NORDA, and KNMI in studies of the impact on numerical weather and wave forecasts of scatterometer wind data (SASS and ERS-1).

**W89-70176** **146-66-06**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**AIRBORNE RAIN MAPPING RADAR**
F. K. Li 818-354-2849

The objective of this task is to develop an airborne rain mapping radar (ARMAR) to demonstrate accurate remote precipitation measurements. ARMAR will be used to verify the technique, technology and data processing algorithms for future satellite rain measurement missions, such as the planned Tropical Rain Mapping Mission (TRMM). In FY88, the design of ARMAR was completed and reviewed in December 1987. The design consists of a 14/24 GHz radar using a TWT amplifier (TWTA) with a narrow scanning antenna beam. Pulse compression will be used to improve signal-to-noise ratio and increase the number of independent samples. It will be flown on the NASA Ames DC-8 and the ER-2. In FY88, a laboratory breadboard of the 14 GHz radar channel without the TWTA was completed and testing was started. All the necessary developments for the installation and flight tests of the 14 GHz radar on the DC-8 in FY90 will also be done. This will include development of the scanning antenna system, procurement of the 14 GHz TWTA packaging of the 14 GHz breadboard for the aircraft, and construction of the hardware for installation in the DC-8.

**W89-70177** **146-70-00**
Goddard Space Flight Center, Greenbelt, Md.
**METEOROLOGICAL OBSERVING SYSTEM DEVELOPMENT**
S. H. Melfi 301-286-7024

The objectives of this report are to develop new and improved spaceborne remote sensing systems in support of the NASA Global Weather Program and develop improved data processing and retrieval techniques to provide for more accurate understanding of processes which influence the state and behavior of the atmosphere. Theory, laboratory measurements, and field experiments will be used to define, develop, and evaluate new and improved remote sensing techniques to observe profiles of atmospheric temperature, moisture and pressure, precipitation, surface properties, atmospheric radiative properties in the infrared, visible and microwave spectral regions, and passive modes. Evaluation, in cooperation with other scientists, will be performed to assess improvement in weather forecasting. Expected results are improved techniques and instrumentation to observe atmospheric parameters, surface properties and atmospheric radiative properties leading to improved weather prediction.

**W89-70178** **146-71-00**
Wallops Flight Center, Wallops Island, Va.
**VERIFICATION AND ANALYSIS OF SATELLITE DERIVED PRODUCTS**
F. J. Schmidlin 804-824-1618

The objectives of this RTOP are to gain a better understanding of the magnitude of upper air instrumentation precision and accuracy. Radiosonde measurements are still depended upon to provide ground truth information for validation of temperatures retrieved from satellite measurements. Instrumentation error analysis and comparison of in situ testing procedures are expected to enhance satellite data products, and with suitable application of results should improve global wide forecasts, as well. Approaches are to: (1) continue radiosonde radiation error analyses at solar elevation angles between -7 degrees and 82 degrees, investigate variability of the thermistor coating emissivity and absorptivity values and improve the algorithms, and obtain additional flight samples over the northern great plains (North Dakota) during the next winter season; (2) conduct analysis of the relative humidity sensor currently used with the U.S. radiosonde to improve the algorithm and sensor response; and (3) compare long-term radiosonde dataset averages with operational satellite data averages to determine whether long-term bias exists and whether temporal wave structure is correlated from the two systems. Temperature corrections will be applied to the radiosonde data base and new comparisons will be evaluated to determine influence on regression method of satellite temperature retrievals. Various statistical and spectrum analysis programs will be employed to make a more detailed assessment. The expected results are improved knowledge of meteorological instrument sensor performance, quality, accuracy, precision, and recommendations for enhanced utilization of meteorological in situ and satellite remote measurements.

**W89-70179** **146-72-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**MICROWAVE PRESSURE SOUNDER**
D. A. Flower 818-354-4151

This RTOP supports the phase 3 of the Microwave Pressure Sounder (MPS) research program, the objective of which is to develop an instrument for the remote measurements of atmospheric pressure at the earth's surface. Design studies have shown that differential absorption measurements in the wings of the 60 GHz oxygen absorption band are capable of providing surface pressure observations with the accuracy and coverage suited to applications in global weather research and operational weather forecasting. These theoretical studies have been supported by an experimental program with a simplified instrument on the NASA CV-990 aircraft. Recent results have demonstrated the ability to determine surface pressure with an accuracy of 1 millibar. A proposal for a flight experiment is being prepared in response to the Earth Observing System (EOS) Announcement of Opportunity. The specific objectives of this work are detailed studies of critical aspects of the instrument design in preparation for the Phase B study of the proposed EOS MPS instrument. The approach will be to reassess current technology in millimeter-wave oscillators, antenna design and electronics, which are critical components of the proposed EOS instrument.

**W89-70180** **146-72-03**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**IR REMOTE SENSING OF SST: BALLOON-BORNE MEASUREMENTS OF THE VERTICAL PROPAGATION OF RADIANCE IN THE NEAR AND MID-IR ATMOSPHERIC WINDOWS**
D. E. Hagan 818-354-7073

The objective of this research is to characterize, from infrared measurements in the 800 to 1200 cm and 2500 to 2800 cm regions, the radiation profile and sea surface radiative properties important to transfers of heat in the lower atmosphere, in order to assess the absolute values of the atmospheric parameters limiting transmission in these spectral intervals commonly used for remote sensing purposes. There is a large uncertainty in radiative transfer modelling for these spectral regions because the transparency is controlled predominantly by water vapor continuum absorption, the behavior of which is poorly understood. Hence, predictions of heat exchanges or techniques for remotely measuring surface radiance, which rely on a knowledge of the quantitative accuracy of the radiative transfer assumptions, have an unknown error. Also unknown are the accuracy limitations that are fixed on a remote measurement of the surface radiance for a representative range of tropospheric conditions. The approach is to make a series of vertical flux measurements over the ocean in tropical (i.e., wet) atmospheric conditions, using a high precision radiometer and atmospheric in situ sensing system carried by a tethered balloon, to determine the dependence of the continuum extinction on the partial pressure of water vapor, the total pressure and temperature. Exploratory measurements are also proposed to refine the determination of the sea surface emissivity for these spectral regions. Sheppard A. Clough of Atmospheric Environmental Research, Inc. will use the experimental results to test the extrapolation of the continuum and empirical line model that is most widely used in radiative transfer computations. Andrew Lacis of Goddard Institute of Space Studies will be concerned with sensitivity studies of the effects of the present measurements in computations of heating for climate simulation.

**W89-70181** **146-72-04**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**TROPOSPHERIC WIND MEASUREMENT ASSESSMENT**
R. T. Menzies 818-354-3787
(146-72-10; 146-72-11)

The objective of this program is to evaluate certain aspects of the Doppler laser radar technique for global measurement of tropospheric wind fields. This technique has the potential for providing global wind data from an orbiting platform. Several types of remote measurement of atmospheric wind velocities have been analyzed, e.g., passive microwave, millimeter wave, infrared radiometry, and active visible and infrared range-rated lidar, with the results indicating that the Doppler lidar technique is the superior technique for tropospheric wind field measurements. During FY89, the work will continue on an experimental study of vertical profiles of atmospheric backscatter at CO2 laser wavelengths in the 9 to 11 micrometer region. This study is being conducted using an existing TEA CO2 lidar facility, employing as single-longitudinal-mode (SLM) injection-controlled TEA laser transmitter and a heterodyne receiver. The use of air parcel trajectory analysis capabilities at UCLA will be continued in order to study the dependence of aerosol backscatter on the history of the air parcel. Continued experimental studies of the correlation time of the aerosol backscatter signal (which is an important parameter for coherent lidar detection analysis) will be conducted. Comparative performance analysis of the major types of Doppler lidar, including both incoherent and coherent detection, have been conducted and reported in the literature. These studies will be re-assessed as new data and new technology become available.

**W89-70182** **146-72-06**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**ATMOSPHERIC PARAMETER MAPPING**
K. J. Hussey 818-354-4016
(146-66-01)

The primary objective is to continue development of the Scientific Data Visualization capability to produce very high quality color maps and time-lapse imagery of global atmospheric parameters derived from NOAA High-Resolution Infrared Sounder 2/Microwave Sounding Unit (HIRS2/MSU) satellite data. Other objectives include: increasing the cost effectiveness of map/time-series production, making the process of climatic map/time-series generation and data analysis more readily available to atmospheric scientists, and to provide continuing support to M. Chahine in the development of new parameter maps/time-series derived from the combination and integration of existing data fields. The approach to continuing research and production of high quality time series images and global atmospheric parameter maps in a cost effective manner is as follows: an upgraded implementation of the VICAR image processing software system and Automated Raster Cartography System (ARCS) will be made operational on the Multi-Mission Image Processing Laboratory (MIPL) VAX Cluster. Time series analysis software will be improved and optimized. Three-dimensional analysis and display software will be improved along with procedures to facilitate the use of the Digital Image Animation Laboratory's (DIAL) computer controlled animation subsystem. New high speed computational hardware will be procured and integrated into the DIAL. The integration of computer graphics and image processing techniques will be investigated as a means of greatly improving the quality of graphics overlay in time series imagery. Animations demonstrating various system improvements will be produced along with a Global Climatological Atlas of Atmospheric Parameters for 1979 under the direction of M. Chahine.

**W89-70183** **146-72-09**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**ATMOSPHERIC DYNAMICS AND RADIATION SCIENCE SUPPORT**
D. J. McCleese 818-354-2317
The objective of this task is to support the NASA Atmospheric Dynamics and Radiation Branch in the development and scientific use of remote sensing techniques to study atmospheric dynamic phenomena in the lower atmosphere, such as wind fields, pressure fields, and precipitation. The approach will consist of inviting distinguished scientists in the field to spend some time (a few weeks to a few months) at JPL to work with JPL scientists and to explore new ideas and concepts of direct relevance and interest to the atmospheric dynamics and radiation program.

**W89-70184** **146-72-10**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**LIDAR TARGET CALIBRATION FACILITY**
R. T. Menzies 818-354-3787
(146-72-04; 146-72-11)
The primary objective of the JPL Lidar Target Calibration Facility is to provide accurate and consistent calibration of CO2 lidar targets. Customers in the lidar community will each provide a sample to JPL of the target surface which is to be used to calibrate the customer's lidar system. Parameters which are used in the lidar calibration, such as the CO2 laser wavelength, incident and reflected polarizations, and the polar angle at the target will be specified by the customer. The measurement result provided to the customer for each set of specified parameters will be the target reflectance parameter, which is used in the reduction of hard target and aerosol backscatter data to obtain the desired profile of the aerosol backscatter coefficient. A secondary objective is to measure the depolarization properties and the proximity to Lambertian (diffuse) behavior of customer-supplied and experimental target surfaces. The calibration methodology to be used will strive for maximum measurement continuity and accuracy between an integrating sphere measurement of a Lambertian primary standard, a backscatter reflectance ratio measurement of the customer's target to the primary standard, and the eventual field use of the customer's target to calibrate a lidar system. Accuracy will be achieved through careful experimental techniques such as incorporating spinning targets to reduce special effects. Continuity between the three measurements will include: (1) target continuity; (2) illumination continuity-wavelength, polarization, and bandwidth; and (3) geometric continuity - polar angles, solid angles and target size to beam size relationship.

**W89-70185** **146-72-11**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**ATMOSPHERIC BACKSCATTER EXPERIMENT**
R. T. Menzies 818-354-3787
(146-72-04; 146-72-10)
The objective of this program is to support studies of the feasibility and scientific value of an earth-orbiting Doppler lidar for global-scale tropospheric wind measurements, by the direct measurement of tropospheric aerosol backscatter coefficients at wavelengths in the 9 to 11 micrometer range over large geographical regions, emphasizing those regions which are important in the global winds measurement studies but difficult to characterize at present due to the scarcity of aerosol measurement data. The use of nadir directed, range-gaged lidar to obtain altitude profiles of aerosol backscatter coefficients is an efficient means of sampling the troposphere at carefully selected times. This investigation consists of the design, fabrication, and flights of an airborne CO2 lidar, which would be mounted on the NASA DC-8 research aircraft and configured to measure vertical profiles of aerosol backscatter from the aircraft altitude (near the tropopause) to the ground. The lidar will be flown on the NASA DC-8 on at least two latitude survey missions over the Pacific Ocean, and possibly on a flight series dedicated to Southern Hemisphere measurements. The data obtained will be analyzed and considered in the context of related instrument measurements of atmospheric aerosols and other atmospheric parameters.

**W89-70186** **146-73-06**
Marshall Space Flight Center, Huntsville, Ala.
**OBSERVING SYSTEMS DEVELOPMENT**
G. S. Wilson 205-544-1628
The objectives of this report are to contribute to the NASA Global Scale Processes Research Program by performing fundamental studies aimed at improving our ability to measure synoptic-scale atmospheric wind profiles on a global basis. Approaches are utilizing the talents of university, nonprofit and industrial contractor groups plus the MSFC in-house talents and laboratory capabilities, specific research activities as described in the tasks of this RTOP will be accomplished.

**W89-70187** **146-73-10**
Ames Research Center, Moffett Field, Calif.
**CO2 LIDAR BACKSCATTER EXPERIMENT**
V. R. Oberbeck 415-694-5496
The objective is to measure aerosol size distributions simultaneous with the CO2 lidar measurements as a means of validating the lidars which will be precursors to the Doppler lidars planned for wind measurements from space. The approach is to fly impactors and laser spectrometers on the Ames DC-8 aircraft to measure the global range in aerosol size distributions. These measurements will contribute data needed for lidar backscatter calculations to assess the sensitivity of CO2 lidar for wind velocity measurements.

**W89-70188** **146-76-00**
Marshall Space Flight Center, Huntsville, Ala.
**STUDIES OF DYNAMICS OF ATMOSPHERIC FLOWS**
G. S. Wilson 205-544-1628
The objective of this RTOP is to contribute to the NASA Global Scale Processes Research Program by performing fundamental studies aimed at improving our understanding of large-scale atmospheric dynamics. The approach will be to conduct studies applicable to the scientific design and interpretation of spherical laboratory models of large-scale geophysical flows. These spherical models must be operated in a low-gravity environment since the radial dielectric body force used to simulate gravity is weak. Support will be given to scientific data analyses of the geophysical fluid flow experiment flown on Spacelab 3 and detailed experiments for the flight of GFFC on the International Microgravity Laboratory will be developed.

## Upper Atmospheric Research Program

**W89-70189** **147-00-00**
Langley Research Center, Hampton, Va.

**UPPER ATMOSPHERIC RESEARCH**
R. R. Nunamaker 804-865-2893

The objective of this RTOP is to support specific theoretical and analytical studies, laboratory investigations, and field measurements aimed at improving our knowledge of the earth's upper atmosphere and its potential for change. High-resolution laboratory spectroscopy with diode lasers and Fourier Transform Spectroscopy systems will be focused on atmospheric measurement needs with emphasis on studies of ozone and methane and on temperature-dependent line halfwidth measurements. Computational chemistry research will be conducted to determine photo- and thermo-chemical properties of atmospheric molecules which are difficult to study experimentally with emphasis on short-lived atmospheric species. In collaboration with other atmospheric spectroscopy research programs, high-resolution infrared atmospheric spectra will undergo comprehensive analysis for determination of trace gas profiles and of data needed for remote sensing experiments. Lidar ozone and aerosol measurements and in situ ozone measurements will be obtained and analyzed as part of a proposed 1989 Arctic Ozone Experiment. Upon recommendations by the NASA Upper Atmospheric Research Program, research tasks at universities and other government laboratories will be supported in the areas of atmospheric measurements and infrared laboratory spectroscopy.

**W89-70190** **147-11-00**
Goddard Space Flight Center, Greenbelt, Md.
**UPPER ATMOSPHERE RESEARCH - FIELD MEASUREMENTS**
William S. Heaps 301-286-5106

The objectives of this RTOP are to determine specific chemical and physical interactions in the atmosphere using coordinated measurement campaigns from balloon platforms. Parameters to be determined include concentration of hydroxyl radical, ozone, hydrocarbons, and water vapor. The approach will be the development and flight of a variety of balloon borne sensors including laser radar, absorption cells, and UV spectrometers. The anticipated outcome of these efforts include absolute concentration measurements of a variety of trace atmospheric constituents.

**W89-70191** **147-11-05**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**IN SITU MEASUREMENTS OF STRATOSPHERIC OZONE**
J. J. Margitan 818-354-2170
(147-21-03; 147-22-01)

Vertical profiles of ozone in the stratosphere will be measured by a dual channel UV photometer flown as part of research balloon flights. Ozone profiles will be obtained on ascent and descent with 1 second (better than 100 meters) resolution. These data will serve as a comparison to other in situ and remote sensing techniques. This research effort is a collaborative project with the NOAA Aeronomy Laboratory using their proven ozone instrument. The ozone data will be useful in improving our understanding of stratospheric chemistry, and in particular in assessing the degree of discrepancy between measurements and calculations for ozone near 40 km.

**W89-70192** **147-11-07**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**BALLOON-BORNE DIODE LASER SPECTROMETER**
C. R. Webster 818-354-7478

The Balloon-Borne Laser In-Situ Sensor (BLISS) task has as its primary objective the collection of reliable data on the concentrations, distributions, and variabilities of the minor and trace species in the stratosphere. These data are to be used by modelers and dynamicists to assess and predict the effects of change in the chemical content of the upper atmosphere due to anthropogenic activity. The BLISS instrument uses tunable diode lasers (TDLs) to measure the absorption due to selected species between the balloon gondola and a lowered retroreflector which defines up to a 1-km absorption path. The TDL beam in use is stabilized onto the lowered retroreflector by use of an optical tracking system. Several species can be measured simultaneously to the 0.1 ppbv level in sensitivity, throughout a diurnal cycle, and with the additional possibility of altitude profiling. The current measurement capability includes NO, NO2, HNO2, HNO3, H2O, CO2, and CH4.

**W89-70193** **147-12-00**
Goddard Space Flight Center, Greenbelt, Md.
**UPPER ATMOSPHERE RESEARCH - FIELD MEASUREMENTS**
J. E. Mentall 301-286-8959

The objectives of this RTOP are to: (1) determine the specific local chemical and physical interactions in the atmosphere by a combination of theoretical studies and coordinated in-situ measurement campaigns from rocket and balloon platforms; (2) investigate the variations and perturbations of the chemical and physical state of the atmosphere, i.e., variations with altitude, solar conditions, season, latitude, and perturbations from volcanoes, tropical storms, industrial and agricultural activity; and (3) develop and calibrate selected instruments for local and remote investigations of the atmosphere. The approaches are to: (1) develop a balloon-borne Michelson interferometer and measure the concentrations and diurnal variations of trace stratospheric species; (2) develop a pointed spectrometer system and measure the solar photon flux within the stratosphere; and (3) perform multi-instrument, coordinated measurements on minor species in the stratosphere, and to develop photochemical models to compare experimental results with theoretical predictions. The expected results are: (1) improvement and validation of photochemical models; (2) improvement of understanding of upper atmosphere composition, chemistry, dynamics, and transport; (3) determination of in-situ solar flux and the accuracy of radiative transfer calculations; and (4) obtain effective absorption cross sections for O2 and O3.

**W89-70194** **147-12-01**
Ames Research Center, Moffett Field, Calif.
**AIRBORNE IR SPECTROMETRY**
J. F. Vedder 415-694-6259

The objective of this program is to obtain information on the spatial and temporal distribution of stratospheric constituents for use in testing current theories of stratospheric chemistry, especially ozone depletion. The approach is to fly infrared absorption and emission spectrometers on balloons and aircraft in coordination with other experimenters in order to identify constituents and infer concentrations from spectra obtained. This research requires 20 hours of U-2 or ER-2 flight time.

**W89-70195** **147-12-05**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**STRATOSPHERIC FOURIER SPECTROSCOPY**
C. B. Farmer 818-354-2039

The task has two distinct science objectives: the first is to acquire high quality infrared stratospheric survey spectra, recorded at different latitudes and times of the year. These will serve as a record of the current state of the atmosphere and may, in the future, be used to investigate temporal variabilities of molecules not currently thought to be important, or molecules for which there are currently no spectroscopic parameters. The second objective is to analyze these spectra to determine the atmospheric composition with sufficient accuracy to test theoretical predictions. The approach taken to meet the science objectives is to measure the spectral absorption of solar radiation by the atmosphere in the 2 to 16 micrometer spectral region using a Fourier transform spectrometer, the JPL Mark IV Balloon Interferometer. Measurements will and have been made from various platforms including stratospheric research balloons and aircraft as well as sea-level and mountain sites at locations of widely varying latitudes, e.g., Antarctica.

**W89-70196** 147-12-06
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**BALLOON MICROWAVE LIMB SOUNDER (BMLS) STRATOSPHERIC MEASUREMENTS**
J. W. Waters 818-354-3025
(673-18-49)

The objective of this program is to improve understanding of earth's upper atmosphere by balloon-based microwave measurements. Well-founded concerns that man's technological activities may perturb upper atmospheric balances, particularly those maintaining stratospheric ozone, justify this objective. The general approach is to first determine which measurements are needed for atmospheric research and perform calculations to define which subset of these can be usefully performed by microwave techniques. A field program is then established for those measurements of sufficient value. The field program is to determine both the capabilities and limitations of microwave techniques so they can be used efficiently in NASA's overall Upper Atmosphere Research Program.

**W89-70197** 147-12-12
Marshall Space Flight Center, Huntsville, Ala.
**TRACE CONSTITUENTS IN THE STRATOSPHERE**
M. R. Torr 205-544-7591

The primary objective of this RTOP is to support and participate in balloon lights of a high resolution ultraviolet spectrograph designed to measure OH and other key trace constituents in the stratosphere. The investigation represents a capability to obtain limb scans (from which height profiles can be inverted) of OH UV emissions for the duration of the time that the balloon remains at float altitude (several hours). The instrument has been developed and successfully tested on balloon flights. This activity is for a three-year operational program with the aim of obtaining a database on OH height and time variations spanning various seasons and conditions. The activity is a joint program with the University of Alabama in Huntsville. The costs for the UAH participation are not included in this RTOP but in a separate proposal.

**W89-70198** 147-12-14
Marshall Space Flight Center, Huntsville, Ala.
**STRATOSPHERIC CONSTITUENT DISTRIBUTIONS FROM BALLOON-BASED LIMB THERMAL EMISSION MEASUREMENTS**
Mian M. Abbas 205-544-7680

A research program involving balloon-based infrared thermal emission observations of the earth's atmosphere for measurement of trace constituent distributions has been in progress during the last several years. This RTOP is for continuing support for analysis of these observations for retrieval of trace constituent distributions presently being carried out at NASA/MSFC in collaboration with NASA/Goddard. A portion of the currently available data set obtained in a balloon flight in 1986 is being analyzed at the present time. Additional data are expected to become available from the ongoing observational program. The diurnal variations of the distributions of a number of trace gases in particular the main elements of the NOx family will be investigated and compared with predictions of one-dimensional photochemical models.

**W89-70199** 147-12-15
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**FAR INFRARED BALLOON RADIOMETER FOR OH**
H. M. Pickett 818-354-6861

A stratospheric hydroxyl radical (OH) radiometer for balloon observations in the far infrared region is to be developed. This instrument will use three Fabry-Perot resonators to resolve stratospheric limb emission of OH at 101/cm (99 micrometer wavelength). The resolution will be 0.001/cm (30 MHz) to match the stratospheric OH spectral line profile. Calculations indicate that the instrument will have sensitivity for retrieving useful OH concentration profiles between 25 km and 46 km with 3 km vertical resolution. The instrument is compact (0.36 cu m), light-weight (68 kg), requires low power (30 W) and thus is well-suited to balloon observations.

**W89-70200** 147-13-15
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**DIAL SYSTEM FOR STRATOSPHERIC OZONE**
I. S. McDermid 818-354-3213

A facility has been established at the JPL-Table Mountain Observatory at Wrightwood, California, from which to make atmospheric measurements. This laser remote sensing technique of differential absorption lidar is being used to derive atmospheric ozone concentration profiles. These are currently being obtained routinely for the stratosphere and will ultimately be made from the ground up to 50 km altitude. This requires two separate lidar systems. For the tropospheric part of the profile a Nd:YAG laser is quadrupled and Raman shifted to emit wavelengths in the 285 to 295 nm region. For the stratosphere much higher laser energies are required and these are provided by a xenon chloride excimer laser system operating fundamentally at 308 nm. Two telescopes, of 40 and 90 cm diameters are used to collect the laser radiation backscattered from the atmosphere. Long-term data records are required to detect the very small trends in the ozone concentration which are masked by large natural variations due to seasonal changes, solar cycle, etc. It is anticipated that the JPL-TMO facility will become an important part of a NASA network of stratospheric monitoring stations making similar, coordinated measurements.

**W89-70201** 147-13-17
Goddard Space Flight Center, Greenbelt, Md.
**UPPER ATMOSPHERE RESEARCH - OZONE GROUND STATION**
T. J. McGee 301-286-5645

The objectives of this RTOP are to measure stratospheric ozone from the ground with a sensitivity sufficient to detect predicted Long-Term Trends. Approaches will be to measure ozone using a differential absorption lidar. The lidar makes use of a XeCl excimer laser. Ozone profiles from 25 to 45 km will be measured on a nightly basis, weather permitting.

**W89-70202** 147-14-01
Ames Research Center, Moffett Field, Calif.
**STRATOSPHERE-TROPOSPHERE EXCHANGE PROJECT (STEP) OZONE HOLE**
P. B. Russell 415-694-5404

The objective is to increase knowledge of the stratosphere and its exchange with the troposphere, with particular emphasis on processes related to ozone depletion. The approach is to develop advanced instrumentation for high- and medium-altitude aircraft (e.g., ER-2, U-2, DC-8), design and fly missions that acquire data on phenomena of interest, and use the data to answer questions of current scientific concern. The measurements encompass stratospheric chemistry, physics, and dynamics. This RTOP includes two existing projects and possible future projects. The Stratosphere-Troposphere Exchange Project (STEP) has as its goal to improve understanding of processes that move chemicals into the stratosphere and toward the ozone layer and to explain the extreme dryness of the stratosphere. Platforms include U-2 and ER-3. Missions from 1984 to 1987 included 12 ER-2 flights in January to February 1987 from Darwin, Australia to study exchange processes the tropics. The goal of the Airborne Antarctic Ozone Experiment (AAOE) is to explain the cause of the large ozone depletion that has developed during Antarctic springtimes over the past decade. Multiple ER-2 and DC-8 flights over Antarctica, based in Punta Arenas, Chile, took place from August to September 1987. Possible future projects include an ER-2/DC-8 mission based in Norway to study ozone depletions and polar stratospheric clouds in northern high latitudes.

**W89-70203** 147-14-07
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**MICROWAVE TEMPERATURE PROFILER FOR THE ER-2 AIRCRAFT FOR SUPPORT OF THE STRATOSPHERIC/TROPOSPHERIC EXCHANGE PROJECT**
B. L. Gary 818-354-3198

The proposed work is to conduct measurements of altitude temperature profiles from the NASA ER-2 and DC-8 aircraft during flight missions to the Arctic ozone hole. The measurements will be used to study potential vorticity and mountain waves in the stratospheric air mass that is depleted in ozone. This information will be used to gain a better understanding of the role of atmospheric dynamics in the formation and maintenance of the Arctic and Antarctic polar stratospheric ozone holes. The proposed work also includes analysis of measurements made during the 1987 Airborne Antarctic Ozone Experiment. Stratospheric Tropospheric Exchange Project (STEP) data, taken in 1987, will also be analyzed. An existing microwave temperature profiler will be used in the ER-2 aircraft to conduct the air temperature profile measurements during the Norway-based 1988 Arctic ozone experiment. Another microwave temperature profiler will be constructed and installed in the NASA DC-8 aircraft, which will also participate in the Norway mission. Potential temperature cross-sections will be constructed from both sets of profiler data. These cross-sections will be used to study mountain wave structures. The STEP data exist, and will be analyzed using software developed for analysis of the ozone flight data.

**W89-70204** **147-15-00**
Goddard Space Flight Center, Greenbelt, Md.
**ROCKET MEASUREMENTS OF THE UPPER ATMOSPHERE AND UV FLUX**
J. E. Mentall 301-286-8959

The objective of this RTOP is to improve our understanding of mesospheric and stratospheric chemistry by measuring the composition and temperature of the upper atmosphere as well as the solar UV irradiance which initiates photochemical reactions. A variety of rocket born instruments are used to measure the properties of the upper atmosphere and incident solar irradiance. A cryogenic grab sampler obtains 4 gas samples between 75 and 30 km. Rocketsondes measure the temperature and density of the middle atmosphere. Temperature soundings are used to obtain temperature profiles. Periodic launches of UV spectrometers measure the absolute UV irradiance outside the atmosphere. Expected results are measurement of trace constituents, temperature and density of the upper atmosphere and to determine the variability of the solar irradiance over a complete solar cycle. These measurements are to be used in atmospheric models and to provide ground truth for satellite instruments.

**W89-70205** **147-16-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**MULTI-SENSOR BALLOON MEASUREMENTS**
J. H. Riccio 818-354-4415
(147-12-05; 147-12-06; 147-12-08)

Continuing technical, logistical and operational support of Upper Atmospheric Research Program stratospheric balloon flights is conducted to measure the abundance and altitude distribution of key chemical constituents in the upper atmosphere. Two modular gondola systems are available to carry multi-instrument packages consisting of several JPL remote sensing instruments and instruments from other institutions in the U.S. or abroad, configured for a particular scientific purpose. Data obtained on the altitude profiles for a number of chemically coupled species from one or simultaneous flights is used for instrument intercomparison purposes and for the validation of atmospheric chemical models. In addition to the balloon support activities, technical support is provided to all elements of the JPL Upper Atmosphere Research Program (UARP) on a time-available basis.

**W89-70206** **147-18-00**
Wallops Flight Center, Wallops Island, Va.
**ECC OZONESONDE TESTS AND DEVELOPMENT**
A. L. Torres 804-824-1553

The objectives of this RTOP are to: (1) complete an Electrochemical Concentration Cell ozonesonde performance evaluation/improvement study; (2) further characterize the annual Antarctic ozone depletion phenomenon; and (3) investigate possible ozone depletion in an Arctic region. The first objective will be met using a laboratory-based flight simulator. During early FY89, the lab efforts will be wrapped up by a series of tests aimed at evaluating potential methods of improving sonde performance (in-guide effort at an estimated cost of $20K). The second objective will be accomplished by conducting a series of ozonesonde soundings over Palmer Station, Antarctica, during the 1989 austral spring. This will be the third consecutive year for this measurement and would allow estimates of changes in the depth and vertical extent of ozone depletion during this season. (A proposal with an estimated $91K budget will be submitted for NASA/National Science Foundation review.) The third objective will be met through a series of ozone soundings conducted from a site such as Spitsbergen in the Arctic region in coordination with the early 1989 DC-8 aircraft program being planned by NASA. The actual site will be chosen at a later date to best coordinate with experiments proposed by other investigators. (A separate proposal with an estimated $67K budget will be submitted for NASA review.)

**W89-70207** **147-21-02**
Goddard Space Flight Center, Greenbelt, Md.
**UPPER ATMOSPHERE - REACTION RATE AND OPTICAL MEASUREMENTS**
Louis J. Stief 301-286-7529

The purpose of this RTOP is to measure kinetic rate coefficients of importance to the stratosphere and mesosphere and to develop new optical techniques for detection of atmospheric species. The laboratory effort in chemical kinetics uses existing equipment of unique capability for the purpose of measuring absolute rate constants of reactions of importance in current models of the stratosphere. Rate constants of atom-molecule and radical-molecule reactions are measured as a function of temperature and pressure using the technique of flash photolysis-resonance fluorescence. Rate constants for reactions of atoms and free radicals with both free radical and molecular species are measured as a function of temperature using a discharge flow system with collision free sampling to a mass spectrometer. Intracavity laser absorption is being developed as a complement to both fluorescence and mass spectrometric detection. Improved knowledge of chemical reaction rates at temperature and pressures appropriate to the upper atmosphere is expected. Use of mass spectrometry for detection, monitoring, and direct analysis of reaction products adds a new dimension to our capability. This allows us to determine reaction channels and provide direct evidence for elucidation of reaction mechanisms. Application of intracavity absorption permits detection of atoms and molecules by exciting forbidden or predissociated transitions, e.g., O(1D) and ClO.

**W89-70208** **147-21-03**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**CHEMICAL KINETICS OF THE UPPER ATMOSPHERE**
W. B. DeMore 818-354-2436

The purpose of this RTOP is to obtain direct measurements of rate constants and temperature dependences for reactions of HOx, NOx, ClOx, BrOx and ROx in stratospheric chemistry, and to develop techniques for laboratory study of relevant transient species.

**W89-70209** **147-21-10**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**KINETICS OF TROPOSPHERIC AND STRATOSPHERIC REACTIONS**
S. P. Sander 818-354-2625

A program of laboratory studies is underway to measure kinetic, photochemical, and spectroscopic parameters relevant to tropospheric and stratospheric chemistry. Attention will be focussed on reactions important in polar ozone chemistry. The experimental approach will utilize several state-of-the-art kinetic techniques including flash photolysis, discharge flow-mass spectrometry and discharge flow-Fourier transform infrared spectroscopy. Part of this effort will include the continued development of a Fourier transform ultraviolet spectrometer for laboratory and field use.

**W89-70210** **147-22-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**PHOTOCHEMISTRY OF THE UPPER ATMOSPHERE**
W. B. DeMore 818-354-2436
The objective is to conduct laboratory studies of stratospheric photochemistry, including photolytic quantum yields, reaction rates and mechanisms, product distributions, and absorption cross sections.

**W89-70211** **147-22-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**ATMOSPHERIC PHOTOCHEMISTRY**
M. J. Molina 818-354-5752
Laboratory studies will be carried out involving the photochemistry of atmospheric species, with particular emphasis on the polar stratosphere. Measurements will include reaction rate constants involving radicals and various polar molecules over an extended pressure and temperature range; absorption cross sections as a function of wavelength and temperature; Fourier transform infrared (FTIR) spectra of reaction intermediates, and chemical reactions involving ice particles and sulfuric acid, nitric acid and hydrochloric acid-ice solutions and hydrates.

**W89-70212** **147-23-01**
Ames Research Center, Moffett Field, Calif.
**QUANTITATIVE INFRARED SPECTROSCOPY OF MINOR CONSTITUENTS OF THE EARTH'S STRATOSPHERE**
C. Chackerian, Jr. 415-694-6300
Remote detection and measurement of stratospheric minor constituent species via spectroscopic techniques is being routinely employed to develop a better understanding of this portion of our atmosphere and man's effect upon it. Proper interpretation of these measurements relies strongly on having the correct molecular parameters. The objective of this work is to obtain laboratory measurements of basic molecular parameters, such as rotational line intensities and half-widths, absorption band intensities, vibrational and rotational constants, vibration-rotation interaction constants, and line position measurements including pressure induced shifts. The determination of these parameters, and their dependence on pressure and temperature, will be obtained by using cooled long path gas cells, high resolution interferometers, and tunable diode laser spectrometers. Also (at Laboratoire d'Infrarouge) various experimental techniques and new theoretical approaches are being used to obtain and interpret infrared spectra of free radical molecules.

**W89-70213** **147-23-08**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**INFRARED LABORATORY SPECTROSCOPY IN SUPPORT OF STRATOSPHERIC MEASUREMENTS**
R. A. Toth 818-354-6860
For the proposed task, high resolution infrared laboratory spectra of stratospheric molecules will be recorded and analyzed to produce linelists of molecular parameters (line frequencies, strengths, widths and lower state energies). The molecules studied will be those minor and trace species of importance in understanding the earth's atmosphere. The particular spectral regions to be analyzed (2 to 16 micrometers) coincide with those used by NASA field experiments that do remote sensing by high resolution spectroscopy--Atmospheric Trace Molecule Spectroscopy (ATMOS), Balloon-borne Laser In-Situ Sensor (BLISS), Mark IV, Upper Atmospheric Research Satellite (UARS) and Earth Observing System (EOS). The laboratory spectra will be recorded at spectral resolutions of 0.0028 cm-1, 0.0056 cm-1 and 0.011 cm-1 with a Fourier transform spectrometer located at Kitt Peak National Observatory. Data reduction and measurement will be performed on the ATMOS Data Analysis Facility at JPL, and modelling of the measurements by quantum mechanics will be done at JPL and elsewhere in collaboration with non-JPL colleagues. Emphasis will be placed on high accuracies for the line frequencies, line strengths and line widths and on comprehensive analyses of important spectral regions to provide complete spectral information for atmospheric remote sensing.

**W89-70214** **147-23-09**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**LASER LABORATORY SPECTROSCOPY**
R. D. May 818-354-3256
The laser laboratory spectroscopy program involves the acquisition and analysis of molecular spectral parameters which are required for the interpretation of data from laser stratospheric measurements, specifically by the Balloon-borne Laser In-Situ Sensor (BLISS) infrared laser instrument. Line positions, absorption strengths, and air broadening coefficients are the spectral parameters measured, including their dependence on temperature. New spectroscopic techniques for laser wavelength calibration and spectral lineshape analysis are also investigated.

**W89-70215** **147-23-10**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**MILLIMETER/SUBMILLIMETER LABORATORY SPECTROSCOPY**
E. A. Cohen 818-354-4701
A program of millimeter and submillimeter spectroscopy research will be conducted in support of upper atmospheric research. This will include laboratory studies, critical analysis of data from all available sources, generation of line list catalogs, and distribution of results to the field measurement community. The program involves the acquisition and analysis of molecular spectral parameters which are required for the interpretation of data from stratospheric measurements. The laboratory spectral measurements will be conducted specifically in support of the JPL millimeter radiometer instruments. Emphasis is placed on accuracy of line frequency, line width, and transition movement measurements, in order to take full advantage of spectroscopic techniques for quantitative atmospheric species measurements. A large portion of the spectral data will also be of value to other groups who use spectroscopic instruments for atmospheric measurements. This will be cataloged in a continuously upgraded millimeter database and made available to interested users.

**W89-70216** **147-51-01**
Goddard Space Flight Center, Greenbelt, Md.
**ASSESSMENT OF OZONE PERTURBATIONS**
R. S. Stolarski 301-286-9111
The objective of this RTOP is a continuing evaluation of the state of knowledge of the stratosphere such that reports to EPA and Congress, as required by law, can be made consistently and accurately. The approach is the formation of evaluation teams to examine the most important current issues in the science today.

**W89-70217** **147-51-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**DATA SURVEY AND EVALUATION**
W. B. DeMore 818-354-2436
An up-to-date tabulation and critical evaluation of kinetic and photochemical data relevant to the stratosphere will be maintained for use by atmospheric modelers, to aid in the establishment of research priorities, and to identify gaps or inconsistencies in the database.

## Planetary Geology R&A

**W89-70218** **151-01-02**
Lyndon B. Johnson Space Center, Houston, Tex.
**FLIGHT SUPPORT FOR REDUCED-GRAVITY EXPERIMENTS IN PLANETARY SCIENCES**
Mark J. Cintala 713-483-5032
A number of investigations in planetary sciences have been proposed or have already been tested under low-gravity conditions on the NASA KC-135 Reduced-Gravity Aircraft. Insofar as a variety of experiments are foreseen for FY89, it would behoove both

NASA and the investigators themselves to pay for flight time internally through transfer of funds. In addition, flight-sharing and scheduling activities would be facilitated by establishing a single point of contact at JSC to act as liaison between the scientists and the Aircraft Operations personnel.

**W89-70219** **151-01-20**
Lyndon B. Johnson Space Center, Houston, Tex.
**PLANETARY GEOLOGY**
Douglas P. Blanchard 713-483-5151

The broad objective of the study of planetary surface processes is to develop a coherent body of data on planetary surface processes which can be used to design planetary missions and to interpret data as well as place boundary conditions on planetary evolution. The study of appropriate analogues not only places boundary conditions on the evolution of other planets such as Mars but also permits, on earth, the evaluation of the characteristics of planetary surface instrumentation. Future exploration of Mars and other planets includes surface analysis and sample return missions. The development of these missions requires suitable instrumentation for analyses on the surface of Mars and analogues of Martian surface material. Specific objectives are: (1) to determine through detailed grain-by-grain studies of several terrestrial soils the processes and history that can be deduced through such data; (2) to characterize the gases released by thermal decomposition of Martian surface analog materials and evaluate the feasibility of accomplishing such analyses in situ,; (3) to map the volcanic stratigraphy on the surface of Io; and (4) to determine the thermochemical properties and kinetics of potential regolith material on Mars and Venus.

**W89-70220** **151-01-60**
Ames Research Center, Moffett Field, Calif.
**SOLAR SYSTEM STUDIES**
P. Cassen 415-694-5597

The purpose of this research is to address selected problems pertaining to the origin, evolution, and present state of the solar system. Theoretical concepts, physical insight, and mathematical modeling are used together with astronomical and geological data, and experiments relating to aeolian processes, to construct self-consistent mathematical models of planetary processes and structures. Problem areas that are being addressed include: the dynamics and evolution of the solar nebula, and protostellar disks in general; the nature of primitive bodies such as comet nuclei; the formation of planets and satellites; the structure and origin of planetary rings; the interaction of planetary atmospheres with surfaces; and the existence and nature of extra-solar-system planets.

**W89-70221** **151-01-70**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**PLANETOLOGY**
S. M. Baloga 818-354-2219

This collection of interrelated tasks at JPL addresses the geology and geophysics of all planetary bodies including planets, satellites, the moon, asteroids and comets. Emphasis is on solid body aspects of these solar system objects including studies of their surface composition and structure, interior structure and thermal states, those atmospheric and magnetospheric aspects which relate to surface and interior properties, their orbital and interior dynamical properties, and their overall histories and modes of origin. The basic objective of this research plan is to determine from observational data, laboratory experiments, and theoretical considerations the present characteristics and past histories of planetary bodies both as individuals and groups, and what comparative studies of all planetary objects tell use about the history and origin of the solar system. Another major objective is to carry out interpretive analysis of observational results obtained by unmanned spacecraft missions and groundbased telescopic observations of objects throughout the solar system, and to derive new missions and new observations to further our knowledge of the solar system. This RTOP supports various laboratory experimental facilities, image processing capabilities, and the NASA Regional Planetary Image Facility at JPL.

**W89-70222** **151-02-50**
Goddard Space Flight Center, Greenbelt, Md.
**MARS GEOLOGY: CRUSTAL DICHOTOMY AND CRUSTAL EVOLUTION**
Herbert Frey 301-286-5450

The objective of this task is to understand the nature, origin and development of the fundamental crustal dichotomy on Mars and its relation to the overall geologic evolution of the planet; determine the nature, origin and evolutionary history of the transition zone which separates the cratered highlands from the northern lowland plains; determine to what extent the lowland plains contain relics of ancient highland crustal material; and study resurfacing history of major regions on Mars in order to determine the age and nature of underlying basement. The approach is photogeological mapping of features characteristic of the highland/lowland boundary transition zone used to define morphological terrain units, within which craters are counted and cumulative frequency curves produced. These curves are analyzed using the Neukum-Hiller approach to determine the number and age of major resurfacing events. These events are correlated with other major events in the geological history of Mars. The extent of buried ancient cratered terrain is also determined this way and is mapped in various parts of Mars in order to better understand the original distribution of this type of crust. Relic old crust is sought in the lowland and other plains regions of Mars, using both large scale and small scale Viking imagery and photomosaics derived from that imagery.

**W89-70223** **151-02-50**
Goddard Space Flight Center, Greenbelt, Md.
**MARS TECTONICS AND LITHOSPHERE STRUCTURE**
Maria T. Zuber 301-286-8826

The goal of this research is to establish relationships between the mechanical structure and state of stress of the lithosphere and the geometries of tectonic surface features, with primary application to the tectonics of Mars. In particular, the formation of ridges located in the volcanic plains of Mars will be investigated in order to understand the relative importance of surficial and deep lithospheric deformation and the depth-varying mechanical structure of the lithosphere. The approach is to develop models for the compressional instability of rheologically stratified viscous fluids, and to relate the deformational length scales predicted from these models to observations of the geometries of the volcanic plains ridges. Models consisting of a high viscosity surface layer overlying a lower viscosity layer overlying a high viscosity halfspace will be examined. Solutions will be obtained for both rigid and deformable halfspace boundaries.

**W89-70224** **151-02-51**
Goddard Space Flight Center, Greenbelt, Md.
**STUDIES OF PHOBOS MICROTOPOGRAPHY AND SEDIMENTOLOGY OF VENUS**
James B. Garvin 301-286-6565

The aim of this RTOP is to quantify the microtopography of Phobos' surface by means of LIMA-D laser altimetry, stereo imaging, and GRUNT radar profiles for the purpose of exploring those processes responsible for regolith formation and erosion on Phobos. Block size frequency distribution will be measured from Viking and Phobos images and compared with data for the lunar regolith. The aim of the second task is to determine the physics of fine material transport on Venus by quantifying changes observed in digital Venera lander images (Venera 13,14). As noted above, the Phobos mission will return at least 3 independent datasets on the microtopography of Phobos' surface, including LIMA-D laser profiles, GRUNT radar altimetry, and FREGAT stereo images. Emphasis will be given to measuring the surface height and slope distributions from LIMA-D laser profiles in an attempt to infer regolith mechanical properties. Stereo images will be used to measure the lengths, widths, and heights of fragments on the Phobos surface. For the second task, digital Venera 13, 14 lander panoramas will be used to measure the areal and volume movement of fine materials in the nearfield to assess the fluid mechanics of fine particle transport on Venus.

## Planetary Materials

**W89-70225** **152-11-40**
Lyndon B. Johnson Space Center, Houston, Tex.
**PLANETARY MATERIALS: MINERALOGY AND PETROLOGY**
Douglas P. Blanchard 713-483-5151

The general objective is to obtain information about the nature, origin and evolution of the solar system. The specific objective is to learn the pressure, temperature and chemical composition of distinct mineralogic phases at the time of their formation. Textures, structures and chemical composition of minerals found in samples of the moon, meteorites (asteroids, comets, Mars), cosmic dust (comets, asteroids) and the earth will be measured using optical and electron microscope and electron microprobe techniques. Comparison of these results with those from laboratory calibration experiments and theoretical models will lead to pressure, temperature and history information for parts of solar system objects.

**W89-70226** **152-12-40**
Lyndon B. Johnson Space Center, Houston, Tex.
**PLANETARY MATERIALS: EXPERIMENTAL PETROLOGY**
Douglas P. Blanchard 713-483-5151

The general objective is to obtain information about the nature, origin and evolution of the solar system. The specific objective is to execute laboratory experiments and develop theoretical models which aid our understanding of the crystallization behavior of rock-forming minerals. Mineral systems similar to those found in samples from the moon, meteorites (asteroids, comets, Mars) cosmic dust (comets, asteroids) and the earth will be studied experimentally by observing the products of crystallization from experimental charges of known composition cooled under known pressure and temperature conditions. Comparison of these results with the mineralogy of naturally occurring samples will lead to pressure-temperature and history information for parts of these solar system objects.

**W89-70227** **152-12-40**
Goddard Space Flight Center, Greenbelt, Md.
**A LABORATORY INVESTIGATION OF THE FORMATION, PROPERTIES AND EVOLUTION OF PRESOLAR GRAINS**
J. Nuth 301-286-9467
(188-41-51; 154-75-80)

The objectives of this program are to: (1) determine the mechanism by which refractory materials condense from the vapor and the relative importance of the factors which control the rate of cluster formation and growth for astrophysically relevant species; (2) determine the structure and composition of solids condensed from cosmically abundant refractory mixtures; and (3) monitor changes which occur as the result of thermal annealing, hydration, and exposure to cosmic rays. The result will be the characterization of the grains present in the primitive solar nebula prior to its collapse. Objective 1 will be investigated using a cluster beam apparatus. The equilibrium composition and size distribution of clusters as a function of temperature will be monitored via quadrupole mass spectrometer. Objectives 2 and 3 require a separate flow multicomponent smoke. The structure and composition of the initial grains will be determined; infrared and UV/visible spectra of the smokes will be obtained and the particle morphology will be studied via SEM and STEM. Samples will be annealed for various times either in vacuo or in liquid/gaseous water and the changes thus induced studied by the above techniques. Accomplishment of objectives 2 and 3 also requires the use of a low T cryostat and 1 MeV proton source to study the interaction of metal/organic ice mantles formed in the interstellar medium with cosmic radiation, and the consequences of such interactions for grains incorporated into the solar nebula. These consequences may include trapping volatile species in silicates and oxygen isotopic fractionation.

**W89-70228** **152-13-40**
Lyndon B. Johnson Space Center, Houston, Tex.
**PLANETARY MATERIALS: CHEMISTRY**
Douglas P. Blanchard 713-483-5151

The general objective is to obtain information about the nature, origin and evolution of the solar system. The specific objective is to measure the concentration of selected chemical elements (major, minor, and trace) in rock samples of interest. Data obtained supplement, and are often combined with, petrologic studies to yield bounds on thermodynamic parameters at the time of rock origin. Rock samples from the moon, meteorites (asteroids, comets), cosmic dust (comets, asteroids, Mars) and the earth will be analyzed using a variety of sophisticated techniques, including neutron activation analysis (NAA), X-ray fluorescence, atomic absorption spectrophotometry, gamma-ray spectrometry, and proton-induced X-ray emission. Relative abundances of trace elements in different samples places bounds on the characteristics of the sources from which the rock-forming materials are derived.

**W89-70229** **152-13-60**
Ames Research Center, Moffett Field, Calif.
**PLANETARY MATERIALS-CARBONACEOUS METEORITES**
S. Chang 415-694-5733

The objective of this research is to understand the processes involved in the origin and early evolution of solid bodies in the solar system through the study of meteorites. The approach taken to meet this objective focuses on the chemical and mineralogical-petrographic analyses of meteorites. The abundance, isotopic composition and distribution of selected elements are measured; and the occurrence and distribution of various mineral phases are determined. Systematic searches for elemental, isotopic and mineralogic-petrologic correlations between meteorites and within a meteorite will be made so as to elucidate physical-chemical relationships in the meteorite population. From these relationships will be deduced the nature of the processes that were involved in the origins, accretion and distribution of these objects and their components in the early solar system. In turn these processes are modeled by laboratory or computer experiments from which the chemical and mineralogical outcomes can be determined. Findings from meteorite analyses and model studies are then compared for self-consistency.

**W89-70230** **152-14-40**
Lyndon B. Johnson Space Center, Houston, Tex.
**PLANETARY MATERIALS: GEOCHRONOLOGY**
Douglas P. Blanchard 713-483-5151

The general objective is to obtain information about the nature, origin and evolution of the solar system. The specific objective is to determine the absolute time when a particular event, such as the eruption of a volcano or the formation of a large impact crater, occurred. The concentrations of radioactive decay products and the corresponding parent isotopes will be measured in carefully selected rock samples using mass spectrometric techniques. With knowledge of the decay constant (half life) for the radioactive element, and assuming a closed chemical system, the time since system closure may be deduced. Systems currently in use are: K-Ar, Rb-Sr, Sm-Nd, Lu, Hf and U-Th-Pb. Study of extinct radioactive nuclides, such as Pu, leads to information on the interval of time between the formation of the nuclide and its incorporation into a solid.

**W89-70231** **152-15-40**
Lyndon B. Johnson Space Center, Houston, Tex.
**PLANETARY MATERIALS: ISOTOPE STUDIES**
Douglas P. Blanchard 713-483-5151

The general objective is to obtain information about the nature, origin and evolution of the solar system. The specific objective is to determine the isotopic composition of selected elements in planetary materials. Isotopically distinct material, which cannot be understood as the product of known fractionation processes, may indicate the presence of pre-solar material. Light elements are studied to learn more about fractionation processes. A secondary objective is to develop an ion microprobe which will provide easier analysis and increased spatial resolution and sensitivity for isotopic composition measurements. Samples of moon rocks and meteorites will be analyzed using mass spectrometric techniques to learn isotopic compositions, mainly of noble gases, hydrogen, carbon, oxygen and nitrogen. Theoretical calculations will be made to relate the expected products of nucleosynthesis to observations of anomalous material in meteorites. A commercially purchased ion microprobe is being upgraded in the laboratory of G. J. Wasserburg, CIT.

**W89-70232** **152-17-40**
Lyndon B. Johnson Space Center, Houston, Tex.
**PLANETARY MATERIALS: SURFACE AND EXPOSURE STUDIES**
Douglas P. Blanchard 713-483-5151

The general objective is to obtain information about the nature, origin and evolution of the solar system. The specific objective is to learn about the interaction between the space environment, which consists of meteorites, galactic cosmic rays, and solar particle and electromagnetic radiations. Samples of the lunar regolith offer the opportunity to find variations in the intensity of the environmental factors over geologic time. A variety of approaches will be used. The radioactivity of cosmic-ray produced nuclides will be analyzed as a function of sample depth. Surfaces will be studied using electron microscopes. Etchable heavy element ionization damage tracks will be revealed and studied. Solar wind noble gases will be analyzed mass spectrometrically. Multidisciplinary studies will be done using selected samples.

**W89-70233** **152-17-70**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**PLANETARY MATERIALS AND GEOCHEMISTRY**
S. M. Baloga 818-354-2219

The objectives of activities conducted under this RTOP are two-fold. Under one task, scientific research is being conducted on meteorites, specifically, to understand the physical processes that may have occurred in ancient asteroidal regoliths. The second objective of this RTOP is to provide support to NASA Headquarters through the services of a JPL detailee. Scientific research on the nature of planetary materials is a necessary function at JPL as part of its general scientific mission of solar system exploration. The results of this research provide support for the planning of future missions. The approach of this RTOP is an experimental study of nuclear tracks in gas-rich meteorites and the maintenance of detailee presently working at NASA Headquarters. Plans for the scientific task under this RTOP include studies of neutron capture effects in two gas-rich meteorites and a comparison of nuclear tracks with neon abundances on a grain by grain basis. It is planned that the detailee presently supporting NASA Headquarters will continue to do so.

**W89-70234** **152-19-40**
Lyndon B. Johnson Space Center, Houston, Tex.
**EARLY CRUSTAL GENESIS**
W. C. Phinney 713-483-5310

If meaningful models are to be developed for the evolution of the solar system, then physical and chemical constraints must be developed for the processes involved in the evolution of the solid objects in the solar system. The specific objectives are: to identify the key physical and chemical processes and the initial conditions for crustal evolution, to understand the evolution of planetary crusts in relationship to the overall history of individual planetary bodies, and to understand the reasons for the differences in evolution among the various planetary crusts. The strategy is to adopt an interdisciplinary and cross-planetary approach to the questions of crustal genesis. The program is a multidisciplinary effort carried out by individual scientists and teams from universities, industries, and government agencies. Major efforts will be devoted to: studying samples that are related to the early formed crusts, searching for early terrestrial crustal units, studying materials from potential terrestrial analogs of early planetary crusts, and modeling crustal evolution.

**W89-70235** **152-20-01**
Goddard Space Flight Center, Greenbelt, Md.
**MICROGRAVITY NUCLEATION AND PARTICLE COAGULATION EXPERIMENTS**
J. Nuth 301-286-9467
(152-12-40; 188-41-51)

Laboratory studies of the vapor-solid nucleation of refractory species have been hampered by thermal convection. This problem is especially severe for refractory species such as SiO, C, Al2O3 and SiC which are important in both astrophysics and meteoritics. Well controlled studies of particle coagulation are difficult to perform on earth since larger particles tend to settle out just as the experiments produce aggregates of macroscopic size. We will construct and test a system which will yield high quality data on the nucleation of refractory materials and also produce a cloud of well characterized particles which would be used to carry out studies of particle coagulation on a number of refractory species aboard NASA's KC-135 research aircraft. Refractory vapor will flow from a heated crucible, down a controlled temperature gradient until nucleation is detected via light scattering from the newly formed grains. Particles will be collected in flight and characterized on the ground: size, composition, crystal structure and morphology will be determined. If the particles produced during the nucleation experiment are uniform, then the end of a nucleation experiment will constitute the beginning of a particle coagulation experiment. Changes in the particle size distribution due to aggregation will be monitored via light scattering and extinction measurements. Because of the short time available in 0 gravity (t is less than 25s) we expect that only nucleation experiments will be possible on the KC-135. Coagulation experiments will await the more extended timescales available during Space Shuttle flights.

**W89-70236** **152-20-40**
Lyndon B. Johnson Space Center, Houston, Tex.
**PLANETARY MATERIALS: COLLECTION, PRESERVATION, AND DISTRIBUTION**
Douglas P. Blanchard 713-483-5151

This RTOP provides for maintenance of the Lunar Sample Collection under secure, controlled environment conditions; for the description of samples as new materials are prepared for analysis; for the maintenance of records of the status and distribution of lunar samples; for providing lunar samples to approved investigators and for display purposes; and for technical monitoring of NASA-funded grants/contracts to planetary materials investigators. The RTOP provides for similar functions for the Antarctic meteorite collection, including initial description, processing for distribution to investigators, and maintenance under controlled environment; dissemination of information on meteorite collection; and staff member participation in field collection. Finally, it provides for the collection of cosmic dust samples using high altitude aircraft; for the characterization of dust particles; for distribution to scientific investigators; for dissemination of information; and for development of curatorial techniques for, and educational use of, materials from the various collections. Operation, which is undertaken by support contractor personnel, is directed by civil servant scientists and administrators. The program provides samples and information for about 65 domestic and foreign lunar sample investigator groups, over 100 meteorite investigator groups, and ten cosmic dust investigator groups.

**W89-70237** **152-30-01**
Goddard Space Flight Center, Greenbelt, Md.
**MAGNETIC RECORD IN METEORITES**
Peter J. Wasilewski 301-286-8317

The remanent magnetism record in the meteorites is the only source of information about the magnetic fields present during condensation and accretion and subsequent thermophysical evolution of meteorite parent bodies. Therefore, the record is important to the NASA Solar System Exploration effort. To this end, the principal objective of this RTOP is to conduct laboratory research on meteorites and man-made materials for the purpose of developing the appropriate experimental paradigm required to ensure that the meteorite magnetic record might be credibly evaluated. Atomic ordering, long-term diffusional development of magnetic phases, martensitic transformations, first and second order shock induced magnetic effects, as well as shock-induced thermal effects are aspects of meteorite magnetism which have no appropriate context in analysis of the magnetic record in terrestrial rocks. The laboratory effort at Goddard will explain the thermomagnetic characteristics of the iron-nickel phase diagram in order to develop techniques for identification of meteorite phase transitions and remanence recording temperatures. Assessment of shock-induced effects will enable the overprinting associated with shocks to be deciphered. Atomic ordering is characteristic of specific compositions having the largest magnetic coercivity, and analyses of the role of atomic ordering is the third important aspect of the experimental program.

**W89-70238** **152-30-40**
Lyndon B. Johnson Space Center, Houston, Tex.
**PLANETARY MATERIALS: GENERAL OPERATIONS AND LABORATORY FACILITIES**
M. B. Duke 713-483-4464

General operations support a variety of institutional and scientific support tasks at JSC that are considered essential for the conduct of research and for implementation of the Planetary Materials and Geochemistry Program (PMGP). Inhouse support provides for co-sponsorship of conference, laboratory costs required by visiting scientists using existing facilities, and for cost required to operate common laboratory and computer facilities. This plan also provides inhouse laboratory maintenance for the visiting scientist programs of NASA (National Research Council, Lunar and Planetary Institute, NASA Graduate Intern, etc.). A significant element of this RTOP is an annually updated plan for the systematic modernization of laboratory equipment and instruments. The overall plan includes funding from other benefiting NASA and other agency programs. The PMGP is asked to support about 20 percent of the modernization.

## Planetary Atmospheres R&A

**W89-70239** **154-10-80**
Ames Research Center, Moffett Field, Calif.
**PLANETARY ATMOSPHERIC COMPOSITION, STRUCTURE, AND HISTORY**
J. B. Pollack 415-694-5530

Theoretical modeling and spacecraft data interpretation are used to determine the properties and physical processes characteristic of planetary atmospheres. These properties include their temperature structure, aerosols, cloud layers, gaseous constituents, and opacity sources. Emphasis is placed on reducing and analyzing data returned from spacecraft missions, such as Pioneer Venus and Voyager or preparing for data expected from future spacecraft missions, such as Galileo. However, use is also made of relevant ground-based observations. In addition, the origin and evolution of planetary atmospheres and the outer planets are studied by constructing models that are constrained by relevant spacecraft and ground-based data.

**W89-70240** **154-20-80**
Goddard Inst. for Space Studies, New York, N.Y.
**INVESTIGATION OF COMPARATIVE PLANETARY DYNAMICS**
Michael Allison 212-678-5554

The general objective of this work is to explore the role of eddy, diabatic, and dissipative processes in controlling the structure and circulation of planetary atmospheres under a range of dynamic, thermodynamic and radiative conditions. Applications to Venus and Titan are expected to help assess the importance of both barotropic eddy and thermal tide interactions with Hadley cells in producing equatorial superrotation. Applications to the Jovian planets will be designed to explore the effects of moist and ortho-para convective processes in very weakly stratified, rapidly rotating atmospheres. Analytic diagnostic studies will be made of the equations of atmospheric motion simplified by scalings appropriate for fast and slow rotation, strong and very weak stratification and linearized parameterizations for diabatic forcing and dissipation. Experiments will be performed with a simplified version of the GISS general circulation model to simulate the fully non-linear and three-dimensional dynamics for a range of forcing and dissipation settings suggested by the diagnostic analysis. Parametric models will be developed for the general circulation of atmospheres based on the results of the general circulation experiments for comparison with planetary observations.

**W89-70241** **154-20-80**
Goddard Inst. for Space Studies, New York, N.Y.
**INVESTIGATION OF THE TEMPORAL AND SPATIAL VARIABILITY OBSERVED IN THE JOVIAN ATMOSPHERE**
Barbara Carlson 212-678-5572

The general objectives are to: (1) develop a cloud retrieval algorithm with which to characterize the temporal and spatial variations observed in the Jovian atmosphere in terms of the cloud model parameters; and (2) develop and apply radiative transfer techniques for extracting information on the atmospheric structure from absolutely calibrated spatially resolved polarimetric and photometric CCD images. Principal elements in the approach are: (1) analysis of the spectrophotometric Jovian data obtained from 1980 to present to obtain information on temporal variations in the Jovian cloud cover; (2) analysis of the polarimetric and photometric CCD images of Jupiter using the increased sensitivity of polarimetric data to the upper level clouds combined with the height information intrinsic in the data due to the variation in strength of the methane absorption in the absorption/continuum filter pairs to refine our understanding of the vertical structure; and (3) refine the radiative transfer techniques used to analyze the polarimetric images.

**W89-70242** **154-20-80**
Ames Research Center, Moffett Field, Calif.
**DYNAMICS OF PLANETARY ATMOSPHERES**
R. E. Young 415-694-5521

The dynamics of the atmospheres of Venus and Mars are being studied using multi-dimensional circulation models. The coupled momentum and energy equations are solved numerically using combinations of finite difference and spectral methods. The principal goals are to compare model results with spacecraft data and attempt to understand the dynamical effects of varying planetary rotation rate, solar energy deposition, infrared opacity, atmospheric mass and composition.

**W89-70243** **154-30-80**
Ames Research Center, Moffett Field, Calif.
**PLANETARY CLOUDS PARTICULATES AND ICES**
O. B. Toon 415-694-5971

Goals of this program are: (1) to determine the physical and chemical processes responsible for the cloud structures observed on Mars, Titan, and the outer planets; (2) to provide comparisons between terrestrial and planetary clouds; and (3) to use computer models to provide a self-consistent framework for determining cloud properties from first principles of physics and chemistry. A generalized planetary cloud computer code has been developed which now allows us to approach a large number of problems from a consistent framework. The model has been used to simulate the haze on Titan, and is being readied to investigate dust storms and water ice fogs on Mars.

**W89-70244** **154-40-80**
Goddard Inst. for Space Studies, New York, N.Y.
**RADIATIVE TRANSFER IN PLANETARY ATMOSPHERES**
Barbara Carlson 212-678-5572

The general objectives are to: (1) further develop and apply techniques for extracting information on planetary atmospheres from remote sensing observations of scattered and emitted radiation; and (2) investigate the interactions and feedbacks between radiative and cloud processes. Applications to Jupiter and Saturn in progress are expected to yield general information on the horizontal and vertical distribution of clouds in these atmospheres, cloud microphysics, and the influence of clouds on the retrieved thermal structure. Information on these interactions has relevance for planetary dynamics and other atmospheric investigations including climate processes for the earth. Principal elements in the approach are: (1) the further development and refinement of radiative transfer algorithms which use a modification of direct spectral integration techniques to model the molecular absorption and the single Gaussian-quadrature-point version of the doubling and adding method to model multiple scattering; (2) analysis of thermal infrared data for Jupiter and Saturn to obtain information on atmospheric structure; and (3) use the analysis results to constrain future microphysical models which will be used to investigate the interactions between cloud microphysics, radiation and dynamics.

**W89-70245** **154-50-80**
Goddard Space Flight Center, Greenbelt, Md.
**ATOMIC AND MOLECULAR PROPERTIES OF PLANETARY ATMOSPHERIC CONSTITUENTS**
Donald E. Jennings 301-286-7701
(196-41-54; 147-12-20; 188-41-55)

The principal goal of this laboratory spectroscopy program is to measure the spectral line parameters of planetary and cometary constituents. In the case of lower resolution planetary observations, such as Voyager Infrared Interferometer Spectrometer (IRIS) (4 cm-1), identifications and abundance determinations require laboratory spectra of similar resolution which can be directly compared with the observations. Condensed phases of some molecular constituents may also contribute to the Voyager spectra. The highest possible spectral resolution is required when single features apparent in medium or high resolution Fourier transform spectra (FTS) are composed of more than one molecular transition, and the parameters, frequency, strength, lower state energy, and foreign broadening must be known for each as input in modeling the atmosphere. For high resolution FTS and heterodyne observations the need for ultra-high resolution laboratory data is especially critical, since the bandwidths accessible to these receivers are narrow and Doppler line profiles are completely resolved in the observed spectra. A combination of tunable diode laser (TDL) and FTS laboratory spectra can supply a complete set of line and band parameters anywhere in the infrared. In this program TDL and FTS spectrometers will be applied to selected vibration-rotation bands of planetary molecular species.

**W89-70246** **154-60-80**
Ames Research Center, Moffett Field, Calif.
**MULTI-DIMENSIONAL MODEL STUDIES OF THE MARS IONOSPHERE**
R. C. Whitten 415-694-5498
(889-50-48)

The objective of this research is to arrive at realistic predictions of ion densities, flow velocities and temperatures over the day and night sides of the Mars ionosphere in order to establish ranges and properties for use in a future Mars Aeronomy Mission. For this purpose, simple spectral models of ion density and plasma heat transport have been developed, and the more complete finite difference ionospheric model for Venus has been adapted to Mars. Simple calculations have shown that the Coriolis force can be neglected to first order; hence two-dimensional (2-D) models (mainly spectral) of ion density, flow velocity, and temperatures are justified and have been or are being constructed. Preliminary results have been obtained with the aid of 2-D spectral models of ion/electron density and temperature. The results show that the plasma flux from dayside to the nightside is much smaller than on Venus. The smaller plasma flux on Mars is attributed to smaller bulk velocities and a lower ionopause height. Similar considerations hold for the transport of heat from the dayside to the nightside ionosphere. A more complete (with respect to ion chemistry) finite difference model, based on a model for Venus, has been constructed; it is now being used for studies of the Martian ionosphere.

**W89-70247** **154-60-80**
Goddard Space Flight Center, Greenbelt, Md.
**PLANETARY AERONOMY: THEORY AND ANALYSIS**
R. E. Hartle 301-286-8234

The basic objective is to study the observed properties of the neutral atmospheres and ionospheres of the planets and their satellites in order to identify and interpret the physical and chemical processes governing their behavior, including solar planetary relationships. One of the motivating philosophies is that the study of processes occurring in the atmospheres and ionospheres of the planets and their satellites provides important insights into the nature of similar processes operative at other planets and satellites (including earth) but under different parametric conditions and vice versa. The investigations are pursued by analyzing and interpreting experimental data derived largely from flight programs after funding from project offices has terminated. The data is used to determine the various chemical, compositional, dynamical and energetic states of the respective atmospheres and ionospheres, including the transport and deposition of mass, momentum and energy in these regimes. In general, the approach involves the development of empirical descriptions of either global or small scale phenomena using data sets from a variety of spacecraft. These empirical descriptions of the atmospheres and ionospheres are subsequently interpreted using theoretical models developed to deduce the physical and chemical processes involved. Some of the specific phenomena addressed in this investigation include: atmospheric and ionospheric motions on Venus, Jupiter and earth, interactions of solar wind and/or magnetosphere with atmospheres of Venus, Titan, moons of Uranus and earth, including modification of transport coefficients by instability processes, solar planetary relationships, comparative planetary atmospheres, etc.

**W89-70248** **154-75-80**
Goddard Space Flight Center, Greenbelt, Md.
**COSMIC CHEMISTRY: AERONOMY, COMETS, GRAINS**
B. Donn 301-286-6859
(188-41-55; 152-12-40; 147-21-02)

This RTOP studies physiochemical phenomena in planetary atmospheres, comets, and related aspects of interstellar matter. Laser spectroscopy, photochemistry, reaction kinetics, condensation processes, and vaporization and irradiation of mixtures of frozen gases are investigated and properties of atoms, radicals, molecules, ice mixtures, and grains are measured. These experimental results are used to interpret astronomical observations and develop theoretical models. Flash photolysis-resonance fluorescence apparatus with computer interface for real time analysis yields absolute atom-molecule rate constants. Rate constants and reaction products are determined for atom-radical and radical-radical reactions using a discharge flow system with collision-free sampling to a mass spectrometer. An excimer laser and/or flashlamp is used for photodissociation studies of planetary or cometary radicals. A tunable dye laser is used to detect and study the properties of these radicals. Gas phase and matrix isolation condensation are used to simulate production of primordial solar system, cometary or interstellar grains and study properties and mechanism of production. Ice mixtures are irradiated with MeV protons and ultraviolet light and the spectra and vaporization of initially deposited and irradiated films measured. Formation and properties of porous, low density ice/dust aggregates representing components for the cometary nucleus are studied. Theoretical models of the nucleus are developed.

**W89-70249** **154-80-80**
Goddard Space Flight Center, Greenbelt, Md.
**SOLAR PLANETARY INTERACTION**
H. A. Taylor, Jr. 301-286-6610

The objective of the RTOP is to advance the understanding of comparative solar-planetary relationships, with emphasis upon interaction of solar radiation and field and partial outputs upon the environments of the earth and associated planets. Phenomena characterizing coupling of various forms of solar energy through the system comprised of the magnetosphere, ionosphere and neutral atmosphere are studied. Examples of phenomena include ionospheric mass loading of solar wind, formation of ionopause and association of ion troughs and electric field as part of lightning study at Venus, and comparative field and particle effects in perturbations of neutral atmospheres of Venus and earth. Approach involves accumulation and analysis of multiparameter data sets from a wide variety of satellites, and solar and earth-based observations. Multivariate analysis of interdependence of parameter is emphasized in search for selective factors governing the global and regional effectiveness of the energy inputs and associated changes in conditions extending from cloud levels to the magnetopause. Method of analysis emphasizes phenomenological investigations of high resolution data during distinct disturbance events used to test concepts of interaction. Results of empirical studies are assessed in terms of current theoretical models. Comparisons of model results for contrasting planetary conditions are performed to test basic physical concepts.

**W89-70250** **154-90-80**
Ames Research Center, Moffett Field, Calif.
**PLANETARY LIGHTNING AND ANALYSIS OF VOYAGER OBSERVATIONS**
W. J. Borucki 415-694-6492

The general objectives of this research are to determine the role of atmospheric electrical processes in the evolution of planetary atmospheres and to delineate the electrical and meteorological processes that give rise to the extreme electric fields required for lightning. The general approach is to use comparative planetology, i.e., to compare the spacecraft observations with terrestrial observations and theory in order to understand the processes occurring on other planets and to check the applicability of the theories that have been developed to explain terrestrial lightning and atmospheric electricity. Efforts will be directed toward determining the location of the lightning activity on Venus and Jupiter. Laboratory work is being conducted to determine the yield of various molecules produced by lightning discharges.

**W89-70251** **154-95-80**
Ames Research Center, Moffett Field, Calif.
**MARS 3-D GLOBAL CIRCULATION MODEL**
R. Haberle 415-694-5491

The climate of Mars is characterized by the seasonal cycles of dust, water and carbon dioxide. While the Mariner 9 and Viking spacecraft missions have provided a good first order definition of the amplitude and phase of these cycles, the processes controlling them remain uncertain. The objective of this work is to further the understanding of the processes controlling these cycles. The approach is to numerically simulate various aspects of these cycles using one, two and three-dimensional climate models. The one-dimensional model is a time-marching boundary layer type model that includes the solar and infrared radiative effects of dust as well as carbon dioxide. It is used to isolate the effects of dust on temperature structure and feedback mechanism between dust loading and dust raising. The two-dimensional model is a zonally symmetric primitive-equation model with a tracer transport capability. It is used to study the role of atmospheric transport on the water cycle, and the radiative-dynamical feedback effects of dust on the general circulation. The three-dimensional model is used to study the effects of large-scale eddy motions on the transport of water.

## Mars Data Analysis

**W89-70252** **155-20-70**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**PLANETARY DATA SYSTEM AND COORDINATION**
J. T. Renfrow 818-354-6347
(656-80-01)

The objectives are to develop and implement an operational Planetary Data System (PDS), to develop operational discipline nodes, and to deliver the completed PDS including the central node, the observation geometry node (NAIF), and the operating discipline nodes. JPL will continue to develop the operational PDS in conjunction with the integrated science testbed nodes. The technologies and data, software, and system standards identified and evaluated under the Code EC allied task are being incorporated into the operational PDS. All the system engineering and system implementation activities of both the integrated science testbed nodes and the operational PDS will be conducted under this RTOP in order to have effectively coordinated development. The process of selecting discipline and data nodes for the operational PDS will be completed, some institutions involved in planetary science research will be placed under contract, and these will be developed into operational discipline and data nodes.

**W89-70253** **155-50-50**
Goddard Space Flight Center, Greenbelt, Md.
**MEVTV: EARLY MARTIAN TECTONICS AND VOLCANO CLASSIFICATION**
Herbert Frey 301-286-5450

The objectives of this RTOP are to: (1) understand the origin of the crustal dichotomy on Mars and its relation to the overall geologic evolution of the planet; (2) describe the global scale evolution of the transition zone between the cratered highlands and northern lowland plains in terms of major erosional processes; (3) investigate the structural development of the Valles Marineris and related older canyons to constrain the pre-Tharsis lithospheric stress on Mars; and (4) classify volcanic landforms on Mars and compare with lunar and terrestrial classification schemes. We will search for evidence of a Borealis Basin in terms of radial or concentric structures through scaling comparisons with the Hellas impact basin and for evidence of a missing rim in western Mars. We will define individual morphological terrain units for the transition zone, Mareotis-Tempe Block and the knobby terrain in Elysium-Amazonis. We will produce cumulative frequency curves, analyze these in terms of Neukum-Hiller resurfacing events, and correlate the age of these events with other major geological events on Mars. We will do similar crater counts and analysis for other areas, especially for ridged plains areas such as Syrtis Major and Hesperian Planum. We will prepare a structural map of the Valles Marineris and related canyons (Echus, Juventae) and associated graben, and determine fault distribution, regions of likely fault interaction and fault propagation. Using linear elastic fracture mechanics, we will determine the stress orientation and magnitude, fault propagation forces and contributions to lateral growth of the Valles Marineris from Tharsis tectonism. Distribution maps will be produced for each landform type classified as volcanic.

**W89-70254** **155-50-70**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**MARS DATA ANALYSIS**
M. P. Golombek 818-354-3883

The goal of this research is to analyze a variety of data sets available for the planet Mars in an effort to develop constraints on the timing, characteristics, and evolution of volcanic and tectonic processes. The primary data source for these investigations are the Viking images, which will be used to identify and characterize volcanic products and tectonic events of interest on Mars. The tectonic research focuses on unraveling the detailed kinematic and structural history of extensional faulting around the Tharsis province. This approach provides a means of inferring the thermo-mechanical state and evolution of the Martian interior that is based on the geologic and structural evolution, as well as the gravity and topography. The volcanic research uses dimensional and morphologic data on lava flows to develop constraints and inferences on magma sources beneath the surface. This work uses physical models of flow emplacement to estimate the vent and sub-surface conditions at the time of eruption and composition of the flows. Results provide new constraints on the composition evolution of the magma source.

## Halleys Comet Watch/Experiments

**W89-70255** **156-02-02**
Goddard Space Flight Center, Greenbelt, Md.
**THE LARGE-SCALE PHENOMENA PROGRAM OF THE INTERNATIONAL HALLEY WATCH (IHW)**
Malcolm B. Niedner, Jr. 301-286-5821

The major objectives of this program are: (1) to construct a worldwide network of observatories with wide-field imaging capability for participation in the Large-Scale Phenomena Network of the International Halley Watch (IHW); (2) to standardize and archive the image data for submission to the permanent Halley Archive at JPL; and (3) to provide support to the deep space comet Halley missions flown by international space agencies. When it is acceptable to the network observers and can be performed on a no-additional-cost basis, a fourth goal is to scientifically analyze network imagery using sophisticated state-of-the-art computer image processing techniques. The International Halley Watch (IHW) is an organization whose steering group is composed of members from many countries and whose purpose and function--the advocacy of worldwide observations of Halley's Comet and the collection and archiving of any data so obtained--has been officially endorsed by the International Astronomical Union (IAU). The present Investigator has been selected as a Discipline Specialist for the Large-Scale Phenomena program of the IHW. He and his Team administer the NASA-GSFC portion of this program via the construction of a worldwide network for the observation of large-scale phenomena such as rapidly-variable plasma-tail features and similarly wide-field dust-tail structures. The program's modus operandi involves the forwarding by participating observatories of their best photographic plates (or film copies) to the DS Team for archiving (and analysis when appropriate). Individual observatories always retain full proprietary rights to the analysis of their own data.

**W89-70256** **156-03-05**
Goddard Space Flight Center, Greenbelt, Md.
**GIOTTO, MAGNETIC FIELD EXPERIMENTS**
Mario H. Acuna 301-286-7258

We have participated in the magnetometer experiment for the Giotto mission to Comet Halley. This experiment has provided rapid (up to 30 vectors/sec), precise (0.1 percent), accurate and very sensitive (+ or - 0.004 nT) vector measurements over a wide dynamic range (7 ranges from + or - 16 nT to + or - 65538 nT, with the uppermost ranges for easy check-out during S/C integration) of the magnetic fields observed during the Giotto encounter of Comet Halley in March 1986. Near closest approach we are most interested in the signatures in the magnetic field of dynamical processes originating near the cometary nucleus. Another major objective is the study of the interaction between Comet Halley and the solar wind at 0.8897 AU. This includes the identification of boundary surfaces such as the cometary bow shock and the transmission region between a cometary magnetosheath and the cometary atmosphere closer to the comet. In addition, we shall investigate the role of the magnetic fields in the coma and magnetosheath, dynamical phenomena in the plasma interaction caused by temporal variations of the cometary gas and plasma source during the fly-by and wave phenomena generated by instabilities in the various magnetoplasma regions and regimes.

## Planetary Instrument Definition

**W89-70257** **157-01-20**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**CIRCUMSTELLAR IMAGING TELESCOPE**
R. J. Terrile 818-354-6158

The objective of this task is to develop the Circumstellar Imaging Telescope (CIT) to the status of a serious candidate for a new flight experiment. Specific objectives are to prepare a detailed instrument definition and to demonstrate key technologies. The CIT is a coronagraphic telescope designed specifically for imaging faint objects located close to bright objects. The principal use of the CIT will be to search for planets and protoplanetary material around nearby stars. The CIT will also be used to study astrophysical phenomena which occur near stars, galaxies, and quasars. The key design features of the CIT are control of scattered light through use of super-polished mirrors, control of diffracted light through use of a coronagraph, and control of image motion through use of an internal fine pointing system. Each of the key features will be designed and modeled separately, and then integrated into an overall system design. Because the performance of the telescope is a strong function of the precision with which it is built, a tolerance budget will be developed. The key technologies listed above will be demonstrated by building and testing of breadboards. Support will be obtained from a major optical systems house for the modeling and breadboard work.

**W89-70258** **157-01-70**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**ADVANCED CCD CAMERA DEVELOPMENT**
S. A. Collins 818-354-7393

The objective of this task is to develop a large-format charge-coupled device (CCD) (approximately 1024 square) and to procure a quantity of these devices for use in imaging systems which will be flown on Cassini. This task is a continuation of work which is currently underway. The approach is to select a baseline CCD which is currently being manufactured and to modify it to satisfy the specific requirements of Cassini. This program is expected to yield several dozen flight-quality CCDs to provide for future availability of such devices at reasonable, reliable costs.

**W89-70259** **157-03-50**
Goddard Space Flight Center, Greenbelt, Md.
**X-RAY, GAMMA-RAY AND NEUTRON/GAMMA-RAY INSTRUMENT AND FACILITY PROGRAM**
J. I. Trombka 301-286-5941

The objective of this investigation is to develop remote-sensing and in-situ measurement systems for geochemical and geophysical exploration of the planets, asteroids and comets. These studies will be consistent with planetary programs recommended by the Solar System Exploration Committee (SSEC). The remote-sensing X-ray spectrometer study will consider proportional counters, solid-state detectors, and imaging systems. Elemental composition for elements with atomic numbers greater than Z=6 (carbon) using solar X-ray fluorescent spectral measurements are being considered. Both theoretical and experimental studies will be used in the investigative program. Both gamma-ray and X-ray detector systems are significantly affected by the space radiation environment. Both induced backgrounds and radiation damage in gamma-ray detectors (i.e., NaI(Tl), CsI(Na), Ge(Li) and Ge(High Purity)) have been studied and methods for predicting the magnitude of these effects of the space radiation environment have been developed. Balloon flights of remote sensing gamma-ray and X-ray spectrometer systems will be conducted in order to ascertain their sensitivities and the magnitude of the space environment induced activity. Our group has been developing in-situ X-ray fluorescent methods, passive gamma-ray methods and neutron/gamma-ray methods for application to the Mars Sample Return Rover Mission. Designs of detector systems for such missions will be carried out using both theoretical and experimental methods. Development of a gas chromatography - mass spectrometer for chemical composition measurements of planetary atmospheres will also be carried out.

**W89-70260** 157-03-70
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**MMII IMAGING**
T. H. Reilly 818-354-6078
(157-01-70)

The objective is to develop an imaging system suitable for use on the Mariner Mark 2 (MM2) spacecraft and the series of missions proposed for that spacecraft. The science objectives are being developed by the MM2 Imaging Science Teams. A conceptual design has been prepared which meets most of the science requirements and the constraints of the MM2 spacecraft. The subassemblies most in need of development work were identified: narrow angle optics, wide angle optics, CCD image detector, video data compressor, square root encoder, and low noise power supply. The two optical systems were designed, breadboarded, and tested in FY86-87-88. The wide angle optics is heavier than predicted, and so alternate designs are being investigated to reduce weight. The original plan to obtain the CCD detectors from another project now appears impractical, so a plan to develop new CCDs is being prepared for submittal to the project. The three electronic subassemblies will be delayed until a CCD selection is made. In FY89, the work will concentrate on development of a new CCD, fabrication and assembly of one set of flight mechanical parts for the narrow angle optics, and evaluation of the square root encoder.

**W89-70261** 157-03-70
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**IMAGING SPECTROPOLARIMETER FOR CASSINI**
J. T. Bergstralh 818-354-2296

The goal of this investigation is to verify our conceptual design for a novel Imaging Spectropolarimeter experiment for the Cassini Saturn-Titan orbiter. Novel aspects of our design include the use of Acousto-Optical Tunable Filter (AOTF) technology and near-infrared array detectors. Our objectives, then, are: (1) to verify that AOTFs can be qualified for planetary spacecraft experiments; and (2) to generate a quantitative data base on AOTF and detector performance upon which we can draw in response to the forthcoming announcement of opportunity for Cassini. Specific issues to be addressed are tuning range, out-of-band rejection, efficiency, and image quality of a sample AOTF; integrity of AOTFs against mechanical and thermal stresses; near-infrared array detector performance; optimum optical configuration for an AOTF-based instrument; optimum efficiency of RF driver circuits; and optimum implementation of polarimetry.

**W89-70262** 157-03-80
Goddard Space Flight Center, Greenbelt, Md.
**LUNAR OBSERVER LASER ALTIMETER**
James B. Garvin 301-286-6565

This Planetary Instrument Definition and Development Program (PIDDP of Code EL) investigation intends to design and build a prototype laser altimeter instrument that would meet many of the topographic data requirements recommended for the Lunar Geoscience Orbiter. Analysis of existing lunar laser altimetry (Apollo system) and lunar topography will result in improved laser system specifications. The laser altimeter will be designed to minimize weight, power and data rate, while maintaining reliable, continuous (long-lifetime) operations. Focus will be on an entirely solid-state laser transmitter involving diode-array pumping. Fast (1 to 3 nsec) Si APD detectors and waveform digitizers will be integrated with the diode-pumped redundant Nd:YAG lasers in a simple design. An Al telescope mirror will form the heat of the receiver. A single channel spectrometer mode (at 1.06 micrometers) will be explored. Techniques for obtaining profiles with two spatial resolutions (30 and 300 m) will be studied. Link calculations will assess how easily the laser altimeter design could be enhanced for operations in Mars orbit.

**W89-70263** 157-03-81
Goddard Space Flight Center, Greenbelt, Md.
**LF-VLF SOUNDER**
W. J. Webster, Jr. 301-286-4506

This study will investigate the feasibility of using a long-baseline correlation receiver array together with a full-wavelength transmitting antenna as a low frequency sounder system for probing the subsurface structure of liquid water-free bodies. The frequency range of interest is from 500 KHz to 5 MHz. In this range, penetration depths of several tens of meters may be expected for dry bodies. Tether technology has direct application to this study since electromagnetic compatibility problems (principally the desire for the highest receiver sensitivity practical) will require separations from the main vehicle of the order of a kilometer and may require a separation between the transmit antenna and the receiver array. The objective of this study is to establish the feasibility of the frequency sounder system. This will be done in the following steps: the design, performance and results of the Apollo 17 instrument will be reviewed; the current state of correlation receiver and low frequency technology will be reviewed; a system tradeoff study will be performed; and a preliminary design will be prepared.

**W89-70264** 157-04-80
Ames Research Center, Moffett Field, Calif.
**PLANETARY INSTRUMENT DEFINITION AND DEVELOPMENT PROGRAM - TITAN ATMOSPHERIC ANALYSIS**
G. C. Carle 415-694-5765
(199-52-52)

The objective of this research is to develop flight instrument capability and hardware prototypes for the comprehensive analysis of the gases and aerosols in the atmosphere of Titan from an entry probe.

**W89-70265** 157-04-80
Goddard Space Flight Center, Greenbelt, Md.
**DEVELOPMENT OF 3D PLASMA EXPERIMENT WITH TIME-OF-FLIGHT MASS ANALYSIS**
Edward C. Sittler, Jr. 301-286-9215

The objective is to develop light weight, low power and fast 3-D plasma instrument that will use time-of-flight technology for mass discrimination of ions in space plasmas. This instrument, which will be able to handle particle counting rates exceeding 100,000 Hz is presently being developed under the Planetary Instrument Definition and Development Program (PIDDP) for the Cassini mission to Saturn. This instrumentation will also have general applicability for other future missions requiring in situ measurements of space plasmas. The approach will be to develop high speed time-of-flight (TOF) electronics that will convert the time interval (20 nsec to 500 nsec) between start-stop pulses from the TOF detection unit into a digital word and then transform the accumulated words into a mass spectrum using a microprocessor based system. These electronics will be able to handle counting rates exceeding 100,000 Hz with power levels less than 1 watt. We will develop a rugged light weight TOF unit which will be composed of a thin carbon foil (2 micrograms/sq cm), electrostatic mirror system, solid state detector and microchannel plate detectors. The fundamental design concept will be to confine almost all the electronics at ground potential, while the TOF unit will be at high voltage (35 kV); improve design of existing 35 kV supply with light weight, lower power and reliability being major design requirements; and perform mechanical design studies that incorporate an electrostatic deflection system and TOF detection units with post acceleration to 35 kV into a multi-sensor configuration.

**W89-70266** 157-04-80
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**IR SPECTROMETER DEVELOPMENT**
D. V. Haffner 818-354-2494

The use of the Visible and Infrared Mapping Spectrometer (VIMS) optimized for the Cassini science objectives supports several technical categories: (1) the study of organic and volatile materials on the surfaces of Saturn's satellites, as regards the origin, composition, abundance and distribution of the materials, as well as the relationship to organics elsewhere in the solar system, including asteroids and satellites of the Jovian system; (2) the composition of Saturn's rings, as related to the known color differences in the rings and the composition of satellites proximate to or embedded in the rings; and (3) a comparative study of the dark material composition of small Jovian satellites (using the Galileo Near Infrared Mapping Spectrometer) with satellites of the Saturnian system. The instrument objectives are to optimize the VIMS design for the Cassini mission requirements, using the mass-reduced Comet Rendezvous Asteroid Flyby (CRAF)/VIMS baseline; to investigate options to employ low mass thermal cooling hardware; and to confirm instrument signal-to-noise ratio (SNR) performance adequately to demonstrate VIMS suitability for the study of dark organic materials of low albedo in the Saturn environment. The VIMS configuration will permit science study of the dark materials on Saturn's icy satellites. The concept requires a lower mass then the current VIMS baseline configuration, while achieving performance with the low-albedo satellite surfaces. This task proposes construction of a development model to confirm VIMS thermal performance with this reduced mass cooler. The RTOP tasks will be: (1) optimize the VIMS design for Cassini mission requirements, using the mass-reduced CRAF/VIMS baseline configuration; (2) explore options to employ the Near Infrared Mapping Spectrometer (NIMS) cooling hardware, to reduce instrument mass, complexity and costs; (3) study optics design concepts for the Saturn environment; and (4) confirm calculations providing adequate instrument SNR, for study of the dark organic materials on the Saturnian moons.

**W89-70267** 157-04-80
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**SURFACE SOUNDING MAPPING AND ALTIMETRY RADAR/TITAN (SSMART)**
C. Elachi 818-354-5673

The objective of this activity is the development of a detailed instrument description of a multi-mode advanced radar sensor which will be carried on Cassini for mapping the surface of the largest Saturnian moon Titan. The surface of this moon is hidden from view by haze and radar offers a unique capability for obtaining unobscured images of the surface, altimetry, and even subsurface penetration data to arrive at a better understanding of the process at work. During the next year the instrument description will be derived from system studies, previously developed engineering models and discussions with members of the sensor development science team.

**W89-70268** 157-04-80
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**DEVELOPMENT OF THE PRESSURE MODULATOR INFRARED RADIOMETER**
J. T. Schofield 818-354-2517

The objective of this task is the development of advanced infrared instrumentation for NASA's program of planetary exploration from spacecraft. The emphasis is on the following atmospheric science goals: (1) determine the thermal structure and its spatial and temporal variability in the terrestrial and outer planets; (2) map the abundance and vertical, lateral and temporal variability of key atmospheric species; (3) measure, by direct and indirect means, atmospheric motion; and (4) determine the physical properties of clouds and aerosols. The investigation of surface phenomena is also of fundamental importance in the rational development of infrared instrumentation. In particular, our objective is the application of infrared remote sensing to the determination of surface thermal balance, thermal inertia measurements and the mapping of surface morphology. The approach will be to develop in the laboratory the critical hardware for an advanced infrared sounder. During FY89 this task focuses on the definition and development of the Cassini Stratospheric Sounder (CSS) for the proposed Cassini Saturn orbiter/Titan flyby mission. CSS employs pressure modulation and narrowband filter radiometry in both limb and nadir sounding modes, to obtain simultaneous vertical profiles of temperature, pressure, selected chemical species and aerosols in the atmospheres of both Saturn and Titan. The CSS instrument concept has been developed from the Pressure Modulator Infrared Radiometer (PMIRR) instrument selected for Mars Observer and has a substantial heritage of flight-proven hardware applications on Earth- and Venus-orbiting spacecraft.

**W89-70269** 157-04-80
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**DIODE LASER IR ABSORPTION SPECTROMETER**
C. R. Webster 818-354-7478

The objective of this task is the definition and development of a tunable diode laser infrared absorption spectrometer for in situ atmospheric composition measurements under NASA's program of planetary exploration. Particular emphasis will be given to the development of a probe instrument for the in-situ sensing of Titan's atmosphere on the Cassini NASA-ESA joint mission, and for gas phase composition measurements on future Mars missions. The diode laser spectrometer uses several narrow bandwidth (less than 0.0001 cm(-1)) tunable diode lasers operating near 80 K at selected, mid-infrared wavelengths (3 to 30 micrometers). For the absorption measurements, these sources are directed over an open pathlength defined by a small reflector located 20 cm away. Because of the high sensitivity of diode laser derivative detection methods, volume mixing ratios of approximately 10 to the minus 9th power should be measurable for most species of interest. For Titan, vertical profiles of the concentrations of molecules such as CH4, CO, CO2, HCN, C2H2, C2N2, C3H4, C3H8, C3HN, C4H2 can therefore be determined, with a vertical resolution of a few km from probe entry to the surface. Using a combination of imaging and light scattering techniques, the vertical extent of the cloud structure, its physical properties of particle size distribution, and number density will also be measured using a diode laser source at 0.78 micrometer returned from the same deployed reflector.

**W89-70270** 157-05-50
Ames Research Center, Moffett Field, Calif.
**HIGH PRECISION PHOTOMETER**
W. J. Borucki 415-694-6492

The objective is to develop methods of making ultra high precision photometric measurements of stellar brightness. With this precision many types of stellar variability can be investigated. However, the purpose of this effort is to use high precision photometric measurements to find other solar systems by searching for planetary transits. Because no existing photometer has sufficient precision, the first objective is to develop a laboratory prototype to test various approaches to increasing the precision. The second objective is to demonstrate that this precision can be routinely obtained when the instrument is attached to an operating telescope. Telescopes introduce many types of errors, such as tracking errors, that must be overcome before it is feasible to actually conduct a search for other planetary systems. The approach is to construct prototype instruments with the state-of-the-art components, test the prototypes and their components in the lab, and then test the improved system at Lick Observatory.

**W89-70271** 157-05-50
Goddard Space Flight Center, Greenbelt, Md.
**PLANETARY INSTRUMENT DEVELOPMENT PROGRAM/PLANETARY ASTRONOMY**
M. J. Mumma 301-286-6994
(196-41-50; 196-41-54)

This RTOP supports the development of components for advanced generation infrared spectrometers for planetary observations. Task-02 addresses the development of compact, power efficient infrared heterodyne spectrometer components suitable for eventual space flight use. Particular emphasis is placed on developing RF-excited waveguide CO2 lasers, and miniaturized integrated spectral line receivers. Task-03 is for laboratory development of a dual interferometer Fourier Transform Spectrometer (FTS) configuration (CIRS) operating simultaneously in the far infrared (10 to 650 cm(-1)) and the mid infrared (650 to 1400 cm(-1)). This development supports development of the baseline infrared thermal emission spectroscopy experiment for the Cassini orbiter. Task-05 consists of a feasibility study of an instrument design for a mapping photopolarimeter spectrometer with which to make high accuracy polarimetric measurements for application to future planetary flight missions to the outer planets. The principal elements of this study are to investigate the applicability of a wedge filter design versus the spectral grating concept for spectral selection and to develop new design features which include variable spectral and spatial mapping capabilities.

## Solar Terrestrial and Astrophysics ATD

**W89-70272** **159-41-01**
Ames Research Center, Moffett Field, Calif.
**STUDY OF LARGE DEPLOYABLE REFLECTOR FOR INFRARED AND SUBMILLIMETER ASTRONOMY**
D. J. Hollenbach 415-694-4164

The Large Deployable Reflector (LDR) will be a 20 m diameter reflecting submillimeter/far-infrared telescope, constructed or deployed in space (possibly at the Space Station), and placed in a free-flying earth orbit to perform as an observatory for at least 10 years. It is currently in the early planning stage, and it is hoped to be operational roughly in the year 2000. Work under this RTOP is a continuation of activities to refine the scientific rationale and the related set of science requirements and to provide scientific input in defining and developing technical concepts and requirements. Problems addressed in this work often emerge from the discussions of the LDR Science Coordination Group, of LDR workshops with industrial contractors, or with the LDR lead center, JPL. These problems include, for example, studies of LDR as a light bucket and the use of LDR toward specific scientific goals such as planet detection. Currently, the work, imposed by the need to achieve the desired sensitivity, focuses on thermal background subtraction by LDR using techniques such as nodding, chopping rate and temperature uniformity.

**W89-70273** **159-41-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**SYSTEM DEFINITION STUDIES FOR SPACE-BASED ASTROPHYSICS**
P. N. Swanson 818-354-3273

The objectives of this RTOP are to understand the scientific opportunities provided by, and the technology developments needed for, future space-based astrophysics applications. System definition studies will be made for both filled and unfilled aperture telescopes operating over the spectral region from the visible to the submillimeter. Three potential space-based mission concepts will be studied: two are filled aperture submm/FIR instruments (the Submillimeter Explorer and Large Deployable Reflector), and one is an unfilled aperture optical interferometer. Where the technology needs for these missions overlap, there is a natural evolution in that technology. In addition, all three missions will be able to leverage off of existing CSTI programs. The Submillimeter Explorer study will examine the science goals and the detailed instrument configuration for a submm/FIR mission; it will also select a spacecraft, booster, and orbit. This experiment is an important precursor for LDR in that it will promote instrument development and help define the most important science goals in this unexplored spectral region. LDR--an ongoing pre-phase A study--will continue to provide an important interface with the Code R CSTI technology program in terms of science and technology needs. Specific technology needs for LDR include lightweight low-cost precision segmented reflectors and space structure, wavefront sensing and adaptive optics, passive thermal control, accurate control and pointing systems, and submm/FIR sensors and cryogenic systems. The optical interferometer activity will take the structures and controls requirements of LDR a step since the shorter wavelength radiation will need more precise characterization and implementation in these areas.

**W89-70274** **159-46-01**
Marshall Space Flight Center, Huntsville, Ala.
**ADVANCED X-RAY ASTROPHYSICS FACILITY (AXAF) - EXTENDED DEFINITION/TECHNOLOGY DEVELOPMENT**
D. C. Cramblit 205-544-0569

The Advanced X-Ray Astrophysics Facility (AXAF) is a free-flying observatory featuring a high performance X-ray telescope for use over a 15-year lifetime through servicing from space station or STS (shuttle) revisits. Due in part to advances in metrology and fabrication technology in X-ray optics, AXAF is expected to be 50 to 100 times as sensitive as its predecessor, the High Energy Astronomy Observatory 2 (HEAO-2). An ongoing technology mirror assembly program has already demonstrated the achievability of nearly all the AXAF optic goals. AXAF is now completing an extended definition activity in FY88-89 with a single prime contractor. Congressional new start approval is expected in FY89, leading to a launch in December 1995. Advanced optics technology development efforts are ongoing to assure complete readiness of this long-lead element of the program. This RTOP activity will place emphasis on completion of the requirements and design definition phases of the AXAF science instrument (SI) and observatory contracts, along with continued emphasis on the demonstration of critical long-lead X-ray optics fabrication technology readiness and SI technology readiness needed to assure a sound basis for program new start readiness early in FY89.

**W89-70275** **159-60-01**
Goddard Space Flight Center, Greenbelt, Md.
**ADVANCED TECHNOLOGICAL DEVELOPMENT, GENERAL: SIGNAL AND DATA PROCESSING ELECTRONICS: CAD/CAE**
D. E. Stilwell 301-286-6282

The objectives of this ATD project are to continue development and test of new on-board signal handling, processing, storage, computing and auxiliary techniques and components for use in particle and astrophysics experiments on spacecraft, rockets, balloons, and in special test and analysis equipment applicable for both ground and shuttle usage. The growing complexity of experiments and the corresponding increase in the volume of data obtained have made signal handling, data processing and data transmission the capability-limiting factors. To reduce the transmission of unnecessary data and support the requirements of ever-more complex instruments, it is necessary to continue to provide the maximum possible on-board processing capability. This program is approached through: (1) the investigation and development of techniques for signal shaping and handling, data processing and auxiliary circuitry; (2) modification of existing techniques by application of advanced CMOS/LSI and gate-array technology for parts, and thick film, multiple chip, or SMT technology for packaging; and (3) establishment of a computer-aided-engineering (CAE) capability and experience base to improve design productivity and make semi-custom IC technology available and qualifiable for instrument designs. The objective of this task is to provide continuing maintenance and support for the laboratory's computer-aided-engineering (CAE/CAD) development. Acquisition of the equipment (jointly with the Data Systems Directorate) is complete and it is now necessary to gain familiarity with and confidence in semi-custom design techniques and sources to remain competitive in future instrument development and proposals.

# Oceanic Processes

**W89-70276** **161-10-00**
Wallops Flight Center, Wallops Island, Va.
**OCEAN ADVANCED STUDIES**
C. L. Parsons 804-824-1390

The objectives of this RTOP are to study advanced instrumentation deemed to have potential benefits for ocean color and active microwave remote sensing. Other objectives are to assist in satellite mission definitions as required to support future ocean program goals, to improve instrument measurement quality and algorithm accuracy for altimetry and ocean color imaging, to use modern technologies to reduce power and weight constraints, to accommodate high data rates, and to minimize costs thereby enhancing the probability of flight opportunities. In FY89, this RTOP contains the following tasks: (1) the improvement and utilization of sub-ten centimeter Global Position System positioning technology for airborne remote sensing applications; (2) further study of the technological issues in multibeam (wide swath) radar altimetry, the completion of the development of an airborne altimeter system for the demonstration of the multibeam concept, and studies extending the design of the Earth Observing System advanced altimeter proposed in response to the January 19, 1988, EOS AO; and (3) support for the definition of a future ocean color imaging mission in collaboration with EOSAT.

**W89-70277** **161-10-08**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**ADVANCED SCATTEROMETRY**
F. K. Li 818-354-2849
(161-80-39)

The objectives of this task are to develop a new airborne research scatterometer (NUSCAT) facility that can be used for geophysical research and as a testbed for new technology development and to develop advanced technology that will improve the performance of future spaceborne scatterometers. Specific objectives are: (1) to complete the fabrication, testing, and calibration of the NUSCAT system, install and test the system on the Ames C-130B, and conduct engineering test flights; (2) to continue the development of a new system concept for a spaceborne scanning scatterometer design (SCANSCAT). The SCANSCAT concept includes dual-scanning pencil-beam antennas and will offer significant performance improvements over the NASA Scatterometer (NSCAT); (3) to conduct a sphere calibration experiment with NUSCAT. This will verify and improve system accuracy for NUSCAT. We will complete the system fabrication and testing of NUSCAT. Subsystem test and calibration will be completed and documented. The system will be installed and tested on the Ames C-130B. Test flights will be conducted in April of 1989. A report detailing the results will be prepared. We will continue the low-level in-house study team which was formed in FY88 for SCANSCAT, and extend the small antenna study contract with Harris. The instrument conceptual design will be documented in preliminary form. The NUSCAT Sphere Calibration system will be configured for operation at a remote desert site. Any special mechanical mounting fixtures will be fabricated. A system for measuring the sphere position within the antenna beam and a system for measuring the distance from the sphere to the radar will be developed. The data will be reduced and analyzed. A report will be prepared.

**W89-70278** **161-20-07**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**CURRENTS/TIDES FROM ALTIMETRY**
M. E. Parke 818-354-2739

The primary objective is to continue the analysis of deep water tides with the use of a year or more of Geosat data. Results will be compared with numerical models, the perturbations of near earth satellite orbits, and lunar laser ranging. An invited review paper will be given at the International Conference on Tidal Hydrodynamics, Nov. 1988. This work will provide an intermediate step towards the high quality tide solutions to be expected from Topex/Poseidon. It is expected that Geosat data will provide an M2 tide solution whose accuracy exceeds the accuracy of current tide models in some parts of the world. The analysis of Geosat data will use and further develop a technique pioneered in the current fiscal year for improving the accuracy of tidal solutions from altimetry data. Errors in the tidal solutions are reduced by estimating part of the gravity induced radial component or orbit error. This is done by adjusting the altimetry data to a selected set of deep water bottom pressure gauge and island measurements. The analysis will be compared at all stages with independent measures of tidal parameters.

**W89-70279** **161-20-21**
Goddard Space Flight Center, Greenbelt, Md.
**PHYSICAL OCEANOGRAPHY**
A. J. Busalacchi 301-286-9502

The objective is to conduct research in physical oceanography that contributes to environmental modelling and remote sensing in terms of environmental dynamics. The RTOP supports the Oceans Program and the end objectives of understanding, predicting and managing the environment. Continuing tasks within this RTOP include the efforts by Marsh and Koblinsky that have updated the precision orbits and basin-scale dynamic topographies as well as the development of new graphical analysis techniques. The task by Atlas has developed four methods whereby directions are assigned to satellite-derived estimates of scalar winds. The funding request for mainframe computing at the NASA Space and Earth Sciences Computing Center by Goddard PIs for RTOP related research sponsored by the Oceanic Processes Program is included in this RTOP. A task by Koblinsky and Marsh examines ocean circulation processes with GEOSAT altimeter data. The task by Busalacchi studies the upper-ocean response to surface wind stress estimates in the tropical Atlantic and Pacific Oceans. The task by Schopf is a study of the assimilation of altimetric and in situ data into real-time models for the tropical ocean circulation. New tasks within this RTOP include a task by Schopf that extends the coupled atmosphere-ocean modelling and a task by Gloersen to compare and validate anomalies of SMMR-derived wind, water vapor, sea surface temperature, and atmospheric opacity with in situ and other satellite observations.

**W89-70280** **161-20-33**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**DETERMINATION OF THE EM BIAS IN OCEAN ALTIMETRY**
E. Rodriguez 818-354-2647

The distribution of scatterers on the ocean surface does not coincide exactly with the distribution of ocean surface heights. This phenomenon is a source of error to the height estimated by an ocean altimeter, such as the Topography Experiment (TOPEX) altimeter. The exact nature and magnitude of this bias is not well understood. The objective of this task is to understand this bias and determine its magnitude. Two complementary approaches have been selected to accomplish this task. First, we investigate the possibility of estimating the EM bias from the actual altimeter returns. During the current year, we have shown that it is not possible to estimate the EM bias by analyzing distortions of the shape of the altimeter return. This leaves the possibility of estimating the functional dependence of the EM bias on the parameters which can be recovered from the altimeter waveform: the significant waveheight, surface skewness, and wind speed. We estimate this dependence by performing a repeat track analysis using the data from the Geosat altimeter. Second, to determine the scattering mechanism responsible for the EM bias, we conduct numerical scattering experiments from simulated ocean surfaces. We then compare these results to theoretical predictions from existing theories and improvements on these which we have made.

**W89-70281** **161-20-33**

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

**EM-BIAS DETERMINED FROM GEOSAT CLIMATOLOGY**

E. J. Christensen 818-354-1992

The long range objective of this work is to refine our understanding of the relationship between ElectroMagnetic Bias (EM-Bias) and Significant Wave Height (SWH) through the analysis of GEOSAT altimetric data on climatological scales. The basis of the analysis is to estimate, in a least squares sense, parameters necessary to the recovery of a consistent global model for mean sea level. The approach is similar to that used by Born, 1982 but differs in two fundamental ways. With GEOSAT we have the advantage of observing the sea surface over seasonal, and eventually annual, time scales and thereby have a large population of differing scenes essential to decoupling EM-Bias from other error sources. Further decoupling will be realized through the assimilation of the global data set into the models. The estimable parameters include those related to EM-Bias, the radial component of the orbit, the altimetric path delay due to water vapor and the ionosphere, tides, and inverse barometer effects. A spherical harmonic model will be used for sea level and spherical model SWH, water vapor, surface pressure, and the ionosphere. It will be assumed that the sea state bias resulting from altimeter tracker corrections will be negligible (e.g., Hayne, 1987), unless it is found that skewness bias is indeed proportional to SWH. Comparison of the findings of this analysis with that of Rodriguez, 1988 will assist in the evaluation of skewness effects on altimetry.

**W89-70282** **161-30-00**

Goddard Space Flight Center, Greenbelt, Md.

**OCEAN OPTICS**

N. G. Maynard 301-286-4718

This RTOP is designed to develop methodologies that utilize remote (airborne and satellite), active and passive, optical sensors for the purposes of investigating physical, biological and chemical processes in the ocean surface layer. Close coordination between the sensor and algorithm development, and applications components of the RTOP is emphasized. Also, joint collaborations with the outside oceanographic community are stressed. The present RTOP consists of seven tasks, four of which are ongoing, and three that are being proposed. The ongoing tasks are for mesoscale oceanic processes (-02, McClain), the Airborne Oceanographic Lidar (-13, Hoge), ocean color in the arctic (-18, Maynard), and CZCS archive (-20, Meeson). New proposals are for optical drifters (-21, Esaias, Mason), atmospheric corrections (-22, Fraser, McClain) and global ocean productivity (-23, Esaias, Elrod, McClain). Elements of this RTOP are closely coupled with the processing of the CZCS data set which is being undertaken by the Nimbus Project.

**W89-70283** **161-30-05**

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

**REMOTE SENSING OF OCEANIC PRIMARY PRODUCTION**

D. J. Collins 818-354-3473

The objective of this research is the investigation of the use of satellite imagery for the estimation of oceanic primary production on regional and global scales. The research includes field studies of light absorption, fluorescence and photosynthesis of marine phytoplankton and the development of physiological models for the prediction of primary productivity in the upper water column. The model for primary production is based on a description of oceanic pigment from the Coastal Zone Color Scanner (CZCS). The spatial and temporal distributions of primary production will be used to investigate the variability of the California Current system, and of the Gulf of California. These studies are in progress. The field work on light absorption, fluorescence and photosynthesis includes the analysis of absorption and fluorescence spectra of marine phytoplankton populations and associated particles, focusing on the contribution of both the photosynthetic accessory pigments and detrital pigments to the absorption spectra of suspended marine particles. We will compare spectral deconvolution and spectral derivative analysis to interpret in situ and remote-sensed data obtained from the phytoplankton community in the ocean and to investigate the means by which the photoadaptive state and taxonomic distributions of phytoplankton may be distinguished in oceanic waters. This work is in progress.

**W89-70284** **161-40-00**

Goddard Space Flight Center, Greenbelt, Md.

**POLAR OCEANOGRAPHY**

D. J. Cavalieri 301-286-2444

The objective is to perform research on sea ice, ice shelves, and continental ice sheets and related oceanographic and climatological processes and their impact on global change. The RTOP supports the Oceans, Ice and Climate Programs with the long-term objective of understanding, predicting and managing the environment. The activities involve observational studies of sea ice variability, sea ice dynamics, and air-sea-ice interactions; modeling of the polar sea ice covers; field programs in the Antarctic and Arctic; analysis of data from previous experiments including the Marginal Ice Zone Experiments in the Bering and Greenland Seas and the Weddell Winter Experiment. Deep water formation in the central Arctic and in the meridional heat transport in the oceans. Related studies include the role of Arctic polynyas in the heat budget and water mass structure of the Arctic Ocean and the variability of surface heat flux in the Greenland and Norwegian seas. Additional activities include the study of Antarctic ice shelves; Greenland and Antarctic ice sheets using SAR and LANDSAT data, and ice sheet mapping with GEOSAT data. The refinement of sea ice algorithms for use with passive microwave radiometry and the analysis of Nimbus-5 ESMR and Nimbus-7 SMMR data are all continuing activities. New initiatives include the analysis of aircraft data from SSM/I Arctic underflights, and the application of DMSP SSM/I data to sea ice studies.

**W89-70285** **161-40-02**

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

**IMAGING RADAR STUDIES OF SEA ICE**

F. D. Carsey 818-354-8163

Our objective remains to learn more about the processes at work in ice covered seas. The key tools for this work are aircraft and satellite data sets, notably the active microwave data sets from Synthetic Aperture Radar (SAR). Our work is focused on obtaining more information on ice kinetics, type and conditions and ice backscatter behavior, especially for measurements taken at C-band, the frequency to be used in the spaceborne systems to be flown for the first time next decade by Europe. We will work on utilization of polarimetric information, analogous to that to be acquired by the Earth Observing System Synthetic Aperture Radar (EOS SAR), by examining aircraft data taken over the Chukchi and Beaufort Seas in March, 1988 and proposed for future aircraft flights. We will also participate in appropriate field projects including the Labrador Ice Margin Experiment (LIMEX) and, possibly, CEAREX for the purpose of improving our data base, advancing ice observations technology and developing validation methods for remote sensing data. Finally, we are responsible for the support and management of the ASF PSWT. Our approach will include tasks to: (1) analyze the March '88 DC8 data for comparison with Special Sensor Microwave Imager (SSM/I) polarimetry analysis, frequency effects, active-passive analysis and P-band interpretation; (2) continue to develop a comprehensive aircraft data set for key regions and seasons; (3) participate in LIMEX'89 to advance skills and technology in SAR validation and ice properties observations; (4) expand the analysis of the data from the U.S.-British aircraft-submarine active-passive-sonar project; (5) learn more about the sub-mesoscale motion of ice and about the geophysics of ice motion; (6) continue to develop computer methods for the extraction of ice geophysical information from SAR images; (7) quantitatively evaluate the behavior of air-sea-ice interaction processes, e.g., grease ice, swell, and eddy interactions; (8) take advantage of flights-of-opportunity over the Southern Ocean for SAR data over sea ice; and (9) manage and participate in the work of the ASF PSWT in the areas of team leadership, ice and oceans science, operations demonstrations, and data systems in preparation for

SAR data reception and processing; and (10) continue to analyze LIMEX data and conduct LIMEX'89 in March '89.

**W89-70286** **161-40-10**

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

**NASA OCEAN DATA SYSTEM (NODS)**

J. Charles Klose 818-354-5036

(656-13-40)

The objective of the NASA Ocean Data System (NODS) is to archive data sets from space-borne ocean viewing sensors, together with required supporting data and metadata, and to distribute these data sets in convenient forms to the ocean research community. NODS will provide: a catalog of data sets relevant to ocean science; abstracts of documents relevant to catalogued and archived data sets; data at processing levels 0, 1, and 2 (swath-oriented), level 3 (gridded); browse files--small data subsets designed for quick, interactive browsing; the ability to select much of the NODS holdings by time, region, project, sensor, data level, and measurement type, as appropriate; the ability to display graphics or tabular data subsets at the user's terminal; the ability to transfer graphics or tabular data subsets to the user, either electronically to the user's computer or shipped as hardcopies, tapes or optical disks. Catalog, bibliography, data selection request, and browse file displays will all be available interactively. In the future it is expected that the functions described above, and others, will be performed in a distributed environment where specific data sets will be managed and distributed by the institutions which have a working knowledge of the data sets. In this context NODS will become a federation of cooperating open systems consisting of data centers connected via wide area networks such as the Space Physics Analysis Network (SPAN) or the NASA Science Network (NSN). An open system is a data system which interacts with other data systems using published protocols. A federation of such systems has no hierarchical structure, and no system wide control function. Rather, each participating system is a peer of the others, with respect to communications. Each NODS node specializes in particular data sets, and may support all or a subset of the NODS functions. Each node is independently managed and funded. The JPL node provides overall system engineering, development, and coordination. Newly created nodes will be offered JPL developed data set directory, catalog, and archive software, thus promoting cost efficiency and as much uniformity as possible within the network.

**W89-70287** **161-40-11**

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

**AUTOMATED GEOPHYSICAL PROCESSOR DEVELOPMENT FOR THE ALASKA SAR FACILITY**

J. C. Curlander 818-354-8262

(656-62-01)

The long-term objective of a geophysical processor development for ice studies is to develop an automated data system for classification of ice types and extraction of ice motion parameters from multi-data Synthetic Aperture Radar (SAR) imagery. The goal is to provide data products that can be directly utilized for the analysis of large-scale ice dynamics in the polar regions as well as for practical applications such as navigation and deployment of drilling platforms. As a means to this goal, new data extraction and image processing techniques will be developed under this RTOP and integrated into an operational system for ice information extraction from SAR imagery. This system will be evaluated using Seasat imagery, with the eventual application of the operational system to process ESA Remote Sensing Satellite-1 (ERS-1) data acquired at the Alaska SAR Facility (ASF) and data from the Earth Observation System (EOS) SAR. The approach is to develop techniques for ice classification, two-dimensional motion tracking and evaluate system architectures that would maximize the autonomy and enhance the performance of the data system. Ice motion tracking is a complex problem due to the translation, rotation and deformation of the different ice types because of the high spatial-temporal variability of sea ice. The primary tasks include: development of contextual classification techniques for categorization of sea ice; development of feature tracking techniques for identification of image sequences; reasoning methodologies for utilization of spatial constraints and motion predicts from ice dynamics models; and evaluation and testing of system architectures that are optimal to the implementation of such a system.

**W89-70288** **161-45-33**

Wallops Flight Center, Wallops Island, Va.

**CONTRACT ADMINISTRATION OF ASF (ALASKA SAR FACILITY)**

G. H. Trafford 804-824-1565

The Alaska SAR Facility (ASF) will be located in facilities owned and maintained by the University of Alaska Fairbanks (UAF). The ASF will be housed in and operated by the Geophysical Institute of the UAF. The antenna structure and ancillaries will be mounted on the roof of the 8th floor of the Elvey Building on the West Ridge campus of the UAF, and the control and signal processing center will be located in the Elvey Building Annex. The roof and annex of the Elvey Building are undergoing major reconstruction and expansion at the expense of the university, specifically to support the requirements of the ASF. The ASF technical equipment will be funded by NASA, including its design, implementation, and operation. The physical facilities and its upkeep, including heat, light, power, security, and custodial services, will be funded by the UAF. The ASF will be operated by the UAF's Geophysical Institute; as a research organization, the Institute expects to participate as a full partner with the development of the scientific applications of the data processed at the station. This fact reflects the primary scientific emphasis of the ASF. Its purpose is to support research; it is not a routine receiving station; although, its data will be freely shared with approved users. The respective responsibilities of NASA and the UAF regarding the ASF are described in a Memorandum of Agreement signed July 18, 1986.

**W89-70289** **161-50-02**

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

**OCEANIC REMOTE SENSING LIBRARY**

J. E. Hilland 818-354-4787

The objectives are: (1) to provide a special technical collection of literature on oceanic remote sensing; (2) to provide related literature devoted to oceanography; (3) to provide comprehensive library management and operation services; and (4) to evaluate and implement technology which results in improved efficiency. The full time librarian is solely responsible for meeting the stated objectives. Contemporary documents are collected by subscription, request, and donation from high-quality oceanographic periodicals, and from NASA, DOD, NOAA, ESA and NASDA internal documents (grey literature). Access to the literature is provided from a facility open during work hours Monday through Friday for patron browsing and document borrowing. Also, an on-line, computer-based bibliography provides query and order capabilities to all users of the NASA Ocean Data System (NODS). Users can access NODS worldwide via the Space Physics Analysis Network or Telenet. Library services consist of: borrowing (local and interlibrary), literature search via NASA REmote CONsole (RECON) and ARIN, document acquisition and ORSL newsletter publication. The ORSL collection is organized by the Library of Congress classification system.

**W89-70290** **161-50-07**

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

**ANALYSIS OF OCEANIC PRODUCTIVITY**

C. O. Davis 818-354-5395

This research focuses on the use of Advanced Very High Resolution Radiometer (AVHRR) Sea-Surface Temperature and Coastal Zone Color Scanner (CZCS) ocean color data for the study of primary productivity and phytoplankton dynamics in upwelling systems. Initially, the focus is on using extensive in situ data for verification and interpretation of the satellite data. Subsequently, the goal is to use the satellite data coupled with a physical-biological model to extrapolate those results in time and space. The first study area is around Point Conception where extensive circulation and primary productivity data were collected in 1981 and 1983 during the NSF sponsored Organization of Persistent Upwelling (OPUS) program. Following that initial study the '81 and '83 results will be used to interpret the entire seven year West Coast Time Series data set for the Point Conception area. I will also initiate a study of the Point Arena area in collaboration with Mark Abbott. An extensive in situ data set will be collected in 1987 and 1988 as part of the ONR sponsored Coastal Transition Zone (CTZ) program. The CTZ program also includes the development of a coupled physical-biological model which, eventually, we plan to use in our analysis of the satellite data. This year the work has been extended to include the equatorial Pacific upwelling area, the largest and most important upwelling region in the ocean. In February, I collected optical measurements of phytoplankton chlorophyll and productivity along a transect across the equatorial region at 150 deg W. These results will be compared with more traditional measurements made by Marlon Lewis, John Cullen and Dick Barber with the goal of establishing the validity of optical methods for measuring phytoplankton biomass and productivity. If valid those methods could then be used on moorings or drifters as sea truth for future ocean color satellites.

**W89-70291** **161-60-15**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**JPL OCEANOGRAPHY GROUP PLAN FOR A COMMON COMPUTER SYSTEM**
D. R. Mock 818-354-8133

The project will provide a multi-user computer system serving the basic computing and data management needs of the Physical Oceanography and Biological-Polar Oceanography groups. The system is based on a closely networked group of minicomputers and workstations with shared peripherals which will be accessible to all members of the group. The need for the Ocean Computing System is dictated by the large and increasing number of research projects undertaken by the group, combined with the recent withdrawal of the NASA Ocean Data Systems computing resources from group use. Presently the two oceanography groups include 28 people and carry out 22 research projects in physical, biological, and polar oceanography. Some projects depend on interactions and exchange of data between individual investigators. This requires a common computing facility capable of storing and processing large volumes of data in real time. The diversity of individual tasks undertaken by the group members makes it necessary to provide standard as well as special software packages plus flexible communications capabilities. The sheer volume and complexity of the data require sophisticated data analysis aids, including the use of high resolution color display and hardcopy devices.

**W89-70292** **161-80-00**
Goddard Space Flight Center, Greenbelt, Md.
**AIR-SEA INTERACTION STUDIES**
F. C. Jackson 301-286-5380

The objective of this RTOP is to gain a better understanding of the statistical and dynamical properties of ocean surface wind-waves and their role in air-sea exchange processes; to apply this understanding to improving existing microwave remote sensing techniques; to develop new remote sensing techniques for measuring wind waves and air-sea fluxes. Task elements are devoted mainly to: (1) laboratory (wind-wave flume) studies of wind-wave, wave-wave, and wave-current interactions and wave statistical distribution; (2) field experiments using newly developed airborne microwave instrumentation; and (3) theoretical studies of wave statistical and dynamical processes and electromagnetic wave/surface wave interaction mechanisms. This RTOP also provides support for the Laboratory for Oceans Computing Facility.

**W89-70293** **161-80-15**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**REMOTE SENSING OF AIR-SEA FLUXES**
W. T. Liu 818-354-2394

The objectives are to study, using spaceborne sensors, the interactive processes of ocean-atmosphere exchanges in momentum, heat and moisture and their effects on ocean thermodynamics and climate processes. Feasibility studies on computing moisture flux using Seasat Scanning Multichannel Microwave Radiometer (SMMR) data were successfully performed. A global relation between precipitable water and surface humidity was established. Adaptation of bulk parameterization models to satellite data in the tropical oceans was examined. Four years of Nimbus/SMMR data were evaluated and used to compute latent heat flux. The seasonal cycles of the anomalies during the 1982 to 1983 El Nino Southern Oscillation (ENSO) episode were studied. In light of our results, the method of computing latent heat flux used in ocean numerical models will be evaluated. A Tropical Ocean Global Atmosphere (TOGA) Heat Exchange Project was established in a synergistic attempt to compute net heat flux in the tropical Pacific. The results will be used to study the sea surface temperature changes during the ENSO episode and during the Tropic Heat Experiment. Low frequency atmospheric forcing on ocean dynamics will be studied in conjunction with NSCAT. Variation of sea level as observed by Geosat will be studied as part of the Ocean Storm experiment. The application of Special Sensor Microwave Imager (SSMI) data in computation of latent heat flux will be evaluated.

**W89-70294** **161-80-37**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**THEORETICAL/NUMERICAL STUDY OF THE DYNAMICS OF OCEAN WAVES**
M. H. Freilich 818-354-6965

The objective of this work is to develop dynamically based models of wave-induced nearshore water motions (depths less than 10 m). This work is one component of a larger collaborative effort, Development and Testing of Shoaling Region and Surf-Zone Nonlinear Wave Models, between Freilich, Guza (SIO) and Elgar (WSU). The overall project has been accepted and funded by NSF (start date 15 January 1987). The one-dimensional shoaling model of Freilich and Guza (1984) will be extended to account for non-normal wave incidence and irregular bottom topography, resulting in a model describing two-dimensional shoaling and refraction including nonlinear wave-wave interactions. One-dimensional shoaling models incorporating near-resonant nonlinear wave-wave interactions (Freilich and Guza, 1984) have been shown to predict accurately the evolution of waves as they propagate into shoal water. Sufficient field data exists to guide and test extensions to the 1-D theory that are needed to fully predict wave-induced fluid motions in the nearshore, such as refraction of non-normally incident waves and generation of steady alongshore currents. Analysis of existing directional data has shown that linear refraction theory cannot account for transformations in frequency-directional spectra that occur in the shoaling region. At the same time, bispectral analysis and detailed analysis of the directional measurements indicates that near-resonant triad interactions can also account for the anomalous evolution of the measured frequency-directional spectra, thus supporting the assumption that the basic physics of the shoaling transformation is embodied in the 1-D model of Freilich and Guza.

**W89-70295** **161-80-38**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**OCEAN CIRCULATION AND SATELLITE ALTIMETRY**
L.-L. Fu 818-354-8167

The long-term objective of the research activities covered under this RTOP is to investigate the utility of satellite altimetry for observing the general circulation and variability of the oceans. The approach taken is to analyze Geos-3, Seasat, and Geosat using the techniques of crossover difference, repeat track difference, and mean sea surface mapping. Following are some near-term objectives: (1) processing of Geosat geophysical data records to produce an edited, gridded data set organized into repeat track data files. The products will include sea surface height, wave height, and sigma naught. The products will greatly facilitate the scientific use of the data; (2) mapping of the Agulhas Current variability; (3) investigation of the Somali Current variability; (4) comparison of Geosat altimeter data with expandable bathythermography (XBT) data; and (5) investigation of the variability of the Antarctic Circumpolar Current.

**W89-70296** **161-80-39**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**SCATTEROMETER RESEARCH**
F. K. Li 818-354-2849

The objective of this task is to improve the understanding of the quantitative relationship between radar backscatter from the ocean and basic geophysical parameters by consolidating data obtained by the Airborne Microwave Scatterometer (AMSCAT). The primary FY89 objective is to develop an archival data package consisting of measurements collected during the Frontal Air-Sea Interaction Experiment (FASINEX) and Ocean Storms projects. This package shall include sufficient parameters to allow the calculation of sigma nought. Auxiliary data collected by AMSCAT, such as sea surface temperature, will also be included to help align the data set with sets gathered concurrently by other experimenters. A second objective is to participate in the write up of the so-called FASINEX monograph. This will provide the science community with access to information gathered by AMSCAT. The FASINEX monograph will provide a unique, cross-disciplined collection of papers which will examine the air-sea interaction processes occurring near sea surface temperature fronts. Along with other FASINEX participants, we will collect specific data concerning the ocean sea state, surface roughness, wind stress, etc. Creating the archival data package of AMSCAT backscatter measurements will involve selecting data parameters, adopting a reasonable data format, recording the data on an appropriate medium, and generating a summary report. The FASINEX monograph will consist of a dozen papers, spanning several facets of air-sea interaction. The papers will be written specifically for the monograph and have multiple authors to promote an interdisciplinary understanding of the data. AMSCAT data will be used primarily in studying wind stress, surface roughness, sea state and other related phenomena around the sea surface temperature front.

**W89-70297** **161-80-40**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**STUDIES OF SEA SURFACE TOPOGRAPHY AND TEMPERATURE**
V. Zlotnicki 818-354-5519

The overall goal of this work is to measure the circulation of the oceans using satellite altimetry and other satellite-sensed quantities. The main objectives for the coming year are: (1) to complete the global variability work from Geosat; (2) to complete the Agulhas Retroflection study; (3) to measure eddy fluxes with altimetric mesoscale variability; and (4) to study Pacific equatorial signals. Approaches are: (1) complete the analysis of Geosat corrections to gain confidence with the data set; (2) generate a global working Geosat data set with blunders removed, interpolated to fixed grid, orbit errors minimized at wavelengths shorter than 2500 km including sigma nought and H1/3, from 11/86 to date; (3) the Agulhas work and the equatorial Pacific work involve, in addition, an objective mapping to a uniform space-time grid, and comparison with Advanced Very High Resolution Radiometer (AVHRR) derived temperatures; and (4) the eddy fluxes study involves the approach by Holloway (1986; Nature 323, p. 243-244).

**W89-70298** **161-80-41**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**EFFECTS OF LARGE-SCALE WAVE-FIELD COMPONENT ON REMOTE SENSING MEASUREMENTS OF WIND AND WAVES**
R. E. Glazman 818-354-7151

Analyses of errors in wind measurements by microwave instruments, i.e., by scatterometer, radiometer and altimeter, reported in recent years exhibit certain geographic trends. Since the error biases responsible for such trends are ultimately caused by environmental factors, it is important to understand the causes of the trends and develop physical models that allow one to eliminate the error biases from the remote sensing measurements. The general objective for FY89 is to investigate the role of the degree of wind wave development in distorting wind speed measurements by the satellite scatterometer and altimeter. The approach undertaken in our work combines theoretical investigation of microwave backscatter by a broad-banded surface roughness with the analysis of altimeter data reported by Geosat. The specific objectives are: (1) to develop a new theoretical model for the radar backscatter at nadir and near-nadir incidence angles (effects of a broad-banded surface roughness will be accounted for in this model); (2) to continue our investigation of geometrical properties of the surface that appear in a well-developed sea and lead to biases in wind and wave height measurements; (3) to quantify the corresponding error trends in the altimeter measurements of winds and waves and relate the biases to the pertinent wind wave factors; (4) to facilitate improvement and development of algorithms for the extraction of geophysical information from the backscattering radar cross section (scatterometer and altimeter). In the experimental part of the research, the Geosat altimeter data will be analyzed together with the in-situ wind and wave measurements available from the NDBC network. This analysis will be accompanied by theoretical studies of sea surface geometrical features characteristic of a well-developed sea. In parallel with the above research, we will continue to work in the area of ocean mesoscale dynamics. Techniques and ideas of multifractal analysis of broad-banded geophysical fields will be further studied and applied to the sea surface temperature (SST) data from the Advanced Very High Resolution Radiometer (AVHRR).

**W89-70299** **161-80-42**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**LARGE SCALE AIR-SEA INTERACTIONS**
D. Halpern 818-354-5327

Satellite observations of sea surface temperature (SST), winds, and sea surface topography and in-situ surface wind and upper ocean current and temperature measurements recorded in the equatorial zones of the Atlantic and Pacific Oceans are being analyzed to determine the primary phenomena responsible for large scale SST variations. Also, relationships between ocean color (i.e., phytoplankton pigment concentrations) observations and the aforementioned physical parameters are being examined. Primary components of the composite data set include: Tropical Ocean Global Atmosphere (TOGA) and Tropic Heat moored measurements recorded in the Pacific; tropical ocean general circulation model simulations; Seasat, Geosat, Nimbus-7, and Advanced Very High Resolution Radiometer (AVHRR) observations. Scientific objectives include: description of the spatial and temporal scales of surface wind field in each equatorial ocean; 20-day current oscillations throughout Pacific equatorial zone in preparation for possible Spaceborne Imaging Radar-C (SIR-C) study; equatorial undercurrent dynamics (zonal slope along equator of Geosat data), ECMRWF wind product, TOGA in situ observations, ocean general circulation model simulations; physical control of large scale, enhanced phytoplankton abundance distribution (Nimbus-7 and variety of physical data); Sverdrup balance of tropical currents (Geosat and ECMRWF wind product); geostrophic and Ekman heat transports in tropical regions; and influence of horizontal and vertical advection upon large scale SST variations. Pre-Topology Ocean experiment (TOPEX)/Poseidon and pre-NASA Scatterometer (NSCAT) studies include: development of ocean general circulation modeling activity for data assimilation and for interpretation of oceanic boundary conditions observed by satellites; analyses of Geosat altimetry data; and analyses of Seasat and Geosat wind data.

**W89-70300** **161-80-43**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**SPACE OCEANOGRAPHY**
W. C. Patzert 818-354-4199

The long-term objective of this research is to prepare for the utilization of the spaceborne data that is anticipated from the NASA Scatterometer (NSCAT) and the U.S./French Topology Ocean Experiment (TOPEX)/Poseidon altimetric missions. In preparation for these future missions, analyses will be initiated with the altimetric data now available from the U.S. Navy Geosat mission, and continued with the scatterometer data from the 1978 Seasat-A Scatterometer System (SASS) mission. For the Geosat data, the objective will be to describe the variability of sea surface topography in the tropical Pacific during the past 18 months of the Geosat Exact Repeat Mission, from November 1986 to the present, June 1988. Of particular interest is the possibility of describing the annual cycle of sea level (circulation) variability for the tropical Pacific during the past 18 months. A study has been initiated utilizing the two weeks of dealiased SASS winds that have been incorporated into meteorological prediction model runs by the European Center for Medium-range Weather Forecasting. In this study, the aim is to demonstrate the usefulness of global scatterometer data to future altimetric satellite missions which will require a knowledge of the oceanic sea-level pressure fields (computed from scatterometer data) in order to correct for the inverse barometer effect on the local calculation of sea surface topography. The analysis of satellite tracked drifting buoy data from the tropical Pacific Ocean is completed; two manuscripts are near completion and will be submitted for publication. In summary, the near-term plan is to finalize the drifting buoy research and devote future efforts to the development of techniques for the scientific analysis of available scatterometer and altimetric data with the long-term intent of preparing for the future flights of the NASA Scatterometer (NSCAT) and TOPEX/Poseidon. This plan is consistent with my present JPL duties as 1/2-time NSCAT Deputy Project Scientist and Co-Investigator on the TOPEX/Poseidon Science Team.

## Space Physics SR&T

**W89-70301** 170-10-01
Goddard Space Flight Center, Greenbelt, Md.
**HIGH ENERGY ASTROPHYSICS: DATA ANALYSIS, INTERPRETATION AND THEORETICAL STUDIES**
T. VonRosenvinge 301-286-6721
(188-46-01)

This RTOP is to support laboratory efforts at processing, analyzing and interpreting the data involving correlative studies from a variety of spaceflight experiments, and to conduct theoretical studies to support this effort. These theoretical and interpretive studies lead to the publication of results in the scientific literature and help in the planning of new missions in the areas of solar energetic particles and cosmic-ray astrophysics. The approach involves use of multisatellite data sets such as Voyager, Pioneer, ISEE, IMP, and Helios and comparisons with data from other observatories, both space and ground based. A strong emphasis is placed on creating the theoretical framework for interpreting the results. This RTOP supports graduate student thesis research, research associates and occasionally a senior faculty member on leave from an academic institution. As an example, we have pioneered the study of He-3 rich events (events in which He-3 is preferentially accelerated compared to He-4 by a factor of 1000 or more). We have shown, using data from ISEE-3, that He-3 rich events are fairly common, and we have established procedures for reliably identifying their parent solar flares. This has made it possible to study the characteristics of these flares as observed by other spacecraft, for example their radio and X-ray signatures. These results are now stimulating new efforts to understand He-3 rich events theoretically. A greatly improved instrument for observing these events is being developed for the GGS-WIND spacecraft.

**W89-70302** 170-10-02
Ames Research Center, Moffett Field, Calif.
**MAGNETOSPHERIC PHYSICS - PARTICLES AND PARTICLE FIELD INTERACTION**
A. Barnes 415-694-5506

The overall objective of this research is to improve our understanding of the solar wind, its origin, termination, dynamics and turbulence, as well as its interaction with planetary obstacles. Theoretical studies will be conducted, aimed at understanding the large-scale dynamics of the solar wind, its acceleration and heating mechanisms, and waves and turbulence in the solar wind. These studies employ known theoretical techniques of plasma physics and magnetohydrodynamics, and also often require extensions of basic theoretical plasma physics. Theoretical developments will be related to spacecraft plasma and magnetic data, as well as to indirect observations of the solar wind. Theoretical studies of the solar wind-Venus interaction will be conducted.

**W89-70303** 170-10-02
Marshall Space Flight Center, Huntsville, Ala.
**MHD STUDIES IN SPACE PLASMA THEORY: CORONAL AND INTERPLANETARY PHYSICS**
S. T. Suess 205-544-7611

We will develop analytical, numerical, and empirical models while studying magnetohydrodynamics waves, the heliospheric termination shock, and the morphology and phenomenology of coronal and interplanetary magnetic fields. Our studies of MHD waves will focus on surface waves, and their propagation, decay, mode coupling, application for heating the solar corona, and use in explaining observed ripples on the heliospheric current sheet. For the heliospheric termination shock, we will model its asymmetry due to the Bernoulli effect, predict this asymmetry at the heliographic latitude of Voyager 1, take into account solar wind mass flux spatial dependences and variations with solar cycle, and consider possible dynamic time-dependent effects. With regard to coronal and interplanetary magnetic fields, we plan several studies including: modeling the plasma beta of magnetic clouds and coronal mass ejections and general consideration of the relationship between solar eruptive phenomena, coronal mass ejections, and magnetic clouds; empirical studies of the location of coronal mass ejections with respect to hydrogen-alpha spectral line maps of the Sun; and further consideration of ripples on the heliospheric current sheet, now as a kinematic effect. Data resources include SMM, the MSFC vector magnetograph, Ulysses (after launch), Helios 1 and 2, the NOAA/SEL hydrogen-alpha magnetic neutral line maps, and Stanford's Wilcox Solar Observatory large-scale magnetic field maps.

**W89-70304** 170-10-02
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**COSMIC AND HELIOSPHERIC PHYSICS (ESC)**
E. J. Smith 818-354-4110

This RTOP consists of four continuing subtasks: (1) Magnetospheric and Interplanetary Data Analysis: analysis and interpretation of Pioneer, ISEE vector helium magnetometer data and ISEE plasma wave data; (2) Radio analysis of Interplanetary Scintillations: probing of solar wind regions inaccessible to spacecraft using the scattering and scintillation of spacecraft radio signals; (3) Interplanetary and solar Causes of Geomagnetic Activity: data analysis tasks involving the origin of geomagnetic activity and instabilities and wave-particle interactions involving hydromagnetic waves and plasma waves; and (4) Solar Wind Data Analysis: investigations of heliospheric physics, including the acceleration of the solar wind and stream-stream interactions, using solar wind data acquired by past missions.

**W89-70305** 170-10-02
Goddard Space Flight Center, Greenbelt, Md.
**HELIOSPHERIC STRUCTURE AND DYNAMICS**
L. F. Burlaga 301-286-5956

The basic objective is to study the observed properties of the interplanetary medium. This is achieved by processing, analyzing and interpreting experimental data derived largely from flight programs after funding from project offices has terminated, permitting the long-term phenomenological studies, comparisons of data with new theories and models, correlative studies of data obtained from various satellites and ground-based observatories, and the deposition of additional data in the NSSDC. The essential data to be used in this investigation include measurements of magnetic fields, plasmas, energetic particles, plasma waves and radio radiation. These data are used to determine the various dynamical and energetic states of the interplanetary medium, and its interaction with magnetospheres. These basic properties and processes are then used in the study of specific phenomena such as interplanetary sectors and flows, energetic particle propagation, turbulence and shocks. Basic theory complementary to the data analysis effort is carried out in the areas of kinetic plasma physics and magnetohydrodynamics.

**W89-70306** **170-10-56**
Goddard Space Flight Center, Greenbelt, Md.
**PARTICLE ASTROPHYSICS AND EXPERIMENT DEFINITION STUDIES**
J. F. Ormes 301-286-5705

The objective is to study the properties of the cosmic radiation in order to understand its origin and propagation, and to study the properties of the sites in which element synthesis and acceleration take place. The particles observed are the nuclear and electronic species of the cosmic ray particles: their energy spectra, their charge and isotopic composition, and their distribution in space. Some of these objectives can be met through the imaginative use of short duration observations on balloons. Experiments which must be outside the magnetosphere can be done on Explorer class spacecraft. Many heavier, larger-area payloads will require a large space platform. The Space Station will be an ideal platform and the presence of people to service, repair, and construct experiments in space opens exciting new possibilities. Supporting these objectives is both the development of new detector systems for measuring the elemental charge and isotopic composition of solar and galactic cosmic rays and associated theoretical studies relating to the sites, origin, models for acceleration, and mechanisms for particles transport. The emphasis will be on precise measurements of isotopic abundances of galactic cosmic rays, on new measurements of cosmic ray antiprotons, and the development of experiments for superconducting magnet spectrometer facilities for balloons and the Space Station.

**W89-70307** **170-10-59**
Marshall Space Flight Center, Huntsville, Ala.
**TECHNIQUES FOR MEASUREMENT OF COSMIC RAY COMPOSITION AND SPECTRA**
T. A. Parnell 205-544-7690

An observational program to study cosmic ray composition, spectra, and interactions in the region 10(12) to 10(14) eV is being pursued with balloon-borne instruments in collaboration with the Japanese-American Cooperative Emulsion Experiments (JACEE) team. Techniques for extending measurements to the 10(14) to 10(16) eV region with future long-duration balloon and space flight experiments are being developed. In addition to analysis of data from previous balloon flights, the following studies are in progress at MSFC: (1) to develop a technique for the estimation of heavy nucleus energy above 10(14) eV by measurement of linear frequency of Coulomb electron pairs in track emulsions; (2) to develop efficient 3-D hadronic-electromagnetic cascade simulation of X-ray film spots, apply the simulations and scanning microdensitometry to primary energy and produced particle transverse momentum measurements; and (3) investigate the background in emulsions and X-ray fims induced by the ambient space radiation.

**W89-70308** **170-38-51**
Goddard Space Flight Center, Greenbelt, Md.
**DEVELOPMENT OF SOLAR EXPERIMENTS AND HARDWARE**
Roger J. Thomas 301-286-7921

The objective of this RTOP is to develop new scientific instruments which will contribute to the solution of well-defined solar research problems. One such problem is the study of coronal structures that relate to the solar wind and interplanetary plasma; another is the study of the sources of high-energy solar-flare particles; a third is the direct study of the solar interior as revealed by surface oscillations. Most of the proposed development programs have the ultimate goal of providing critical hardware for future payloads on problem-oriented space missions using the shuttle or free-flyers. Instruments considered for such payloads include: (1) a stigmatic EUV spectrograph to observe coronal features with 1 arcsec spatial and 30 mA spectral resolutions; (2) a high-resolution imaging system for measuring the spatial, spectral, and temporal characteristics of hard X-ray emissions from solar flares; and (3) a novel device to make high precision measurements of the Sun's diameter and its variations with time. Another program under this RTOP will develop special ground-based instrumentation to provide supporting observations necessary to supplement data obtained by solar space missions. Also covered are extended definition studies for future solar instrumentation and evaluation of new optical and detector technologies that may be applicable to future solar EUV and X-ray observations. The latter category will include investigations of state-of-the-art technologies such as high speed data acquisition systems, multilayer optical coatings, phosphor wavelength shifters, and two-dimensional hard X-ray detectors.

**W89-70309** **170-38-51**
Goddard Space Flight Center, Greenbelt, Md.
**GROUND-BASED OBSERVATIONS OF THE SUN**
Brian R. Dennis 301-286-7983

The major objectives of this program are: (1) to obtain and analyze observations of solar velocity and magnetic fields, global oscillations and wave motions, coronal holes, active regions, and flares at wavelengths observable from the ground. These observations complement UV, EUV, X-ray, and gamma-ray observations made from NASA spacecraft such as the Solar Maximum Mission (SMM); (2) to support operational planning for spacecraft experiments; and (3) to conduct basic research and develop specific instrumentation and observational programs relevant to objectives for future flight missions.

**W89-70310** **170-38-52**
Marshall Space Flight Center, Huntsville, Ala.
**RESEARCH IN SOLAR VECTOR MAGNETIC FIELDS**
M. J. Hagyard 205-544-7612
(170-38-53)

The objective of this research is a program of ground-based observations for basic research concerning solar vector magnetic fields and for support of NASA solar missions using the facilities of the MSFC Solar Observatory. In the program of basic research, theoretical and observational programs are undertaken to study vector magnetic field structures which are relevant to current problems in solar physics. To support future NASA solar programs, techniques of observation and of data reduction and analysis are developed using the MSFC vector magnetograph; such techniques will generate guidelines for operations of planned space-based magnetographs, and will provide more focussed direction for the research performed with these instruments. Support of ongoing NASA solar missions is provided through daily observations, transmission of magnetograms to PI's and other relevant personnel, and coordinated observing programs associated with collaborative investigations with mission PI's.

**W89-70311** **170-38-52**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**SOLAR CORONA PLASMA PHYSICS**
John W. Armstrong 818-354-3151

The purposes of this research are to: (1) study using radio scintillation data, and interpret small-scale electron density spectra, flow velocity, and random velocities in the 2 to 10 R region of the coma; (2) numerically perform self-constraint calculations of three-dimensional turbulent magnetic reconnection in the solar corona, thereby determining enhancements in magnetic merging due to anomalous resistivity; and (3) measure electron-ion collision parameters needed in solar plasma diagnostics, using the JPL energy loss method.

**W89-70312** **170-38-53**
Goddard Space Flight Center, Greenbelt, Md.
**THEORY, LABORATORY AND DATA ANALYSIS FOR SOLAR PHYSICS**
Stuart D. Jordan 301-286-8811

The primary objective of the RTOP is to support the laboratory's ongoing programs by developing techniques for the interpretation of solar data. One specific goal is to correctly interpret the nature of observable solar phenomena by understanding the fundamental spectroscopic processes. In this regard, we will focus on the calculation of atomic transition probabilities and studies of nuclear and atomic collision processes in solar plasmas. A second specific goal is to understand the flow of mass, energy, and momentum from a mechanical energy reservoir such as the convection zone to the chromosphere and corona. We will focus on the following areas: (1) the conversion of mechanical energy associated with the photospheric velocity fields into a nonthermal energy flux; (2) the propagation of this nonthermal energy from its point of generation with the photosphere to the chromosphere and corona; (3) the irreversible conversion of this energy into thermodynamic products with the chromosphere and corona; (4) the nuclear processes occurring in solar flares as revealed in the gamma-ray spectrum; and (5) the consolidation of the above processes (one through four) into models that predict new solar phenomena and explain those already observed.

**W89-70313** **170-38-53**
Marshall Space Flight Center, Huntsville, Ala.
**ANALYSIS AND MODELING OF FLOWS IN THE SOLAR CONVECTION ZONE**
D. H. Hathaway 205-544-7610

The objective of this RTOP is to develop an understanding of the fluid flows in the solar convection zone and how they interact with the Sun's magnetic field. The approach is to use data from instruments like the Solar Oscillations Imager on SOHO to determine the structure and evolution of flows observed in the solar photosphere and to numerically model these flows in the presence of magnetic fields to determine how solar magnetic fields evolve.

**W89-70314** **170-38-53**
Marshall Space Flight Center, Huntsville, Ala.
**STRUCTURE AND EVOLUTION OF SOLAR MAGNETIC FIELDS**
R. L. Moore 205-544-7613
(170-38-53)

The general objective is to determine and understand basic empirical properties of solar magnetic fields, their effects in the solar atmosphere, and their generation within the Sun. The general approach is to analyze MSFC vector magnetograms along with complementary data from solar space missions and from ground-based observatories, and to interpret observed effects with physical models. The results will guide choices of specific observing programs for future solar space missions, including SOLAR-A, SOHO, and HSRO, and for the balloon program of Max '91. We will pursue the following studies: (1) Active regions: form and action of the magnetic field in flares and coronal mass ejections; reconnection and submergence of magnetic flux in relation to buildup of magnetic shear; magnetic structure in relation to enhanced heating and microflares; and magnetic canopies of sunspots; (2) Quiet regions: fine-scale magnetic structure of the network and its implications for the heating of the transition region and corona; microflares and their relation to coronal heating and spicules; and trapping and pumping of global p-mode oscillations in the photosphere and chromosphere; (3) Solar cycle: evidence in the sunspot record for bimodality of the solar dynamo; cycle behavior of the number of sunspots and of the number of sunspots per sunspot group; and search for giant-cell surface flows traced by chromospheric filament drift.

## Mesoscale Atmospheric Processes

**W89-70315** **175-50-00**
Marshall Space Flight Center, Huntsville, Ala.
**MESOSCALE PROCESSES RESEARCH SUPPORT**
G. S. Wilson 205-544-1628

The objectives of this RTOP are to contribute to the NASA Mesoscale Processes Research Program by conducting applied research and development activities using space-related techniques and observations that will increase the basic understanding of storms and mesoscale phenomena. The approach will be to utilize the talents of university and private contractor groups, plus the Marshall Space Flight Center (MSFC) in-house talents and laboratory capabilities and specific research activities as described in the tasks of this RTOP.

## Tropospheric Air Quality

**W89-70316** **176-00-00**
Langley Research Center, Hampton, Va.
**TROPOSPHERIC CHEMISTRY PROGRAM**
James M. Hoell, Jr. 804-865-4779

The objective of the RTOP is to develop a basic understanding of the chemistry of the global troposphere and its interaction with the stratosphere, land, and oceans through a coordinated program of atmospheric modeling, theoretical studies, instrument/technique development, laboratory studies, and measurements from satellite, aircraft, and ground-based platforms. The approach for achieving the objectives will consist of: (1) improvements in instrument detection limits for measurement of the very low concentrations of trace gases encountered in the remote troposphere; (2) improvements in response time of measurement systems to enhance our capabilities for coupling chemical sensors to meteorological sensors for improved flux determinations; (3) expansion of measurement techniques; (4) expansion of the range of validity of laboratory measurement techniques to conditions encountered in field measurements; and (5) establishment of reliable absolute calibration procedures for instruments measuring key tropospheric species and intercomparisons of different instruments that can measure the same species in an effort to identify and correct any systematic errors.

**W89-70317** **176-10-03**
Goddard Inst. for Space Studies, New York, N.Y.
**GLOBAL TROPOSPHERIC MODELING OF TRACE GAS DISTRIBUTIONS**
Michael Prather 212-678-5625

The objectives are: (1) contribute to an understanding of global budgets for chemically and radiatively important trace gases and to an assessment of human impact on atmospheric composition; (2) determine measurement requirements and sampling strategies for tropospheric chemistry program, and aid in interpretation of observations. The approach is 3-D studies of trace gas distributions in cooperation with McElroy/Wofsy (Harvard Univ.). We will employ a progressive series of studies of trace gases: chlorofluorocarbons (source known, checks ability to model global/regional transport including stratospheric/tropospheric exchange), methyl chloroform (source known, checks chemistry involving OH), carbon monoxide (sensitive to OH, provides information on sources), and other trace gases. Two-dimensional models will be used to support field programs and identify sources from global/regional observations. We will couple trace gas transport to dynamics and physics (including parameterizations) in the General Circulation Model (GCM). The expected results are to determine the OH content of the troposphere consistent with observations of trace gases. We will validate 3-D chemical tracer models for further predictive studies.

**W89-70318** 176-10-17

Goddard Space Flight Center, Greenbelt, Md.

**TROPOSPHERIC PHOTOCHEMICAL MODELING**

A. M. Thompson 301-286-2629

The objectives of this task are: (1) analyze field data, including NASA Global Tropospheric Experiment/Amazon Boundary Layer Experiment (GTE/ABLE) and precipitation, to derive budgets for ozone and other reactive gases in boundary layer; (2) develop parameterizations of random atmospheric processes for global models; and (3) predict perturbations to tropospheric CH4-CO-NOx and O3-OH (oxidizing capacity) with a photochemical-transport model. The approach will be to combine theoretical (modeling) and data analysis based on statistical representation of random atmospheric processes and on detailed study of particular events from field experiments. Modeling will use 0-D and 1-D models. One-D and 2-D-diagnostic models will be used for multiple runs based on alternative scenarios, with emphasis on evaluating propagation of uncertainties from various inputs: assumed scenarios, lab and field measurements. The expected results are: (1) better understanding of O3, NOx, CO photochemistry and transport in the boundary layer; and (2) projected trends of tropospheric OH, methane, ozone, CO and NOx and interactions with stratospheric ozone depletion and climate change.

**W89-70319** 176-20-99

Ames Research Center, Moffett Field, Calif.

**GLOBAL TROPOSPHERIC EXPERIMENT AIRCRAFT MEASUREMENTS**

H. B. Singh 415-694-6769

The objective of this program is to provide atmospheric measurements aboard NASA aircraft to support the science goals of the Global Tropospheric Experiment. The approach is to develop and test airborne instrumentation, integrate it on the aircraft platform (Electra, DC-8), operate it during Global Tropospheric Experiment flights, provide data as required by Global Tropospheric Experiment project office, and analyze, interpret, and publish individual and/or collaborative results.

**W89-70320** 176-30-01

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

**KINETIC STUDIES OF TROPOSPHERIC FREE RADICALS**

S. P. Sander 818-354-2625

A program of laboratory studies is underway to measure kinetic and photochemical parameters involving key free radical reactions in tropospheric chemistry. Attention will be focused on reactions involved in methane oxidation cycle, and the homogeneous mechanisms for the oxidation of non-methane hydrocarbons including isoprene and the terpenes. The experimental approach will utilize several state-of-the-art kinetic techniques including flash photolysis, discharge flow-mass spectroscopy and discharge flow-Fourier transform infrared (FTIR) spectroscopy.

# Solar Terrestrial and Astrophysics SR&T

**W89-70321** 188-41-23

Goddard Space Flight Center, Greenbelt, Md.

**OPTICAL TECHNOLOGY FOR SPACE ASTRONOMY**

Theodore R. Gull 301-286-6184

Space based instrument systems for astronomy afford scientists important advantages that can not be fully realized with ground based optical technology. In space, optical systems escape detrimental atmospheric effects such as absorption and turbulence, allowing observations in previously inaccessible spectral ranges and the potential to measure ultra-faint and ultra-small objects. However, the technologies for space optics are fundamentally different than those for ground based systems. Technology developments for space optics specifically must address the expanded spectral region (X-rays to far-IR), the vacuum environment, zero gravity, contamination, radiation damage, and the severe weight and volume constraints placed on payloads. The objective of this research and technology program, therefore, is to conduct investigations in those technology areas generic to the development of astronomy instrumentation for space. Relevant technical areas include optical system design and analysis, optical materials, optical fabrication, optical system design and diffraction grating technology. We are presently conducting investigations in two technical areas that will have substantive cost/performance pay-offs. In optical materials research, we have placed major emphasis on ultraviolet mirror coating developments for improved system throughput. In the area of diffraction grating technology, we are conducting studies of advanced design, fabrication, and testing methods. Specific applications include high and low resolution spectrographs and imaging spectrometers for the ultraviolet and extreme ultraviolet.

**W89-70322** 188-41-24

Goddard Space Flight Center, Greenbelt, Md.

**ULTRAVIOLET DETECTOR DEVELOPMENT**

Andrew M. Smith 301-286-3900

The objective of this RTOP is the development of photon-counting detectors suitable for future space astronomy missions such as Lyman, second generation ST instrumentation, the Ultraviolet Imaging Telescope on Astro and other Shuttle payloads. The detectors will be sensitive to far ultraviolet radiation, and have both a large format and high spatial resolution. An in-house effort will continue to develop an intensified charge coupled device (CCD) detector consisting of a microchannel plate (MCP) intensifier fiber optic coupled to four CCD arrays. Attention will be focussed on minimizing the data field lost at the junctions of the CCD formats and on providing a real-time centroiding capability. Additionally, methods of UV enhancement of CCD arrays by ion implantation will be utilized by Tektronix, Inc. in fabricating CCD arrays which will subsequently be tested at NRL and GSFC. Work at Stanford University under the direction of Dr. Timothy will be directed to improving the readout method and to reducing the effective pixel size of the Multi-Anode Microchannel Array (MAMA) detector.

**W89-70323** 188-41-51

Goddard Space Flight Center, Greenbelt, Md.

**UV ASTRONOMY AND DATA SYSTEMS**

T. R. Gull 301-286-8701

The objectives of this task are to perform theoretical and observational astronomical research of particular interest for space observations and to develop tools and techniques which will facilitate and improve the reduction, analysis and understanding of astronomical data, primarily through the application of computers for managing large blocks of bibliographical and observational information, including digitized images and spectra, obtained at all wavelengths for stars, galaxies and other extended objects. The approach is to: (1) obtain detailed stellar evolutionary models to interpret globular cluster observations; (2) develop suitable instrumentation for and maintain the NASA/GSFC 36 inch telescope; (3) utilize the facility to check out new instrumentation leading to flight hardware, to test new observational techniques, and to provide support data for spacecraft observations; (4) develop and use imaging systems to detect fainter emission-line astronomical objects than currently possible; (5) perform appropriate ground and space observations to study stars, nebulae, the interstellar medium and extragalactic objects; (6) develop tools and techniques for using astronomical data bases; (7) incorporate new astronomical data sets and maintain currency of the databases via journal searches; and (8) maintain and enhance the operation of the Interactive Astronomical Data Analysis Facility.

**W89-70324** 188-44-01
Goddard Space Flight Center, Greenbelt, Md.
**SOUNDING ROCKET EXPERIMENTS (ASTRONOMY)**
Andrew M. Smith 301-286-3900

The astronomical sounding rocket program provides a unique capability to perform observations from above the earth's atmosphere. The present objectives are to develop instrumentation which takes advantage of this capability and to obtain spatial images of faint extended celestial sources in the far ultraviolet (FUV). The emphasis in our instrumental development program is on photon counting, two dimensional array detectors optimized for astronomical applications. This effort is primarily devoted to adapting the Multi-Anode Microchannel Array (MAMA) detector to our sounding rocket needs. In addition, we are presently developing a new instrument consisting of a 20 inch Cassegrain telescope combined with an imaging spectrograph. The instrumental development results from our group's scientific interests. These include observations of condensations in cooling flows of intercluster gas, jets associated with active galaxies, and luminous arcs in galactic clusters.

**W89-70325** 188-44-23
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**NEAR INFRARED IMAGING AT PALOMAR**
C. Beichman 818-584-2904

A program of Galactic and extra-Galactic science for the Palomar 5 m telescope using a near-infrared camera is proposed that incorporates a 128 x 128 element HgCdTe array from the High Resolution Imaging Spectrometer (HIRIS) project. The first camera has already been built and will begin observations in June 1988. Among the scientific projects proposed are studies of regions of low mass star formation, searches for high luminosity brown dwarf stars, searches for Infrared Astronomical Satellite (IRAS) sources without optical counterparts, mapping of emission lines in ultra-luminous IRAS galaxies, and the search for star formation in galaxies at a redshift of -0.5. Support is requested for FY89 to upgrade the present camera to incorporate a larger format array of 256 x 256 pixels and to add a coronograph to enable searches for faint companions or structures close to bright objects. Support is requested in FY90 and FY91 to build a new camera that will use a Fabry-Perot spectrometer to make a wide-field imaging camera capable of resolution up to 10,000. The spectrometer will allow spectrally and spatially resolved images of regions of star formation in our own and external galaxies. An important by-product of this research will be the detailed understanding of the science and technology underlying the infrared instrument planned for the Hubble Space Telescope (HST). The detectors and science proposed here are very similar to those planned for both the Hubble Imaging Michelson Telescope (HIMS) and the Near-Infrared Camera and Multi-Object Spectrometer (NICMOS). A good understanding of how HgCdTe arrays work at the ground-based telescopes and what objects and spectral lines are important to observe will maximize the scientific return of whichever infrared instrument is selected for HST.

**W89-70326** 188-44-23
Goddard Space Flight Center, Greenbelt, Md.
**INFRARED, SUBMILLIMETER, AND RADIO ASTRONOMY**
N. W. Boggess 301-286-6989

The scientific objective of this program is to provide a better understanding of the current state and evolution of the universe as a whole and or specific objects within it. This is achieved by making observations spanning IR and radio wavelengths and at a wide range of spectral resolving powers, and by conducting theoretical research in conjunction with the observations. Many IR and submillimeter wavelengths require high altitude platforms such as the Kuiper Airborne Observatory, balloons, or satellites. High sensitivity composite bolometers are being developed in the far infrared to take maximal advantage of low background conditions at those altitudes. A balloon-borne 1.5 m telescope is used to measure the small-scale anisotropy of the cosmic background radiation. An infrared camera is used to image efficiently galactic and extragalactic sources. Infrared and submillimeter spectrometers are used to detect and resolve intensity profiles for molecular and atomic lines. Correlative studies, including radio observations, are made to enable maximum insight into the physics of the medium. Laboratory studies of sample materials enhance ability to interpret observations. Improved computing techniques will facilitate and improve data reduction, analysis, and understanding of astrophysical data.

**W89-70327** 188-44-53
Ames Research Center, Moffett Field, Calif.
**THEORETICAL STUDIES OF GALAXIES, THE INTERSTELLAR MEDIUM, MOLECULAR CLOUDS, STAR FORMATION**
B. F. Smith 415-694-5515

The objective of this research is to better understand: (1) the formation and evolution of galaxies and clusters of galaxies; (2) molecular cloud formation and evolution; (3) star formation; (4) the structure and evolution of the atmospheres of evolved stars; and (5) basic processes which determine the state and infrared radiative properties of the interstellar medium. This research is being stimulated by observational advances and expected capabilities of new NASA observational programs. A significant fraction of this effort involves computational astrophysics employing a wide variety of numerical codes developed at Ames to treat fundamental problems in the areas of interest. These numerical codes treat multi-dimensional hydrodynamic and complex chemistry and radiative transfer situations. This effort makes effective use of the advanced computational facilities at Ames.

**W89-70328** 188-44-53
Goddard Inst. for Space Studies, New York, N.Y.
**RESEARCH IN ASTROPHYSICS: SOLAR SYSTEM, TURBULENCE**
Vittorio Canuto 212-678-5571

The objectives of this program are the study of the phenomenon of Large Scale Turbulence (LST) and its implications in astrophysics. The great diversity of physical settings (geophysics, atmospheric physics, origin of planets, accretion disks in general, molecular clouds, etc.) in which a detailed knowledge of turbulence is needed, is in stark contrast with the lack of analytical models sufficiently general to be applicable to the above cases. Since the only available methods are either phenomenological expressions or numerical simulations of the full hydrodynamic equations, (neither of which is satisfactory), we have had as an objective that of constructing an analytical model for LST. The approach uses as the only ingredient for both the energy source as well as for the cascade integral the growth rate of the unstable modes that ultimately generate turbulence. The results thus far fare very satisfactorily with a large variety of laboratory data.

**W89-70329** 188-44-57
Ames Research Center, Moffett Field, Calif.
**LABORATORY STUDY OF CHEMICAL AND PHYSICAL PROPERTIES OF INTERSTELLAR PAHS**
L. J. Allamandola 415-694-6890

It has recently been proposed that free molecular sized, polycyclic aromatic hydrocarbons (PAHs) are surprisingly abundant in many different astronomical objects and thus a widespread, but previously unrecognized, component of the interstellar medium which could play a dramatic role in many processes such as energy balance, molecular cloud collapse and dust particle formation. Testing of this hypothesis and its impact on the larger astrophysical picture is severely hampered by a general lack of knowledge of the spectroscopic, physical and chemical properties of PAHs in the forms they are likely to be in space: ions, radicals, neutral species and clusters. Spectroscopic properties of these unique species are particularly important to know since virtually all observational data pertaining to this problem is spectroscopic in nature. The major goal of this research is to provide the data necessary to test the PAH hypothesis and further our understanding of their potential role in astrophysics. Experiments will be performed in the laboratory in which the PAHs to be studied are prepared under conditions which duplicate, as much as possible, the interstellar conditions in which they are found. A special laboratory is being prepared to aid in getting the best possible test results.

**W89-70330** **188-46-01**
Ames Research Center, Moffett Field, Calif.
**THEORETICAL STUDIES OF ACTIVE GALAXIES AND QUASI-STELLAR OBJECTS (QSOS)**
L. J. Caroff 415-694-5523

This research effort seeks to understand the origin of the continuum spectra of quasi-stellar objects (QSOs) and other compact luminous objects. An optically thick, relativistic outflow is postulated to arise in the central core of these objects and arbitrary input energy spectrum of photons and/or electron-positron pairs is assumed. The evolution of the energy distribution functions of the photons and pairs is followed until either the system becomes optically thin or thermal equilibrium sets in. At that time the emerging spectra are compared with observations. Interaction processes which are likely to be important to the spectral evolution are: pair-production, annihilation, Compton scattering, bremsstrahlung, Coulomb scattering, and, if a magnetic field is present, synchrotron/cyclotron emission.

**W89-70331** **188-46-01**
Goddard Space Flight Center, Greenbelt, Md.
**HIGH ENERGY ASTROPHYSICS: DATA ANALYSIS, INTERPRETATION AND THEORETICAL STUDIES**
Stephen S. Holt 301-286-8801
(170-10-01)

This RTOP is to support laboratory efforts at processing, analyzing and interpreting the data involving correlative studies from a variety of spaceflight experiments, and to conduct theoretical studies to support this effort. These theoretical and interpretive studies lead to the publication of results in the scientific literature and help in the planning of new missions in the areas of X-ray and gamma-ray astronomies, energetic particles and cosmological studies. Multisatellite data sets, such as those of Ariel 5, Orbiting Solar Observatory (OSO) 8, and High Energy Astrophysical Observatories (HEAO) 1 and 2 provide a basis of information which for many X-ray sources remains complementary to the results of recent missions such as Exosat and the current Ginga. These data continue to provide important pieces of the still incomplete pictures of the unresolved physical systems that make up cosmic X-ray sources, especially when they are compared to other data, either from other X-ray observatories, or from space or ground based observatories at other wavelengths. Strong emphasis is placed on creating the theoretical work, and carrying out studies to test the feasibility of measurements with future missions. This RTOP supports graduate student thesis research, research associates and occasionally a senior faculty member on leave from an academic institution.

**W89-70332** **188-46-01**
Goddard Space Flight Center, Greenbelt, Md.
**SOUNDING ROCKET EXPERIMENTS (HIGH ENERGY ASTROPHYSICS)**
E. A. Boldt 301-286-5853

High energy astrophysics (especially X-ray astronomy) is a rapidly evolving field of research, both scientifically and technically. Our exploitation of the capabilities of short lead time, planning flexibility, accurate pointing and extremely high telemetry rates afforded by rocket-borne experiments are major factors in our success to date; a vigorous elaboration of this activity with Spartan-like experiments as well as sounding rockets is now necessary for continuing to make timely and important contributions that complement data from our satellite missions and for the effective planning of advanced future missions. This involves experiments with systems incorporating newly developed spectrometers and X-ray concentrators.

**W89-70333** **188-46-50**
Marshall Space Flight Center, Huntsville, Ala.
**X-RAY ASTRONOMY**
M. C. Weisskopf 205-544-7740

The objectives of this program are: (1) to analyze and interpret existing satellite and ground-based observations of the time variability of X-ray sources and their optical counterparts; (2) to utilize Fourier transform, epoch folding, and auto- and cross-correlation techniques to classify and quantify the time variability of these sources; (3) to interpret the results in terms of existing theoretical models or to establish new theoretical models if required and feasible; and (4) to utilize these results in guiding the design of the sounding rocket payload. A second set of objectives is: (1) to design, build, test, optimize, and eventually fly on sounding rockets and satellites an advanced X-ray imaging detector which utilizes both fluorescence of the atoms in the detector gas together with parallel field preamplification regions to obtain the highest performance (this has application for X-ray imaging, spectroscopy, and polarimetry); and (2) to develop new methods and systems for detecting X-ray polarization.

**W89-70334** **188-46-57**
Marshall Space Flight Center, Huntsville, Ala.
**GAMMA RAY IMAGING TELESCOPE SYSTEM (GRITS)**
R. B. Wilson 205-544-7695

A development program is proposed to better determine the secondary gamma-ray background rejection properties and sensitivity of the Gamma Ray Imaging Telescope System (GRITS), a proposed high energy (greater than 200 MeV) gamma-ray detector which would make use of a Space Transportation System external tank (STS-ET) as a gas Cherenkov detector. A report was produced by D. Koch/SAO for NASA HQ Code EZ in October 1987 in which analytical calculations were used to estimate the sensitivity of such a detector. Reviews received by Headquarters indicated that the appropriate next study to be performed is to evaluate the charged particle-induced neutral emission from material in the aft dome overlying the active telescope elements. Under this RTOP, Monte Carlo simulations of charged particle interactions with the ET/telescope elements will be performed, using existing computer codes. The sensitivity of GRITS will be estimated, using other existing Monte Carlo codes for gamma-ray/electromagnetic cascade processes.

**W89-70335** **188-46-57**
Marshall Space Flight Center, Huntsville, Ala.
**GAMMA RAY ASTRONOMY**
G. J. Fishman 205-544-7691

An observational program in gamma-ray astronomy is being pursued using balloon-borne experiments. Techniques and instrumentation for future space flight experiments are developed concurrently. The following are the objectives of the MSFC research program: (1) to perform new scientific observations in gamma-ray astronomy using balloon-borne detectors; (2) to develop new detectors and experimental techniques for future spaceborne gamma-ray astronomy observations; and (3) to study various sources of background radiation, primarily atmospheric gamma-ray radiation and activation of detectors and materials in order to increase the sensitivity of gamma-ray observations.

**W89-70336** **188-46-57**
Goddard Space Flight Center, Greenbelt, Md.
**GAMMA RAY ASTRONOMY**
Carl E. Fichtel 301-286-6281

The technical objective is to develop the most appropriate detector systems for the observation of astrophysical sources of very energetic photons. The first approach was the development of a large high energy telescope using digitized spark chambers. Many major improvements to this basic telescope system are still being pursued and other approaches to detector systems are now being developed for high energy, intermediate energy, and low energy gamma-ray observations. In the high energy region improvements in the track imaging chamber systems are continuing, and special attention in the track imaging chamber research is now being directed towards drift chambers. At the same time, several approaches are being explored to improve angular resolution, including techniques to concentrate on higher energy photons. Improved attitude and aspect systems are being built. In the 1/2 to 40 MeV region different interaction processes become dominant and hence, new detector techniques are required. A totally new detector has been developed based on the Compton interaction process, but including several new concepts which together should increase the sensitivity by a factor of ten. For gamma-ray burst studies, new detector systems are being developed both for the gamma-ray energy range and for detection at other wavelengths. In particular a ground-based system is being developed to detect and precisely locate optical flashes that are likely to occur in coincidence with gamma ray bursts.

**W89-70337** **188-46-58**
Goddard Space Flight Center, Greenbelt, Md.
**GAMMA RAY SPECTROSCOPY**
Bonnard J. Teegarden 301-286-5277

The objectives of this effort are: (1) to develop new instrumentation to perform high resolution spectroscopy and imaging celestial gamma-rays in the 0.01 to 10 MeV range; and (2) to fly this instrumentation on high altitude balloons to assess the performance in a space-like environment and to gather scientifically meaningful data. In particular, the instrumentation will be designed to search for and measure the properties of narrow lines in the celestial gamma-ray spectrum. A major goal of this work will be the demonstration of new ideas and techniques for eventual use in a satellite-borne experiment. The approach will center on the use of high purity Germanium detectors to perform the most precise possible measurements of the gamma-ray energy. In addition, new techniques will be explored to further suppress instrumental background and thereby improve the sensitivity of the experiment. Finally, new methods will be explored for constructing images of the gamma-ray sky with an accompanying improvement in angular resolution over earlier experiments.

**W89-70338** **188-46-59**
Goddard Space Flight Center, Greenbelt, Md.
**X-RAY ASTRONOMY**
E. A. Boldt 301-286-5853

Celestial X-ray sources have introduced us to rich new aspects of astronomy ranging from the millisecond bursts of hard X-rays coming from compact stars to the extensive diffuse emission associated with clusters of galaxies. The combination of large sensitive area, low detector background, high temporal resolution and energy-dispersive spectroscopy over a broad bandwidth has been our approach in discovering and exploring these phenomena. The power of this approach has been well demonstrated. Extending it with improved spectral resolution and broadband imaging is a major area of development now indicated. This involves the creation and evaluation of new systems incorporating low noise detectors of optimum energy resolution, large area X-ray concentrators and imaging devices.

**W89-70339** **188-48-52**
Ames Research Center, Moffett Field, Calif.
**CENTER FOR STAR FORMATION STUDIES**
D. J. Hollenbach 415-694-4164

The general objective of the proposed research is to undertake a unified theoretical analysis of the problem of star formation. Solid achievement is likely to come, however, only with a healthy awareness of constraints placed on theoretical ideas by the ever increasing data base. Moreover, the interrelated theoretical problems cannot be attacked in isolation, but must be approached from the viewpoint of overall consistency with advances in other fields. Our comprehensive investigation includes studies of patterns of star-forming regions on galaxy wide scales; dynamics, structure, energetics, and chemistry of the interstellar medium; details of the fragmentation of molecular clouds and gravitational collapse of their dense rotating cores; possible differences in the formation of high and low mass stars; formation and evolution of protostars and nebular disks; mechanisms of planetary system formation and disk dispersal; and the origin of bipolar flows and their effect on the surrounding gas and dust.

**W89-70340** **188-78-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**TAU MISSION**
A. B. Meinel 818-354-0963

The goal of the Thousand Astronomical Units (TAU) study is to identify space science objectives unique to a dedicated voyage beyond the planets. The science objectives are in two areas: (1) parallax astrometry and astrophysical observations over a broad spectral region, including thermal infrared; and (2) space physics involving crossing the heliopause into the region of undisturbed interstellar space. The continuation of the TAU study under this RTOP will build on the progress made in internal JPL/Caltech workshops and presentations at meetings of the International Astronomical Union and the American Astronomical Society, plus a workshop sponsored by EZ to be held shortly. The main objective of this RTOP work is to select specific science objectives compatible with a modest size/cost TAU spacecraft, and identification of a provisional spacecraft concept. The objectives are to explore the heliopause and interstellar space characteristics, the astronomy objectives being those requiring a large payload capability not yet immediately available. The main work under this RTOP would be done by A. B. Meinel and M. P. Meinel with consultation with appropriate scientists within and outside JPL/Caltech.

**W89-70341** **188-78-03**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**SENSOR TECHNOLOGY**
S. A. Collins 818-354-7393

Charge Coupled Devices (CCDs) are being developed for use as camera/spectrograph detectors throughout an unprecedented spectral range: 1 to 1000 A. The objective of this task is to implement and demonstrate CCD design modifications which enhance CCD performance at X-ray and ultraviolet wavelengths. Specifically, good detection efficiency (greater than 30 percent) is to be achieved through the range of 1 to 4000 A, and low readout noise (less than 5 electrons/pixel, rms) is to be demonstrated. Our approach is to contract for modification of the design of an existing visible-light CCD, to procure such enhanced CCDs, to evaluate their performance at low signal levels, and to undertake additional design/fabrication iterations as required to achieve the stated objectives.

**W89-70342** **188-78-41**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**GRAVITATIONAL EXPERIMENTS IN SPACE**
R. W. Hellings 818-354-3192

The objectives of this RTOP are to identify and document scientific objectives, technology issues, and opportunities for gravitational experiments in space, and to take the first steps in planning for future flight projects in this area. This work will grow out of a NASA workshop to be held in Annapolis in June 1988. At this workshop, many ideas will be presented relative to the future directions that NASA should take in experimental gravitation in space. These ideas will include theoretical foundations for the various tests, readiness of the various technologies, and proposed details of the possible missions themselves. Under this task, the work thus begun will be pursued by: (1) forming a Science Coordinating Committee for Experimental Gravitation to review the results of the workshop and coordinate the subsequent studies; and (2) supporting studies that will enable the questions raised at this workshop to be answered. This will include clarifying the theoretical situation as to the value of the various experiments proposed and pursuing scientific and engineering studies of the missions (feasibility studies, pre-phase-A studies, etc.).

**W89-70343** **188-78-44**
Ames Research Center, Moffett Field, Calif.
**DEVELOPMENT OF SPACE INFRARED TELESCOPE FACILITY (SIRTF)**
W. F. Brooks 415-694-6547

The objectives of this RTOP are to define and develop the Space Infrared Telescope Facility (SIRTF), to define and develop scientific instruments for the SIRTF focal plane, and to develop operational procedures for SIRTF as a free flyer observatory. SIRTF is an observatory that will accept multiple focal plane instruments for use by infrared astronomers. The conceptual studies have identified the key technologies for SIRTF and for the science instruments, and technology development is being conducted. The approach for this RTOP is to: (1) continue development of the technology needed for the design and development of SIRTF; and (2) to coordinate the results of the previous studies and the technology development and to increase the depth of the design definition and systems analysis by performing Phase B studies of the telescope facility and the selected instruments.

**W89-70344** **188-78-60**
Ames Research Center, Moffett Field, Calif.
**STRATOSPHERIC OBSERVATORY FOR INFRARED ASTRONOMY (SOFIA)**
G. W. Thorley 415-694-5917

The objectives of this RTOP are to define and initiate development of the Stratospheric Observatory for Infrared Astronomy (SOFIA), to define the ground support system and to develop the operational procedures for the airborne observatory. The SOFIA is a proposed new observatory to continue NASA's airborne IR astronomy program into the 1990s as the successor to the Kuiper Airborne Observatory (KAO). The SOFIA features a 3-meter class telescope mounted in a modified Boeing 747SP aircraft. Potential users of the SOFIA would make observations ranging from about 0.3 microns to 1.6 mm in wavelength. The SOFIA will provide a significant increase in scientific capability over the KAO. The approach for this RTOP is to: (1) continue development of the technology needed for the design and development of the SOFIA; (2) to coordinate the results of the previous studies and the technology development, and to increase the depth of the system definition and systems analysis by completing definition studies of the aircraft system, telescope system and ground support system; (3) to select the contractors and continue development of the aircraft system and the Federal Republic of Germany (FRG) telescope system; and (4) to procure and refurbish the used Boeing 747SP for the SOFIA platform. The work will be performed inhouse at Ames Research Center, under contract to industry, and in collaboration with the FRG.

**W89-70345** **188-87-44**
Ames Research Center, Moffett Field, Calif.
**KAO CAMPAIGNS - SUPERNOVA**
L. Haughney 415-694-5338

The objective of the RTOP is to provide support of the NASA 714 Kuiper Airborne Observatory (C-141/KAO) so that it can perform observations of Supernova 1987A (SN). This RTOP provides the mission peculiar funds for operating the C-141/KAO at Christchurch, New Zealand; that is, the extra costs of operating the facility at a remote base. Two deployments are planned for FY89, each of four to eight weeks duration and separated by approximately six months. To meet our objectives in support of the C-141/KAO's SN observations in the Southern Hemisphere, our approach will be to provide the logistics support needed to operate the C-141/KAO facility at a site very remote from our home base. Supplies, equipment, spare parts, etc., will be shipped as needed for the operation. Some support will be obtained locally in New Zealand, as convenient, available, and economical. Mission peculiar costs include, but are not limited to, premium cost of aviation fuel, shipping cost for ground support equipment, A/C peculiar parts, and cryogens used by investigators. This support will allow the C-141/KAO to support approximately eight flights for four investigator teams per deployment.

**W89-70346** **188-87-46**
Goddard Space Flight Center, Greenbelt, Md.
**X-RAY AND GAMMA-RAY SUPERNOVA**
Bonnard J. Teegarden 301-286-5277
(188-46-58; 188-50-46)

The objective of this RTOP is to support X-ray and gamma-ray spectroscopic observations of Supernova 1987A (SN 1987A). The first year of such observations has already provided a wealth of information about explosive nucleosynthesis and ejecta mixing in this event. Since August, 1987, the measurements of X-ray continuum emission and gamma-ray line and continuum emission has driven the models of the ejecta structure. With continuing X-ray and gamma-ray observations, the flaring soft X-ray component discovered by Ginga can be studied, the light curve of the gamma-ray lines from Co-56 can be measured, the first detection of Co-57 gamma-ray lines may be possible, and the possible emergence of X-rays and gamma-rays from an embedded pulsar can be studied. The approach is to fly the Supernova X-ray Spectrometer (SXS) in the February 1989 Woomera rocket campaign and the Gamma-Ray Imaging Spectrometer (GRIS) in the November 1988 and April 1989 Alice Springs balloon campaigns.

## Planetary Astronomy

**W89-70347** **196-41-03**
Lyndon B. Johnson Space Center, Houston, Tex.
**ATMOSPHERIC AND SURFACE COMPOSITIONAL STUDIES OF MERCURY AND THE MOON**
A. Potter 713-483-5061

The primary objective of this work is to understand the exospheres of Mercury and the moon by study of the sodium and potassium atmospheres of these objects. High-resolution spectroscopy with ground-based telescopes provides information on the abundance and spatial distribution of these atmospheres, and theoretical modeling and radiative transfer calculations are used to interpret the data. A secondary objective is to determine the surface mineralogy of Mercury by means of spectroscopic measurements. Infrared measurements of the Christiansen peak in the 7 to 8 micron range can determine the acidity of the surface minerals, and infrared measurements in the 2 to 4 micron range can determine the presence of characteristic mineral bands.

**W89-70348** **196-41-30**
Marshall Space Flight Center, Huntsville, Ala.
**INFRARED IMAGING OF COMETS**
C. M. Telesco 205-544-7723

The objective of this RTOP is an observational program using detector array instruments for infrared imaging of comets. An existing infrared array camera containing 20 bolometer detectors will be used to study the large-scale spatial distribution of infrared emission in comets in the wavelength region from 10 micrometers to 30 micrometers. These observations will be performed from gound-based infrared observatories. An additional infrared system with an InSb detector array spanning the wavelength region 1 micrometer to 5 micrometers is now under development. Beginning in the second half of FY89, observations with this instrument will importantly complement those obtained with the bolometer array.

**W89-70349** **196-41-50**
Goddard Space Flight Center, Greenbelt, Md.
**GROUND-BASED INFRARED ASTRONOMY**
Donald E. Jennings 301-286-7701
(188-41-55; 154-50-80)

The scientific objective of this program is to obtain infrared spectra of planets with a combination of the highest possible sensitivity and the best resolution. A cryogenic postdisperser, developed at Goddard Space Flight Center, has been used with the Fourier Transform Spectrometers at the Kitt Peak 4-meter and McMath telescopes. This narrow-band focal plane instrument improves the sensitivity of the Fourier transform spectroscopy (FTS) in the thermal infrared by an order of magnitude. Using this instrument on the 4-meter telescope, acetylene and ethane were observed in and out of the hot spot at Jupiter's northern latitudes. In addition, carbon-13 ethane was detected in Jupiter. With the

McMath telescope carbon dioxide was observed, and hydrogen peroxide was sought near 8 microns. These observations were made at 0.01 cm-1 resolution. A new spectrometer is being constructed to take advantage of the improved sensitivity available with modern detector arrays. A large cryogenic grating will disperse the spectrum onto a 10 by 50 element array. This instrument will yield another order-of-magnitude improvement in sensitivity.

**W89-70350**
Goddard Space Flight Center, Greenbelt, Md. **196-41-51**
**PASSIVE MICROWAVE REMOTE SENSING OF THE ASTEROIDS USING THE VLA**
W. J. Webster, Jr. 301-286-4506

The objective of this RTOP is to infer structure and composition parameters for a selected set of the ten physically largest asteroids by employing microwave remote sensing techniques originally developed for earth observations. Precise flux density measurements made with the Very Large Array (VLA) of the National Radio Astronomy Observatory will be used to define the microwave continuum spectra of these asteroids. These spectra will be inverted in order to estimate the near-surface bulk properties (radii, roughness, composition) independent of previous optical or infrared spectroscopy. The expected results will be radio emission spectra spanning the widest range in wavelength for 1 Ceres, 2 Pallas, 4 Vesta and 10 Hygeia; 2 cm observations of selected smaller asteroids; and interpretation of the spectra by inversion techniques.

**W89-70351**
Goddard Space Flight Center, Greenbelt, Md. **196-41-52**
**IMAGING STUDIES OF COMETS**
Malcolm B. Niedner, Jr. 301-286-5821

This RTOP provides for the operation of a small high altitude observatory, Joint Observatory for Cometary Research (JOCR). The imaging data obtained at JOCR are both wide- and narrow-field, and principally address the interaction of comets with solar radiation and solar wind. Research is most effective when in situ solar wind and IMF data from spacecraft are available to compare with the imagery. Data which have recently become available are those of the International Cometary Explorer (ICE) and Halley Armada spacecraft. Funding under this RTOP provides support for the operation of the observatory only; however, analysis of research results is funded by the interested program office. The observatory site in central New Mexico is one of the darkest sites left in the continental U.S. Wide-field photography (using the comet Schmidt camera) of approximately 12 bright comets since 1973, including recent comets Giacobini-Zinner and Halley, has been carried out. Analysis of some of the imagery have provided important information on the interaction of comets with high-speed solar-wind streams and magnetic sector boundaries, the magnetic field strength in the tail, the injection speed of ions into the tail, the pressure balance conditions across the tail, etc. The sudden growth of a plasma tail in comet IRAS appears to have been caused by a very large X-class solar flare and a resultant sudden pulse of photoionization in the coma. Most spectacular, disconnection events (DEs) of the plasma result from sector boundary crossings and magnetic reconnection.

**W89-70352**
Goddard Space Flight Center, Greenbelt, Md. **196-41-54**
**ADVANCED INFRARED ASTRONOMY AND SPECTROSCOPIC PLANETARY DETECTION**
M. J. Mumma 301-286-6994
(154-50-80; 157-05-05)

The objectives of this RTOP are twofold. Task 1 studies the molecular constituents of solar system objects (e.g., planetary atmospheres and comets) through observations of their IR line spectra. High spectral spatial resolution is utilized in order to obtain information on spatially localized phenomena and on dynamical processes (e.g., winds in planetary atmospheres). The approach is to develop and utilize laser heterodyne spectrometers for ultrahigh spectral resolution in the mid-infrared (8 to 30 micrometers), and to utilize grating and Fourier transform instrumentation or the near infrared (lambda less than 8 micrometers). These techniques provide optimum sensitivity, resolution and spectral stability needed for problems such as mapping the excitation conditions and outflow velocities in cometary comae. Observations are conducted from ground-based observatories and from the Kuiper Airborne Observatory. Task 2 is directed towards extending our knowledge to planetary systems which may exist around other solar-type stars. The underlying principle is that such extra-solar planetary systems could be detected by measuring the small Doppler reflex which planetary orbital motion produces in the spectrum of the parent star. The objective of this task is to validate such an approach by measuring the velocity stability of integrated sunlight. Solar-cycle related effects which are observed are compared to the 13 meter/sec Doppler reflex induced by the orbit of Jupiter, and prescriptions are developed for separating these effects so that planetary Doppler signatures can be identified in stellar spectra. In order to obtain great spectral stability, the observational approach is to use Fourier transform and laser heterodyne spectrometers in the infrared spectral region.

**W89-70353**
Ames Research Center, Moffett Field, Calif. **196-41-67**
**PLANETARY ASTRONOMY AND SUPPORTING LABORATORY**
F. P. J. Valero 415-694-5510

The composition of planetary and cometary atmospheres and surfaces and the abundance, temperature and pressure of certain atmospheric constituents can be determined by spectroscopic observations from ground-based and airborne observations. Such data are necessary for the preparation of valid model atmospheres, which are needed to evaluate the possibilities of life on the planets, to design systems for exploratory missions and for the preparation of evolutionary models of planetary interiors. The objectives of this work are to obtain, study and analyze spectroscopic observations of comets, planets and their satellites; to obtain and analyze, in the laboratory, spectra appropriate for valid interpretation of the observations; and to develop the analytical and computational techniques necessary to interpret the observational spectra in terms of real planetary atmospheres and surfaces, and cometary gases and ices. The objective will be pursued in measuring, in the laboratory, basic molecular parameters such as basic band modeling parameters, absorption line half-widths, vibration-rotation interaction constants, and line pressure induced shifts and absorption in the gas phase as well as absorption band profiles and intensities for these molecules condensed as ices.

## Life Sciences SR&T

**W89-70354**
Lyndon B. Johnson Space Center, Houston, Tex. **199-02-31**
**LONGITUDINAL STUDIES (MEDICAL OPERATIONS LONGITUDINAL STUDIES)**
Edward C. Moseley 713-483-7102

The objective of this research is to conduct longitudinal retrospective and prospective studies of medical data from astronauts, a control group of civil servants, and other JSC employees. The studies involve individuals in a relatively closed population in an attempt to relate changes in physiology and/or pathology to specific factors associated with individual traits of the astronauts and occupational exposure. Areas of study and particular interest include long-term adaptive mechanisms to weightlessness, changes observed in complete annual physical examinations, and the effects (if any) of the occupational exposures of crewman to the aging processes and disease incidence. The approach includes: (1) input and storage of all astronaut medical exams (annual, flight, and illness exams) in computer databases;

(2) collecting and storing similar information on a control group of civil servants (matched on age, sex, body size and smoking history) and other civil servants; (3) analysis of the longitudinal information comparing these groups; (4) cumulative evaluation of pre/postflight physiological changes across missions; and (5) periodic reviews to include new parameters.

**W89-70355** **199-02-31**
Lyndon B. Johnson Space Center, Houston, Tex.
**SPACE STATION HEALTH MAINTENANCE FACILITY**
D. K. Broadwell 713-483-7120

Current Space Station (SS) mission scenarios describe up to a 180-day mission for a 4 to 14 person crew in low earth orbit. The Space Shuttle is presently the only means of transportation of an ill or injured crewmember, and after the decision to evacuate is made, it could take up to 45 days to effect an unscheduled rescue. The Medical Sciences Division, Space Station Office, has been developing the requirements and systems for a modular inflight medical system known as the Health Maintenance Facility (HMF). The HMF will provide preventive, diagnostic, and therapeutic capabilities for SS, with these goals: (1) to ensure the health and safety of the crew; (2) to prevent an unnecessary rescue; and (3) to increase the probability of success of a necessary rescue. HMF requirements derive from operational constraints such as weightlessness, previous inflight medical experiences, and potential medical and surgical contingencies associated with long-term spaceflight aboard Station. As a possible non-Shuttle crew return capability develops, this must also be considered for integration into the medical program. The unique challenge of providing medical coverage for SS requires the development of low weight, low volume, highly automated medical care based as much as possible on terrestrial medical tenets and equipment.

**W89-70356** **199-04-11**
Lyndon B. Johnson Space Center, Houston, Tex.
**ENVIRONMENTAL HEALTH**
J. M. Waligora 713-483-7200

The objectives of the Environmental Health RTOP are: (1) to support research involving specification, measurement, and control of the man-made internal environment in the manned spacecraft and habitats; (2) to support research and technology assessment essential for the definition, development, and updating of the Space Station Environmental Health Subsystem; and (3) to support research to study the response of the body to deleterious levels of environmental factors that may be encountered inflight, to allow prediction of physiologic or pathologic response, and to prevent or ameliorate this response. The approach utilized to accomplish these objectives will be to sponsor in-house and outside studies which are needed to define requirements for environmental health factors, and acceptability limits; to provide the technology to detect compliance with these requirements; and finally, to define the mechanism of response of the body to deleterious environmental factors and investigate potential countermeasures.

**W89-70357** **199-04-31**
Lyndon B. Johnson Space Center, Houston, Tex.
**RADIATION HEALTH**
D. S. Nachtwey 713-483-7202

This RTOP describes a long-term program of research to examine the nature of the space ionizing radiation environment and determine its consequences for manned space operations. While currently available information is sufficient for early low inclination Shuttle missions, research priorities of the attached program are based on the assumption that long-term plans involve polar orbits, a permanently manned Space Station, manned sorties to geostationary orbit, lunar bases, and piloted Mars missions. Based on knowledge obtained from previous research under this RTOP, exposure to ionizing radiation may be the limiting factor in both mission and career durations for space workers. Shielding considerations, based upon radiobiological responses, may influence significantly the detailed design and total mass of a spacecraft, especially for protection from solar particle events. To provide timely solutions to these problems in the mission planning stage, the underlying research must be conducted now. A plan is presented for research in specific areas of radiobiology and radiation dosimetry. Specific attention is given to the effects of high energy heavy ions of space since the problem is unique to NASA. A coordination effort with other NASA programs and programs of related government agencies augments the information required by NASA in its long-term radiation research effort.

**W89-70358** **199-04-34**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**RADIATION EFFECTS AND PROTECTION**
G. A. Nelson 818-354-4401

The objective of this RTOP is to delineate the genetic and developmental effects of heavy ion radiation similar to that found in space as cosmic ray or HZE particles. We are using the simple animal C. elegans as a model system in studies conducted at JPL, the Lawrence Berkeley Laboratory BEVALAC accelerator (source for accelerated ions of desired properties) and the Argonne National Laboratory (neutron source). Cell survival and differential have been investigated using the development of a 4-cell gonad primordium into a complex functioning adult structure. Autosomal visible and lethal mutations, formation of nucleoplasmic bridges (produced by chromosomal rearrangements), and duplications of X chromosome segments are analyzed to understand particle-induced genetic lesions. The kinetics of production of these various lesions are being investigated as functions of particle fluence and linear energy transfer (LET). Relative biological effectiveness (RBE) and action cross sections versus LET have been described for several lesions. The structures of ion-induced mutants are under investigation and modification of kinetics is being tested in four radiation sensitive strains as well as by variation of ion velocity, oxygen tension and the concentration of free radical scavenger radioprotectants. The activities of DNA repair systems will be investigated by the isolation of new radiation sensitive mutants and transposon Tc1 insertion/excision will be examined to relate mutagenesis to virally mediated cell transformation. Characterization of ion-induced mutants in the unc-22 gene will be tested at the molecular level by DNA hybridization. Ion-induced lethal mutations in the eT1 balanced regions of chromosomes 3 and 5 are being analyzed by conventional crosses and deletion mapping to quantify the proportions of chromosomal rearrangements, deletions and point mutations.

**W89-70359** **199-04-36**
Langley Research Center, Hampton, Va.
**SPACE RADIATION EFFECTS AND PROTECTION (ENVIRONMENTAL HEALTH)**
R. R. Nunamaker 804-865-2893

In support of existing and future manned space efforts, including Space Station, manned geosynchronous orbit (GEO) sorties, lunar bases, and interplanetary travel, there is a critical need to provide adequate space radiation protection measures with minimum weight penalties. As a result, comprehensive studies of the physical interactions and transport of space radiations (protons, electrons, and galactic heavy ions) with extended matter have been initiated. Because laboratory radiobiological studies suggest that high-energy heavy ions (HZE particles) possess unique radiation damage characteristics, and may be highly carcinogenic for chronic low exposures, such as encountered in prolonged manned space missions, present research efforts are focused upon this particular component of the space radiation spectrum. Experimentally verified models of HZE particle interaction (especially nuclear fragmentation) and transport, necessary to determine ultimate shield requirements, are being developed in a collaborative effort involving theoreticians at Langley Research Center and experimentalists at Lawrence Berkeley Laboratory. Present research is focused upon accurately characterizing the radiation field inside the thick target absorber as to particle fluence, type, charge, mass, energy or velocity, and direction of travel. These models will be used to design advanced spacecraft and astronaut personal shielding and will enable more accurate assessments of astronaut radiation exposures and body self-shielding factors to be made. The overall objective is to develop a Space Radiation Protection handbook of evaluated methods for future use in manned spaceflight.

**W89-70360**
Lyndon B. Johnson Space Center, Houston, Tex. **199-06-11**
**BIOBEHAVIORAL RESEARCH**
Patricia A. Santy 713-483-7999
(199-22-06; 199-06-12)

While psychological factors have not proven to be significantly limiting to manned space flight to date, the approach of extended duration missions and a permanent manned presence in space raise new issues of biobehavioral adaptation and techniques of optimizing the human element. Although considerable research has been conducted on earth-based work environments (e.g., in R and D, educational, and manufacturing organizations), the relative lack of data regarding biobehavioral factors in space work environments is potentially limiting planned extended duty rotations in the space environment. The program outlined in this RTOP is directed toward identifying and optimizing psychological, psychophysiological, social, or behavioral factors which affect the attainment of mission objectives. Specifically, factors which might impact individual and crew performance and productivity will be focus of the study. The goal of this program is to identify these factors, understand their effects (or potential effects) upon the achievement of mission goals, and develop operationally useful optimizing or countermeasure strategies. The overall goal of the research is to develop the countermeasures necessary for psychiatric/psychologic health maintenance. The major objectives are: (1) to identify those biobehavioral factors which may impact extended work activity in the space environment; (2) to conduct applied research which leads to better understanding of those factors and which will help provide psychosocial support to individuals and crews in space; (3) to develop strategies to facilitate psychological adaptation to the space environment; (4) to integrate operational input into the identification, planning, and conduct of the research; (5) to verify baseline parameter data developed through ground-based research; and (6) to develop measurement and status monitoring procedures/hardware which are consistent with operational constraints and needs.

**W89-70361**
Lyndon B. Johnson Space Center, Houston, Tex. **199-06-11**
**BEHAVIOR AND PERFORMANCE**
Barbara Woolford 713-483-7301

The objectives of this RTOP are: (1) to quantify human performance capabilities and limitations and move toward quantification of man-machine engineering data, both on the ground and in flight; (2) to continue to pursue state-of-the-art technology and to advance that technology for the purpose of creating more effective and efficient man-machine interfaces for manned spacecraft; and (3) to improve techniques of man-machine engineering design so that innovative steps may be taken toward creating better interfaces in future vehicles. The approach is: (1) to implement a series of continuing tasks to identify and implement practical instrumentation packages for acquiring quantitative man-machine engineering data in one-g, simulated zero-g and reduced-g, and actual flight conditions; (2) to continue those efforts currently defined that lead toward definitive design requirements for use as inputs to an automated crew station design system; and (3) to pursue feasibility studies of promising new crew interface items and methods.

**W89-70362**
Ames Research Center, Moffett Field, Calif. **199-06-12**
**BEHAVIOR AND PERFORMANCE**
H. C. Foushee 415-694-6114
(505-67-01; 506-47-11)

The general objectives of this RTOP are: (1) to develop better methodological approaches to the study of group process variables in naturalistic environments; (2) to achieve, through the use of these approaches, a better understanding of those factors that affect group function in space environments; (3) to identify and assist in the solution of current and future operationally significant group performance problems in aerospace environments; (4) to provide design guidelines for better crew reliability based upon aspects of selection, organization, and training; and (5) to track the impact of these approaches so that further improvement and understanding may be obtained. These general objectives are aimed at the production of practical guidelines for issues confronting the U.S. space program. Heretofore, group productivity research has been of little use because it has typically been conducted in sterile laboratory research environments that are not generalizable to aerospace operations. Moreover, the methods of analysis and performance criteria have had little to do with the conduct of meaningful work in challenging and often stressful environments. One of the strengths of the proposed research plan is that it is organized to integrate the best principles in the most high fidelity environments available. It is believed that the net effect will be knowledge that can be immediately utilized by space operations planners.

**W89-70363**
Lyndon B. Johnson Space Center, Houston, Tex. **199-14-11**
**CARDIOVASCULAR RESEARCH**
J. B. Charles 713-483-7224

The overall objective of this program is an understanding of the cardiovascular changes (the Cardiovascular Readaptation Syndrome) which occur with space flight and their impact on crew members. Specific aims are to: (1) define the underlying mechanisms of cardiovascular readaptation; (2) provide appropriate countermeasures for these effects; (3) develop systems to aid in accomplishing these goals; and (4) apply the results to the selection, retention, and health maintenance of future space travelers. Ground-based studies on both human and animal subjects will in part utilize: (1) provocative techniques such as lower body negative pressure and exercise testing; (2) bed rest studies as analogs to weightlessness; (3) noninvasive and invasive cardiovascular monitoring; and (4) pharmacologic interventions, all in an effort to accomplish the goals set forth above. Direct inflight applications or continued research will be performed as required. Impact will be greater access to the space flight environment for more diverse segments of the population under a greater variety of conditions.

**W89-70364**
Ames Research Center, Moffett Field, Calif. **199-14-12**
**CARDIOPULMONARY PHYSIOLOGY**
A. Hargens 415-694-5746

The overall objective of this program is to develop an understanding of the cardiopulmonary and fluid-electrolyte changes occurring with spaceflight. Specific aims are to: (1) define underlying mechanisms; (2) determine whether specific cardiovascular risks occur with short- and long-term microgravity exposure; (3) develop and test appropriate models and countermeasures to prevent or to treat cardiopulmonary deconditioning; and (4) develop and implement appropriate spaceflight experiments. The approach in accomplishing this goal will involve ground-based studies on both human and animal subjects. Specific activities will include: (1) determine effects of exercise training on deconditioning; (2) use exposure of humans to horizontal and head-down bed rest and water immersion to study mechanisms of deconditioning; and (3) test procedures, devices and drugs, including the use of artificial gravity, to prevent and counteract deconditioning. Results should lead to: a better understanding of mechanisms of cardiopulmonary deconditioning; better devices and procedures for modifying deconditioning effects; and specific spaceflight experiments. Results of proposed studies will improve flight safety and understanding of spaceflight risks. They will also provide access to flight of a broader segment of population, and will use weightlessness to expand our understanding of cardiopulmonary/fluid-electrolyte function and autonomic nervous system control of the cardiopulmonary system.

**W89-70365** 199-16-11

Lyndon B. Johnson Space Center, Houston, Tex.

**NEUROSCIENCE**

F. A. Kutyna 713-483-7214

(199-16-12)

Manned space flight has demonstrated that the Space Adaptation Syndrome (SAS) is unpredictable and may be variable among individuals. Up to 50 percent of Shuttle crewmembers experience symptoms of space motion sickness which can persist through the first 2 to 4 days of the flight. Thus, on short-duration Shuttle flights, a significant portion of the mission time may be spent with some crewmembers affected by symptoms of space motion sickness. The program outlined by this RTOP is directed specifically towards understanding and resolving the problems caused by SAS. These problems, which arise from rearrangement of sensory motor interactions during exposure to 0-G, impair operational efficiency and the health and safety of astronauts and other crewmembers. The goal of this program is to understand the underlying causes of SAS in order to develop effective and operationally useful countermeasures. The major objectives are to conduct research which leads to a better understanding of the underlying mechanisms of SAS and fully develop effective and operationally oriented ground-based and space flight studies designed to address one or more of the above objectives in the areas of pharmacology, neurohumoral and biochemical correlates, adaptation techniques, psychophysiological studies, and vestibular studies. Human subjects will be used primarily. New facilities, hardware, and measurement procedures will be developed as required.

**W89-70366** 199-16-12

Ames Research Center, Moffett Field, Calif.

**NEUROSCIENCE (BIOMEDICAL)**

N. G. Daunton 415-694-4818

Significant changes occur in the way the central nervous system (CNS) processes sensory inputs and programs motor outputs during adaptation to the micro-gravity environment of space and during re-adaptation to earth's gravity. These changes in CNS processing result in space motion sickness, perceptual illusions, performance deficits, and postural control deficits, all of which impair the operational efficiency of astronauts, especially during the first 3 to 5 days of exposure to micro-gravity and immediately upon re-exposure to earth's gravity. It is not known whether the changes in CNS structure and function will be reversible after long-term (years) exposure to micro-gravity. The overall objective of this program is to identify CNS components and mechanisms underlying the process of adaptation/re-adaptation to altered gravitational conditions so that the consequences of long-term, as well as short-term, exposures to micro-gravity on the CNS can be determined. The general approach to understanding these components and mechanisms involves behavioral changes that occur in the vestibular and other sensory-motor systems during adaptation to altered-gravity environments and then determining the neurophysiological, neurochemical, and structural changes in the CNS that underlie these changes. With this knowledge, countermeasures can be developed to minimize specific problems and ensure the productivity, health, and safety of astronauts in space and on return to earth.

**W89-70367** 199-16-22

Ames Research Center, Moffett Field, Calif.

**NEUROSCIENCE (INFORMATION PROCESSING)**

M. D. Ross 415-694-5757

(199-28-22; 199-26-22)

The long-term goal of this RTOP is to increase understanding of information processing in animal linear bioaccelerometers, on earth and in the microgravity of space. The RTOP represents a coordinated approach to research on mechanisms underlying transduction, on the functional organization of the neural network of the receptor, on physiological characteristics of nerve responses, and on the development of the receptor. Related to this research, which is already in progress, are proposed new directions to understand what type I and type II cells do in the context of a neural network and to begin mathematical modeling of a mammalian macula, to learn how it achieves its organization and how it possibly functions based upon neural network theory. These new directions have grown out of current research and will both extend and capitalize upon the most recent findings that maculas are weighted neural networks functionally organized for parallel processing of information. The approach to achieving the goal of increased understanding will place heavy emphasis upon experimental study combined with computer integration and analysis, to produce working models to predict changes likely to occur in space. The model will be tested through highly focused experiments to study mechanisms of adaptation to microgravity. The ground-based and space research goals are relevant to the Space Biology Initiative, to some of the technological goals of Pathfinder, and to development of the 1.8 M centrifuge as a research tool for the space environment.

**W89-70368** 199-18-11

Lyndon B. Johnson Space Center, Houston, Tex.

**REGULATORY PHYSIOLOGY (ENDOCRINOLOGY AND PHYSIOLOGICAL CONTROL**

Nitza M. Cintron 713-483-7165

(199-21-10; 199-22-31)

The absence of hydrostatic forces, which results in body fluid shifts, and the absence of deformation forces on normally load-bearing tissues, are postulated to cause the principal disturbances found during and after space flight in the fluid and electrolyte, cardiovascular, erythropoietic, musculoskeletal, and metabolic systems. These alterations result in a multitude of physiological imbalances such as a reduced body fluid volume with concomitant losses of electrolytes, loss of body calcium stores, skeletal muscle atrophy, and a negative energy balance after prolonged space flight. The purpose of the present program is to study and define, at the cellular, biochemical, and endocrine levels, key elements underlying the integrated physiological responses to space flight which allow the definition and assessment of crew health status and which reveal areas of countermeasure development. Results of the individual research investigations are anticipated to provide an enhanced understanding of the effects of weightlessness on man and his readaptation to the earth environment. Using principally model systems in human clinical research, investigations will be directed toward the identification and study of biochemical and neurohumoral agents which are active in the various adaptive phases of space flight. Primary focus will be made in describing the integrated relationship between these substances and those physiological systems and integrated processes (e.g., drug handling and kinetics) which have been identified to be affected by the null-gravity environment. The approach of the program is two-fold: ground-based research designed to investigate operational factors and basic mechanisms and a flight experiment definition program designed to test and evaluate procedures and hypotheses resulting from these preceding ground efforts. All research will be conducted in man as much as possible and will include animal studies where necessary.

**W89-70369** 199-18-12

Ames Research Center, Moffett Field, Calif.

**REGULATORY PHYSIOLOGY (BIOMEDICAL)**

J. Vernikos-Danellis 415-694-5100

(199-14-12; 199-06-12; 199-16-12)

The objectives of this program are to determine the integrative mechanisms regulating acute and long-term physiological responses. The consequences on crew health and performance of the underlying physiological adaptation to spaceflight will also be investigated. In addition, the integrative systems responses to individual countermeasures will be evaluated. To accomplish these objectives, ground-based simulation research designed to investigate operational factors and basic mechanisms will be conducted. All research will be conducted in man as much as possible and will include animal studies where necessary. The physiological responses induced by spaceflight will be simulated using immersion, horizontal or head down bedrest in humans or tail suspension in the rat. Specific activities will include: (1) the development of countermeasures for the impaired thermoregulation during exercise in deconditioned subjects; (2) the involvement of oxytocin in the response to the stresses of spaceflight; and (3) the effect of altered/adapted physiological baseline on the body's stress responding systems on the ability of crews to respond to physical, emotional and operational stresses. Results will improve flight and extravehicular activity (EVA) safety and improve the development of safer and more effective countermeasures.

**W89-70370** **199-18-22**
Ames Research Center, Moffett Field, Calif.
**REGULATORY PHYSIOLOGY (SPACE BIOLOGY)**
M. D. Ross 415-694-5757
(199-26-22; 199-16-22; 199-28-22)

All biological species on earth have evolved under the influence of gravity. In response to this force, organisms have developed regulatory mechanisms which may be optimized for terrestrial gravity. The objectives of Regulatory Physiology are: (1) to identify mechanisms by which gravity affects cells and organisms emphasizing neural, endocrine, metabolic adaptation, and systemic response mechanisms; (2) to determine ionic mediators of gravity effects on regulatory mechanisms; (3) to determine the importance of interaction of environmental factors (e.g., temperature and light) with gravity in altering regulatory mechanisms; and (4) to use microgravity as a tool to understand whether gravity directed evolution of regulatory mechanisms. Ground-based and spaceflight experiments are both required.

**W89-70371** **199-26-11**
Lyndon B. Johnson Space Center, Houston, Tex.
**EXERCISE COUNTERMEASURE FACILITY (MUSCULOSKELETAL PHYSIOLOGY II)**
Bernard A. Harris, Jr. 713-483-4895

The Space Station Exercise Countermeasure Project is a joint effort between the NASA Headquarters Life Sciences Division and the Space Station Program Office whose objectives are to: (1) define the requirements and candidate systems for the Exercise Countermeasure Facility (ECF); (2) develop subsystem hardware and software for the ECF; and (3) formulate the Space Station crew exercise countermeasure regimen (prescription). The hardware definition and developmental activities are essential to the formulation of the crew exercise profile. Recommendations resulting from a workshop of consultants have resulted in the formulation of a working exercise regimen for long-duration space flight. It is anticipated that the regimen will need continual modifications over the years prior to the permanent manned presence of Space Station. This will be accomplished through ongoing ground-based, and KC-135 and Shuttle flight. When the Space Station is manned, the Exercise Countermeasure Facility will be fully operational. Three exercise modalities have been selected for further development. These are the treadmill, combination recumbent bike/rower, and resistive exerciser. The ergometer/rower device has the capability of operating as a recumbent bicycle and/or rowing machine. Its primary function will be for aerobic conditioning, maintaining postural muscular tone, and physical evaluation. The Space Station treadmill prototype has been redesigned from the Shuttle treadmill to improve the integrity and effectiveness. This prototype must undergo further testing and inflight evaluation before the final configuration is determined. An anaerobic exercise device is included because anaerobic exercise has been identified as an excellent means of building muscle strength.

**W89-70372** **199-26-11**
Lyndon B. Johnson Space Center, Houston, Tex.
**MUSCULOSKELETAL PHYSIOLOGY**
V. S. Schneider 713-483-7100
(199-18-11; 199-14-11)

The regulation of musculoskeletal integrity and function during space flight and the causes of bone's apparent demineralization and dissolution are the central questions addressed by the present research program. We intend as outlined in the FASEB reports on muscle and bone to elucidate and define the mechanisms operative in the processes associated with calcium metabolism and bone loss during weightlessness, to determine the interrelationship between muscle and bone physiology, to develop methods to assess changes in bone and muscle more accurately by non-invasive means, to develop effective countermeasures to these potential deleterious skeletal changes in order to optimize crew's performance and recovery upon return to a one-g environment, and to protect the astronaut from potential post-career early onset osteoporosis. Shuttle and ground-based systems will be applied. Clinical human and animal models will be used to define the mechanisms underlying bone and muscle mass regulation and loss during space flight. The focus will be on the biochemical, endocrinological, and physico-mechanical levels of function. Preventive and remedial countermeasures will center primarily around mineral supplementation, drug administration, diet modification, and physical manipulation.

**W89-70373** **199-26-12**
Ames Research Center, Moffett Field, Calif.
**MUSCULOSKELETAL (BIOMEDICAL)**
S. B. Arnaud 415-694-6561
(199-26-22)

The overall objectives of this research program are to characterize, qualitatively and quantitatively, muscle atrophy and alterations in skeletal and mineral metabolism in man and animals in space, to determine underlying mechanisms, to develop non-invasive means of monitoring these changes, and to find suitable countermeasures. The specific objectives directed toward muscle atrophy are to determine: (1) its extent and rates of development and recovery; (2) the basic biochemical and physiological mechanisms which regulate skeletal muscle mass and function; (3) methods for monitoring atrophy of skeletal muscle; and (4) countermeasures. The specific objectives directed toward bone metabolism are focused on the mineralization defect, which may or may not be directly related to the other three changes in calcium metabolism: negative calcium balance, modest increases in circulating calcium and phosphorus, and calciuria. Goals are approached through research projects emanating from a variety of disciplines in basic science and clinical medicine, involving animal and human subjects. Studies are coordinated with flight projects to validate models for weightlessness. These models can range from bedrest subjects and suspended animals to cell culture systems developed to pinpoint the cellular responses to biochemical changes in a space environment. Nutrition, exercise regimens, pharmacologic agents, and electrical stimulation are the main countermeasures to be evaluated to ensure the health and productivity of space travelers.

**W89-70374** **199-26-14**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**MUSCULOSKELETAL**
R. H. Selzer 818-354-5754

The objective of this task is to develop and validate methods to measure muscle volume change associated with disuse. A technique is currently under development to measure lower leg volume from magnetic resonance images. This technique is designed for use in bedrest studies or for pre- and post-flight monitoring of muscle atrophy. A new technique based on ultrasound imaging is proposed for development beginning in FY89. This method utilizes a magnetic spatial locator to track the position of the ultrasound scanning device as it is applied to various positions along the length of a muscle. Computer image processing methods will be used to reconstruct the volume of the entire muscle. The ultrasound technique has potential application for in-flight use.

**W89-70375** **199-26-22**
Ames Research Center, Moffett Field, Calif.
**MUSCULOSKELETAL (SUPPORT STRUCTURES AND BIOMINERALIZATION)**
E. M. Holton 415-694-5471
(199-28-22; 199-18-22; 188-16-22)

All biological species on earth have evolved under the influence of gravity. In response to this force, organisms have developed structures to withstand gravity loads which may be optimized for terrestrial gravity. The objectives of this RTOP are: (1) to identify, compare and contrast structures that living systems have evolved in response to gravity and to understand the influence of gravity on regulation of size, shape, composition, maturation, metabolism and function; (2) to elucidate whether gravity directly affects cells regulating structural mass and/or exerts its effect extracellularly through local or systemic factors; (3) to determine the role and/or utilization of ions (e.g., calcium) in mediating gravitational responses resulting in gravity-dependent structure; and (4) to use microgravity as a tool to understand the role of gravity in evolution of structural elements. The approach requires both ground-based and spaceflight experiments. Using the ground-based rat model, research will be initiated in biomineralization. Mineralizing bone cell cultures and invertebrate mineralization mechanisms will also be studied. Spaceflight experiments on Cosmos, shuttle or Lifesat missions will be used as possible to obtain data for comparison with the simulation model.

**W89-70376** 199-28-21

Lyndon B. Johnson Space Center, Houston, Tex.

**CELL AND DEVELOPMENT BIOLOGY**

Clarence F. Sams 713-483-7160

(199-21-51)

Space flight has been demonstrated to cause a variety of alterations in biological organisms. Analysis of these adaptive processes is frequently complicated by the number of interacting systems contributing to the observed physiological changes. The use of cell biology methods frequently enables reduction of complex problems to levels that are approachable for scientific investigation. Since biological adaptation occurs as a consequence of biochemical alterations in cellular processes, detailed knowledge of basic cell function in the terrestrial and microgravity environments will further understanding of the more complex processes occurring in man. The goal of this program is to develop and support systems and procedures for the application of cellular/molecular techniques to the investigation of space flight relevant biological problems. The projects included in this RTOP are basic research efforts designed to examine the fundamental mechanisms of cellular systems which exhibit a sensitivity to the spaceflight environment or a related environmental factor (e.g., stress, hypokinesia). The understanding of these mechanisms at the cellular and molecular level may provide a basis for the analysis of spaceflight induced physiological changes within higher organism.

**W89-70377** 199-28-22

Ames Research Center, Moffett Field, Calif.

**CELL AND DEVELOPMENTAL BIOLOGY (DEVELOPMENTAL BIOLOGY)**

M. D. Ross 415-694-5757

(199-16-22; 199-26-22; 199-18-22)

Gravity has been an omnipresent force throughout the evolution of life on this planet. How it has influenced the evolutionary process and continues to impact the daily existence of life on this planet is largely unknown. The major objective of this research program is to further the understanding of the role and influence of gravity and the lack thereof on the processes of reproduction, growth, development and aging. Specific hypotheses currently under investigation include: (1) gravity is a determinant of pattern specification in amphibian and avian embryogenesis; (2) gravity is required for the normal development of the musculoskeletal, nervous, and other organ systems in mammals, amphibia, and echinoderms; (3) cytoskeletal formation is influenced by the gravity vector in a variety of vertebrate and invertebrate species; and (4) gravity plays an important role in the behavior and aging of poikilotherms. Ground-based studies using hyper-gravity (centrifuges) and gravity vector randomization (clinostats) are performed to develop techniques and baseline data in support of flight experiments. Spaceflight investigations are conducted aboard the STS/Spacelab, Soviet Cosmos Biosatellites, and ultimately the Space Station.

**W89-70378** 199-30-32

Ames Research Center, Moffett Field, Calif.

**BIOSPHERIC MONITORING AND DISEASE PREDICTION**

P. D. Sebesta 415-694-5232

(199-30-37; 199-55-12)

The objective of this RTOP is to employ NASA-derived technologies to study and model the environmental parameters which influence the distribution and prevalence of vector-borne diseases. A series of NASA-sponsored workshops has identified malaria as the candidate disease. The approach of this RTOP is to carry out in situ studies that will relate the environmental variables to the disease vector. These environmental variables will be studied by remotely sensed data. The relationship between remotely sensed data and vector population dynamics will be established and modeled. Modeling will be in the context of a Geographic Information System and used for purposes of predicting the temporal and spatial occurrence of vector populations and malarial transmission.

**W89-70379** 199-30-34

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

**GLOBAL MONITORING OF VECTOR-BORNE DISEASES**

J. F. Paris 818-354-6936

The objective of the research being performed under this RTOP is to improve the understanding and prediction of vectorborne diseases through the use of remotely sensed information. Presently, the focus is human malaria transmission by mosquitos. Research is being conducted in two test-site regions: California rice fields (Phase 1) and southern Mexico and analogous regions (Phase 2). Phase 1 involves understanding the time dynamics of mosquitos only in a well-documented and easily accessible site (California). Phase 2 involves the more difficult problem of using the developed technology in a malaria endemic region (vicinity of Tapachula, Mexico). Phase 2 also involved the exploration of the limits of remote sensing (especially of radar imaging) by conducting field research in analogous vegetation in the U.S. (e.g., bananas in Hawaii). The basic approach is to predict the dynamics of larval mosquitos in time (timing within a season) and in space (distribution over a region) by using environmental information such as rainfall, surface state (e.g., flooded), vegetation type and condition obtained by airborne and/or spacecraft-borne imaging remote sensors. We are investigating several multisensor approaches that use combinations of data from weather satellites (Geostationary Operational Environmental Satellite--GOES--and NOAA Advanced Very High Resolution Radiometer--AVHRR), LANDSAT Multispectral Scanner (MSS) and Thematic Mapper (TM), Speed Position and Track (SPOT), airborne TM simulators, Airborne Visible and Infrared Imaging Spectrometer (AVIRIS), and airborne synthetic aperture radar (SAR). A multidisciplinary team from NASA Ames Research Center, JPL, UC Davis, Uniformed Services University of Health Sciences, University of Texas Health Science Center, and Mexican Institute for Malaria Studies has been formed to attack the technical issues (remote-sensing, environment-vector, and vector-malaria research issues). We are using sophisticated information extraction techniques to optimize the remotely sensed information and time-series and Geographic Information System (GIS) based modeling to relate the remotely sensed information to the dynamics of mosquito production and the transmission of malaria.

**W89-70380** 199-30-62

Ames Research Center, Moffett Field, Calif.

**BIOGEOCHEMICAL RESEARCH IN TROPICAL ECOSYSTEMS**

P. A. Matson 415-694-6884

(199-30-72; 677-21-31)

The objective of this research is to quantify fluxes of important biogenic gases from tropical ecosystems, and to understand the sources, sinks, and processes that control flux out of the systems. The long-term goal of this project is to establish a geographic perspective on trace gas flux and biogeochemical processes in tropical environments. This encompasses measurement of gas fluxes from soil and vegetation and estimation of their importance over large areas. The approach is to measure emissions of nitrous oxide, nitric oxide, non-methane hydrocarbons and other gases in a range of forests representing gradients of climate, fertility, and disturbance. Studies along such gradients will improve understanding of the factors that control flux, and will provide the basis for developing models that predict flux. Such models, driven by variables such as forest type, climate-moisture characteristics, and canopy characteristics, will be tied to remote sensing techniques for extrapolation to regional and global scale.

**W89-70381** **199-30-72**
Ames Research Center, Moffett Field, Calif.
**BIOGEOCHEMICAL RESEARCH IN TEMPERATE ECOSYSTEMS**
D. L. Peterson 415-694-5899
(677-21-35; 677-21-31)

The objectives of this project are to model the processes of carbon, nitrogen and water cycling through temperate coniferous forests and to develop the principles of how nitrogen and water interact to control carbon assimilation and allocation in intact and disturbed ecosystems. The approach is to validate an existing ecosystem model of carbon, nitrogen and water fluxes and interactions through a combination of field and remote sensing studies during an intensive multisensor aircraft campaign in 1989. This test of principles, involving surface climate, nutrient cycling and remote sensing, will be used to specify minimum general measurements. These techniques will then be expanded to companion sites the following year to permit extrapolation to larger areas and to support a workshop in the third year.

**W89-70382** **199-30-99**
Goddard Inst. for Space Studies, New York, N.Y.
**REMOTE SENSING OF NATURAL WETLANDS**
Inez Fung 212-678-5590

The objective of this RTOP is to explore the feasibility of monitoring the global seasonal distribution of natural wetlands by remote sensing techniques. Dr. B. Choudhury of Code 624 has obtained global distributions of the monthly brightness temperature from 1979-1984 from dual-polarized radiation at 37 GHz measured by the Scanning Multichannel Microwave Radiometer (SMMR) aboard Nimbus-7. The brightness temperature has been shown to be a good monitor of soil moisture as well as of vegetation dynamics. We propose to compare the distributions of brightness temperature with a global digital database of wetland ecosystems to explore the ability of the brightness temperature to distinguish natural wetlands. Also, the seasonality of the brightness temperature will be examined against field observations of flooding to test the validity of the timing and areas of seasonal inundation obtained from SMMR data.

**W89-70383** **199-30-99**
Goddard Space Flight Center, Greenbelt, Md.
**GLOBAL INVENTORY MONITORING AND MODELING EXPERIMENT**
Compton J. Tucker 301-286-7122
(677-21-32)

The objective of this RTOP is to develop the techniques and scientific basis for studying terrestrial renewable resources at regional, continental, and global scales with multilevel satellite remote sensing data. Satellite data will be obtained at spatial resolutions of 30 m, 80 m, 1 km, 4 km and 15 km for selected local areas (30 and 80 m), regional test sites (1 km), continental test areas (4 and 8 km), and the entire planet (15 km). These data will be analyzed to provide high temporal frequency vegetation biomass and condition information for assessing productivity and other large-scale vegetation information of interest to global science questions such as the earth's radiation budget, biogeochemical cycles and the hydrological cycle. Specific studies will be undertaken for studying ecologically coupled disease outbreaks in Africa. The expected results are: (1) the understanding of large-scale vegetation response and its relationship to atmospheric $CO_2$ concentrations; (2) estimates of grassland biomass production across entire continental ecological zones; (3) improved documentation of forest spatial extent for selected tropical and boreal forests; and (4) comparisons between disease outbreaks of Rift Valley fever and vegetation dynamics from East Africa for the time period of 1980 through 1988.

**W89-70384** **199-30-99**
Goddard Inst. for Space Studies, New York, N.Y.
**GLOBAL MODELING OF THE BIOLOGIC SOURCES OF METHANE**
Inez Fung 212-678-5590

The objectives of this RTOP are to: (1) obtain estimates of methane emission from natural wetlands on a global basis; (2) investigate seasonality of methane emission based on climate variations; and (3) verify estimates of emissions using a three-dimensional transport model and observations of atmospheric methane. A global model of seasonal emission of methane from natural wetlands will be developed. The model will account for the influence of wetland ecology and seasonal climate variations on the rates of methane emission. The emission model will be calibrated against field measurements of methane emissions, where such measurements exist. To validate the seasonal emission of methane on a global basis, the emission will be used as inputs to a three-dimensional atmospheric transport to simulate the variations of methane in the atmosphere. The comparison between the simulated and observed distributions of atmospheric methane will constrain the magnitudes and timing of the biospheric emissions.

**W89-70385** **199-52-11**
Lyndon B. Johnson Space Center, Houston, Tex.
**CHARACTERISTICS OF VOLATILES IN INTERPLANETARY DUST PARTICLES**
Everett K. Gibson, Jr. 713-483-6224
(199-52-31)

The goal of this study is to investigate the elemental and molecular compositions of volatiles present in interplanetary dust particles (IDPs). Interplanetary dust is important to studies of the origin of the solar system because it is the material from comets and asteroids, the smallest surviving bodies from the early solar system. The investigation will obtain compositional information about the volatiles present at the time of formation of these primitive particles. Because of the possibility that the dust particles may have a cometary origin, their analysis could provide information about the volatiles associated with the dusty component present in comets. Exobiological interest in cosmic or interplanetary dust particles stems from their potential for contributing to the elucidation of the cosmic history of the organogenic elements (i.e., H, C, N, O, S, and P) that make up all living systems. Therefore, the study of IDPs will enhance our understanding of comets, asteroids, primitive meteorites, and the solar system along with providing an increased knowledge of the interstellar medium.

**W89-70386** **199-52-12**
Ames Research Center, Moffett Field, Calif.
**COSMIC EVOLUTION OF BIOGENIC COMPOUNDS**
T. Bunch 415-694-5909
(199-52-22; 199-52-32; 199-52-42)

The overall concept of the program is to understand the history of biogenic elements (C, H, N, O, P, S) and their compounds in the galaxy and the early solar system. The specific objectives of this RTOP are to: (1) trace the physical and chemical pathways taken by the biogenic elements and their compounds from their origins in stars to their incorporation in the pre-planetary bodies; (2) determine the kinds of measurements that can be made on the biogenic elements and compounds in the galaxy and solar system in order to develop theories about the formation of the solar system and the prebiotic evolution and origin of life; and (3) determine the ways in which the physical and chemical properties of the biogenic elements and compounds may have influenced the course of events during the formation of the solar system and the component bodies. The approaches of the RTOP are to: (1) characterize plausible chemical reaction pathways for candidate interstellar organic species by quantum chemistry methods; (2) obtain laboratory infrared spectra of artificial molecular mixtures for comparison with astrophysical observations; (3) analyze U-2 aircraft-collected interplanetary dust particles for biogenic and inorganic elements and characterize their phase structures; (4) simulate the planned Space Station Dust Collector process by using the Ames Vertical Gun Range for hypervelocity projectile capture and determine followup changes that occur as the result of impact; and (5) determine exobiology requirements for new telescope capabilities and recommend observation priorities.

**W89-70387** 199-52-14

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

**EXOBIOLOGY STUDIES**

S. L. Manatt 818-354-4256

This program seeks to carry out research concerned with the evolution of carbon containing molecules from the primordial mixtures of materials that existed in the primitive universe and appear to exist today in interplanetary and interstellar space, and in comets and meteorites. Two lines of work would be undertaken which will make extensive use of JPL's new MSL-200 nuclear magnetic resonance (NMR) system. The first line of work would seek to shed some light on how the D-sugars might have evolved in the biochemistry fabric of life and what role the reactions of oxiranes may have played in the chemical evolution of sugars. The second line of work would seek to develop NMR techniques for studying organic components in terrestrial geological and meteorite samples along with development of the geochemical separation techniques to obtain the carbon-rich phases of these materials free of ferromagnetic particles. This second line of work should lead to development of protocols useful for studying any returned Mars samples that might be obtained in the future.

**W89-70388** 199-52-14

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

**COSMIC EVOLUTION OF BIOGENIC COMPOUNDS**

M. S. Hanner 818-354-4100

The spectrum of Halley had an emission feature at 3.36 microns and the grain composition was high in H, C, N, and O. Grains were the likely source of excess CO, C(+), and CN detected in the coma. We plan to undertake a systematic study of gas-grain chemical interactions using JPL's Planetary Surface Facility. Infrared reflectance and transmittance spectra of the solid phase reaction products will be obtained for comparison with the comet spectrum. Our goal is to understand the carbon budget of the comet and the chemical evolution of the organic components in grains. We will carry out systematic studies of: (1) the kinetics of binary ices under UV irradiation at T greater than 20 K; (2) absorption of gas molecules and radicals on solid surfaces, such as amorphous carbon, formation of new species on the surface during irradiation, and the gaseous emission products when the sample is subsequently heated or irradiated; and (3) reflectance and transmittance spectra of the products formed in (1) and (2). It is well-known that the fundamental molecular vibration frequencies are altered by coupling with the solid-state lattice.

**W89-70389** 199-52-22

Ames Research Center, Moffett Field, Calif.

**PREBIOTIC EVOLUTION**

S. Chang 415-694-5733

(199-52-12; 199-52-32; 199-52-42)

The objective of research in prebiotic evolution is to understand how the evolutionary sequence leading from simple chemicals to living systems occurred during the development of earth and other planets. The approaches taken to meet the objective fall into two major study areas, each of which involves the use of both laboratory experiments and computer simulations: (1) the consequences of planetary evolution on the physical environments of the earth and planets; and (2) the evolution of molecules and molecular systems under the constraints imposed by the physical environment, and by the appearance, a posteriori, of living systems on earth. Studies of planetary evolution assess the importance of the physical-chemical processes associated with the dynamic development of planetary surfaces, on both global and microenvironmental scales, which could have been involved in, or provided constraints on the development of living systems for earth and other planets. Studies of molecular evolution focus on the energetics, dynamics and synthesis of chemicals and chemical systems in order to elucidate feasible mechanisms by which these systems acquired biological attributes within the constraints of the environment.

**W89-70390** 199-52-24

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

**STUDY OF ABIOGENIC SYNTHESIS ON MINERAL TEMPLATES**

G. E. Voecks 818-354-6645

In order to determine how early simple life could have originated, the production of simple organic building-block molecules has to be understood. The process of generating simple organic molecules such as sugars and amino acids requires the attainment of proper conditions for not only activating the initial reactions but stabilizing the products as well. In this effort, the objective is to ascertain the role of cation-type and starting reactant gas mixture on two zeolites under photolytic excitation to produce simple sugar molecules. To meet the objective of this effort, a synthetic faujasite and a naturally occurring zeolite will be examined as templates for sugar production from a CO2, CO, H2, and H2O gaseous mixture. Zeolites have been demonstrated to form sugars, but the mechanism by which this occurs, regarding the cation species and the structure change relative to the cations and the gaseous reaction mixture has not been determined. Thus, various-size mono and divalent cations will be exchanged into two zeolites having one and two dimensional access cavities. These zeolites will be exposed to light (gas mixture absorption) in the presence of various mixture ratios of CO2, CO, H2, and H2O. Products will be analyzed by gas chromatography. Use of molecular modeling graphics will help direct and explain results. Subsequent investigation of other zeolite structures will be performed based on the initial findings.

**W89-70391** 199-52-26

Langley Research Center, Hampton, Va.

**EARLY ATMOSPHERE: GEOCHEMISTRY AND PHOTOCHEMISTRY**

Joel S. Levine 804-865-2187

The objective is to develop a better understanding of the biogeochemical and photochemical processes that controlled the composition of the atmosphere over geological time. The approach consists of: (1) the development and application of a geochemical flux model to investigate the transfer of carbon, nitrogen, oxygen, hydrogen, sulfur, and chlorine species between the atmosphere, oceans, solid earth, and biosphere over geological time; (2) photochemical calculations of the composition of the early atmosphere and its evolution over geological time; and (3) studies of the geochemistry, geology, and atmospheric chemistry of early Mars to better understand the early earth and to assess the possibility of life on Mars.

**W89-70392** 199-52-32

Ames Research Center, Moffett Field, Calif.

**THE EARLY EVOLUTION OF LIFE**

L. I. Hochstein 415-694-5938

(199-52-22; 199-52-42)

The objective of this RTOP is to understand the nature and evolution of primitive microorganisms, especially in the context of those forces which guided the evolution of the planet itself. The approach will be to explore the mechanisms, processes and environments associated with the early evolution of life on earth as an approach for understanding life elsewhere in the universe. Two repositories of evolutionary information are examined, namely, the molecular record in living microorganisms and the geologic record in rocks. Biological studies address the early evolution of the complex systems that constitute the essential attributes of life. Energy transduction is being studied by examining archaebacteria (e.g., extreme halophiles, thermophilic acidophiles) and comparing their properties with those of eubacteria. The development of oxygen-requiring pathways in lipid synthesis is investigated both in eubacteria and in eukaryotes. Geologic studies seek to elucidate earlier biochemistries through analysis of ancient biological material preserved in stromatolitic rocks. The paleoenvironment (e.g., its structural setting and the chemical composition of its ocean and atmosphere) is also being described.

**W89-70393** 199-52-42
Ames Research Center, Moffett Field, Calif.
**EVOLUTION OF ADVANCED LIFE**
D. DesMarais 415-694-6110
(199-52-22; 199-52-32; 199-52-72)

The goals of this research are to understand possible evolutionary pathways for advanced life; to examine the influence of astrophysical, stellar and solar system events on the evolution of advanced life on earth; and to develop a program plan for a paleontological data base. Specific correlations will be sought between extraterrestrial interventions and major events in biological evolution. The geologic record is to be examined for geochemical indicators of meteoritic and cometary impacts. Features of the record such as periodicities, selectivity of biological extinctions, and the biological consequences of other natural planetary phenomena (e.g., volcanic, oceanic, and atmospheric effects) will be explored.

**W89-70394** 199-52-52
Ames Research Center, Moffett Field, Calif.
**SOLAR SYSTEM EXPLORATION**
G. C. Carle 415-694-5765
(199-52-12; 199-52-22; 805-19-00)

The objective of this research is to provide specific information on the elemental and chemical composition, mainly in respect to the biogenic elements, of the atmospheres and surfaces of solar system bodies including planets and their satellites, comets, asteroids, meteorites, and dust in space. This information is essential for selecting or devising the most appropriate model for the evolution of the solar system and for each of the investigated bodies. Further, it will provide a basis for understanding the conditions necessary for the origin of life by comparisons of the evolution and chemistries of these bodies. Improved methods, instrumentation, and experiments will be defined and developed for in situ chemical analyses of the selected species associated with the bodies to be investigated. Special emphasis is directed to development of the gas chromatographic approach since it is now proven to be among the most effective means for measuring complex, gaseous mixtures. Improvements in gas chromatographic techniques, e.g., multiplex chromatography, and components, e.g., detectors and columns, will be rigorously explored. Other techniques and experiments for extraterrestrial studies related to the understanding of the origin of life will be investigated and developed for other flight opportunities as appropriate, e.g., Space Station.

**W89-70395** 199-52-54
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**COMET INTACT CAPTURE EXPERIMENT**
P. Tsou 818-354-6673
(196-41-80; 805-19-00)

Significant progress has been made in laboratory intact capture of hypervelocity particles under normal ground environment. The next important step is a test of the technique in realistic space environment. A three-month flight opportunity on France's COMET experiment starting in November 1988 has been offered to the NASA intact capture team with the potential of follow-on flights. COMET is an approved investigation on the Soviet MIR Space Station. The French will provide to NASA their already developed flight hardware trays. The significant advantage in this opportunity is a flight early in the development stage which confirms ground testing results with minimal risk and cost. The scientific value of doing experiments on COMET is the ability to expose the selected cosmic dust collection media in a realistic space environment for three months and to test its ability to capture realistic hypervelocity particles, i.e., cosmic dusts. In addition to the cosmic particles, space debris at orbital altitudes will also be gathered and returned. The ultimate objective in this activity is to return to earth, intact particles. Unlike other destructive capture techniques, intact capture can preserve the chemistry, biogenic elements and petrology of the particles. This RTOP covers the preparatory engineering tasks necessary to realize the first cycle of space flight and some limited post flight analysis. The first flight will include an engineering test of the collection media and a definition of captured particle analysis methodology. Follow on flights will expand and concentrate on the particle extraction and analysis. According to the COMET schedule, flight hardware filled with intact collector media will be delivered by the end of September 1988. A possible return of the flown hardware may be in March of 1989.

**W89-70396** 199-52-72
Ames Research Center, Moffett Field, Calif.
**THE SEARCH FOR EXTRATERRESTRIAL INTELLIGENCE MICROWAVE OBSERVING PROJECT (SETI MOP)**
B. M. Oliver 415-694-5166

The objectives of the Search for Extraterrestrial Intelligence (SETI) Microwave Observing Project are to build, deploy and operate the equipment to conduct a search for microwave transmissions of intelligent extraterrestrial origin. Specific objectives for FY89 are: (1) issue request for proposal and implement a contract for building the Extended Operating Configuration of the SETI Targeted Search system and part of the Sky Survey System; (2) implement the Targeted Search Initial Operating Configuration; (3) continue development of the Sky Survey Engineering Design Model; (4) conduct a study of the Radio Frequency Interference environment and develop the telescope interface software at Arecibo; and (5) continue observatory selection and preparation. The approach will include implementing the SETI project to the standards of a NASA flight project. Commercially available computer systems will be evaluated as signal detectors. The Sky Survey Operating Configuration will be developed in-house at JPL, except for the use of a modified Targeted Search spectrum analyzer. The prototype system will be used at Arecibo to develop the telescope interface and conduct an interference survey and observations. The interference survey at the Deep Space Network will continue. Agreements on system upgrades and observing time will be negotiated with selected observatories. A NASA Research Announcement will be issued.

**W89-70397** 199-55-12
Ames Research Center, Moffett Field, Calif.
**ADVANCED PROGRAMS IN BIOLOGICAL SYSTEMS RESEARCH**
S. Chang 415-694-5733
(199-52-22; 199-61-12; 199-30-32)

The objectives of the RTOP are two-fold: (1) to understand the relationship between the causes and effects associated with changes in biological systems ensuing from natural or artificial changes in their environment, in the past, present, and future. The focus here is on conducting research and analysis tasks that are multi-disciplinary, that establish interfaces between Exobiology, Biospherics and Controlled Ecological Life Support System (CELSS) research programs and that begin laying the groundwork for advanced missions; (2) identify, determine the feasibility of, and develop programmatic approaches to implement new areas of investigation within the overall context of Biological Systems Research. The approaches of this RTOP are to: (1) determine the basis for the origin and development of ecological interactions between organisms and their environment in both natural and artificial ecosystems; (2) develop methods for characterizing the state and dynamical interactions of biological systems in and with their environment; and (3) assess the requirements for and feasibility of creating habitable extraterrestrial environments.

**W89-70398** 199-59-12
Ames Research Center, Moffett Field, Calif.
**SCIENCE DEFINITION FOR PLANETARY PROTECTION**
G. C. Carle 415-694-5765
(199-52-52; 805-19-00; 199-52-22)

The objective of the research conducted within this RTOP is to provide specific information that will enable the agency's Planetary Protection Officer to define the planetary protection requirements for specific future solar system exploration missions, e.g., Mars Rover Sample Return Mission. In addition, this research will provide a data base enabling Ames Research Center (ARC) to act as the Agency's technical advisor to specific mission project offices and science working groups with the direction of the Planetary Protection Officer. The approach to this activity will be to conduct workshops to define concerns and problem areas. Based on recommendations, a science data base will then be developed from research studies specific to each mission. Technical information regarding planetary protection issues will then be disseminated in response to recommendations of the Agency's Planetary Protection Officer. In addition, existing data will be updated and re-evaluated based on new findings from the research.

**W89-70399** **199-59-14**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**PLANETARY PROTECTION**
S. L. Bergstrom 818-354-2496

The objective of the Planetary Protection Program is to ensure that: (1) the exploration of extra-terrestrial bodies is conducted in accordance with established contamination agreements and with proper safeguards against the uncontrolled introduction of contamination; and (2) detrimental effects do not result from the introduction of extra-terrestrial materials into the Earth's biosphere. This RTOP supports the objective by: (1) conducting studies and analyses to synthesize Planetary Protection constraints for future missions and developing methods for satisfying these constraints; (2) studying terrestrial protection implications of sample return missions and developing procedures/constraints; and (3) conducting research and development activities in microbiology, contamination control and materials to support planetary protection objectives. This RTOP also provides for program planning and review, technical monitoring, reporting, solicitation and review of proposals, contracted studies, consultant services and other management functions as required.

**W89-70400** **199-61-11**
Lyndon B. Johnson Space Center, Houston, Tex.
**CELSS RESEARCH PROGRAM**
D. L. Henninger 713-483-5034

Future NASA mission scenarios to explore the solar system are by nature long-duration missions and as such require extensive utilization of space resources to limit resupply from earth. In addition, it will be necessary to efficiently regenerate all consumables and prevent the loss of any material. The concept of a Controlled Ecological Life Support System (CELSS) to sustain human crews in the hostile environment of space and planetary surfaces is a key enabling technology for these advanced missions. A manned lunar base will be one of the first post-Space Station missions undertaken. While the life support systems for Space Station and a lunar base have similar components, the availability of lunar resources adds a new dimension to a lunar base CELSS. The objective of this RTOP is to continue and initiate new research in support of a lunar base CELSS. Four tasks will continue the investigation into the use of lunar regolith as a plant growth medium and a source of plant growth nutrients. The FY89 approach is to: (1) continue dissolution laboratory experiments on simulated lunar glass; (2) continue research on the formation, characterization, and utility of zeolitic minerals which can be synthesized from lunar regolith under mild hydrothermal conditions; (3) develop a fairly representative lunar mineral and lunar glass simulant for continued investigation and to allow comparability of results among researchers; and (4) initiate research on the use of zeolite/apatite mixtures preloaded with nitrogen and potassium as a plant growth medium in a plant growth chamber.

**W89-70401** **199-61-12**
Ames Research Center, Moffett Field, Calif.
**BIOREGENERATIVE LIFE SUPPORT RESEARCH (CELSS)**
R. D. MacElroy 415-694-5573
(199-61-23; 199-61-32)

The objective of this RTOP is to support the scientific experiments and technological investigations, and potential flight experiments necessary for the development of bioregenerative life support systems. Investigations are directed toward the practical use of higher plants, algae, microorganisms and physical-chemical devices for the production of water, food and oxygen, and absorption of carbon dioxide and processing of waste materials in orbit or on planetary surfaces. The goal is to insure recycling and regeneration of materials needed for crew support. Included also are studies of the control and the efficiency of such bioregenerative systems. The approach involves study of the rates at which organisms or physical-chemical devices produce or consume biomass, food, oxygen, carbon dioxide, potable water, and fixed nitrogen in response to changes in environmental variables such as temperature, atmospheric gas composition, light (intensity, duration, and quality) humidity, wind speed, and the composition of nutrient medium. These investigations are also conducted to improve the methods available for increasing system efficiency, stability and control through automated sensing, data collection, and data interpretation. Data collected forms a science-requirements base for the design and operation of the Controlled Ecological Life Support System (CELSS) Breadboard Project.

**W89-70402** **199-61-14**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**EVALUATION AND DESIGN OF FERMENTERS FOR MICROGRAVITY OPERATIONS**
G. R. Petersen 818-354-7019

The development of bioreactors that operate in microgravity now will be necessary for their eventual implementation in either food production or waste processing in the Controlled Ecological Life Support System (CELSS) in order to prevent long delays in development when the actual needs arise. The objective of this effort is to obtain basic engineering data on bioreactor operation in microgravity so that a relevant data base is available when the need is imminent. The approach is to evaluate, design, construct and test a prototype model of a microgravity fermenter. A phase separated membrane bioreactor prototype model has been designed and constructed. Tests using this model will permit basic engineering data regarding mass transfer of oxygen to the culture, equipment requirements and culture viability to be obtained. This work will also lead to the design and construction of an additional prototype model that can be integrated into the Johnson Space Center Bioreactor test facility for further testing.

**W89-70403** **199-61-31**
Lyndon B. Johnson Space Center, Houston, Tex.
**CONTROLLED ECOLOGICAL LIFE SUPPORT SYSTEM (CELSS) DESIGN PROGRAM**
H. S. Cullingford 713-483-8402

Long-duration future space missions including settlements on the lunar and planetary surfaces will require a spectrum of life support systems that regenerate food, air, and water from wastes produced within the system. The Controlled Ecological Life Support System (CELSS) program provides the scientific and practical technology development to sustain a human crew in such future environments. The objectives of the CELSS design program is to develop viable options for potential missions of the 21st century. Conceptual designs for CELSS of the lunar and Mars missions and the evolutionary space station will be developed to further our understanding and system definition for future space systems. FY89 approach is to: (1) select a contractor for the preliminary conceptual design study of a lunar-base CELSS; (2) investigate CELSS stability issues with a computer-based emulator; (3) prepare an RFP to initiate preliminary conceptual design study of a Mars CELSS; and (4) determine initial conceptual design of a ground-based, crew-rated CELSS test bed.

**W89-70404** 199-61-32
Ames Research Center, Moffett Field, Calif.
**BIOREGENERATIVE LIFE SUPPORT FLIGHT EXPERIMENTS, TESTS AND EQUIPMENT**
R. D. MacElroy 415-694-5573
(199-61-12; 199-61-23)

The objective of this RTOP is to develop the requirements, concepts, and initial designs for test protocols and hardware to support the Controlled Ecological Life Support Systems (CELSS) program space flight experiments. These experiments will be directed to defining effects of the space environment (microgravity and radiation fluxes) on productivity of higher plants and algae, potential biological components of a CELSS. Devices capable of directing and controlling the flow of liquids, and of separating liquid and gas phases, will be evaluated. Both of these techniques are essential for the development of non-stressful growth environments for higher plants and for the growth and harvesting of single-celled organisms. Scientific and technological requirements will be developed by means of workshops and other advisory panels which will bring together scientific and engineering experts to consider, evaluate, and prioritize basic concepts for flight experiments and tests. Specific requirements, such as size and power parameters, for proposed experiments will be considered in respect to planned mission resources. Hardware mock-ups will be fabricated to better describe physical and operational characteristics of the equipment.

**W89-70405** 199-70-12
Ames Research Center, Moffett Field, Calif.
**EXTENDED DATA BASE ANALYSIS**
R. W. Ballard 415-694-6748

The objective of this effort is to expand the use of computer assisted analysis of data from spaceflight experiments. This also includes the development of techniques to relate spaceflight and ground collected experiment data. The work involved in the RTOP includes extending the opportunity for science investigators to extend and enhance the analysis of data that has been previously collected in spaceflight experiments, and the development of new approaches to increase the scientific yield of flight data. This RTOP will also support the publication and presentation of significant results.

**W89-70406** 199-70-22
Ames Research Center, Moffett Field, Calif.
**DATA ANALYSIS - EXOBIOLOGY PLANETARY DATA STUDIES AND LIFE SCIENCE DATA SYSTEM DEVELOPMENT**
G. C. Carle 415-694-5765
(199-52-52; 805-19-00)

The objective of this RTOP is to provide an interdisciplinary focus for the various Life Science activities where major data archive development and archive study techniques can be addressed by providing new and conducting studies of existing data bases which are supportive of Life Sciences science goals in previous and future flight experiments. In the area of exobiology, the approach will be to conduct computational studies of existing data bases from Mariner 6 and 7 and Viking to obtain information about the geochemical nature of the Martian surface. In the area of biomedicine, a comprehensive data base will be assembled from previous Cosmos biosatellite activities to make this data available to a broader cross section of Life Science investigators. Additionally, a data base will be prepared from previous bedrest studies to allow the integration and cross referencing of this data.

**W89-70407** 199-70-32
Ames Research Center, Moffett Field, Calif.
**DATA ANALYSIS TECHNIQUES - ADVANCED DATA HANDLING STUDIES FOR LIFE SCIENCES**
G. C. Carle 415-694-5765
(199-52-52; 199-52-12; 199-52-22)

The objective of this RTOP is to provide an interdisciplinary focus for various advanced data analysis techniques required in the laboratory and by future Life Sciences flight experiments in earth orbit and in solar system exploration. In the area of exobiological solar system exploration experiments, new analytical approaches based on advanced computational techniques will be developed which will significantly increase the data returned from a flight experiment without increasing the requirements for spacecraft resources. In physiological studies, accurate mathematical models of physiological effects of microgravity will be developed. Additionally, the concept of a Biocomputational Center which seeks to apply advanced computational methods and large-scale computational devices to more general Life Sciences science goals will be investigated.

**W89-70408** 199-80-32
Ames Research Center, Moffett Field, Calif.
**ENVIRONMENTAL SYSTEMS**
G. C. Carle 415-694-5765

The objective of this study will be to provide fully developed advanced flight instrumentation concepts and laboratory breadboards for the monitoring and control of spacecraft atmospheres, crew support systems, and other environments. The approach will involve instrument and experiment development based on advanced analytical concepts and engineering technology. Feasibility studies will be performed and based on validated concepts. Prototypes will be constructed and tested. Experiments and instruments based on these development efforts will be proposed for flight.

**W89-70409** 199-80-42
Ames Research Center, Moffett Field, Calif.
**ADVANCED TECHNOLOGY DEVELOPMENT - BIOSENSORS SYSTEMS**
J. W. Hines 415-694-5538
(199-80-92; 199-80-57)

The objective is to develop, implement, evaluate, and apply specific advanced bioinstrumentation and biotelemetry techniques and technology to measurement requirements particular to NASA Life Sciences flight programs and experiments. A comprehensive, cohesive long-term program plan has been established to support programs requiring specific biopotential, biophysical, biochemical, and biological measurements primarily from animals, under actual and simulated microgravity situations. The Ames Research Center Biomedical Sensor Project objectives can be divided into three main categories: Project Planning/Management; Biomedical Sensor/Bioinstrumentation Development; and Technology Insertion and Applications. A coordinated effort to ascertain science requirements and priorities, to develop prototype sensors and instrumentation, and to transfer the technology to flight programs is to be implemented.

**W89-70410** 199-80-62
Ames Research Center, Moffett Field, Calif.
**ADVANCED TECHNOLOGY DEVELOPMENT--BOTANY/CELSS**
R. D. MacElroy 415-694-5573

The objectives of this research are to evaluate methods of reducing the power requirements for operating a Controlled Ecological Life Support System (CELSS) or plant growth experiments in space. Approaches will include evaluating the efficiency of electrical power conversion to light, assessing the development of lamps with specific spectral characteristics, and evaluating methods for capturing and distributing solar light for plant growth.

**W89-70411** 199-80-72
Ames Research Center, Moffett Field, Calif.
**ADVANCED TECHNOLOGY DEVELOPMENT - GEOBIOMETRY**
G. P. Livingston 415-694-5896

A prototype instrument designed for the purpose of making quantitative estimates of the surface-to-atmosphere flux of selected trace gases is nearing completion under the Small Business Innovative Research Program. The instrument will incorporate a tunable diode laser with micrometeorological sensors and a data analysis package to allow rapid measurements of the concentration of selected gases to be correlated with measures of the turbulent eddy velocity field above the trace gas source or sink, yielding an accurate estimate of the flux for the selected gas species. The objective of this RTOP is to evaluate and qualify a field instrument for incorporation into Ames Research Programs. The approach will be to conduct a series of controlled experiments to address the operating performance and sensitivity of the prototype instrument under field conditions. This effort will require iterative verification and hardening of the prototype instrument to assure its survivability and performance stability when subjected to the environmental stresses anticipated under field conditions. These studies, in addition, will provide insight into application of current atmospheric surface layer turbulence theory for estimating trace gas fluxes in terrestrial ecosystems.

**W89-70412** **199-80-82**
Ames Research Center, Moffett Field, Calif.
**ADVANCED TECHNOLOGY DEVELOPMENT - EXOBIOMETRY**
G. C. Carle 415-694-5765
(199-52-52; 805-19-00)

The objective of this study will be to provide fully developed advanced flight instrumentation concepts and laboratory breadboards for future exobiology flight experiments where accurate, comprehensive, and sensitive instruments and highly specialized devices will be required. These instruments, experiment concepts, and devices are critical to the science needs of the exobiology community to gain specific data only obtainable from space flight and unaddressed elsewhere, e.g., measurements of the biogenic elements and their compounds in solar system exploration and simulation and collection experiments on Space Station. The approach will involve instrument and experiment development based on advanced analytical concepts and engineering technology. Feasibility studies will be performed and based on validated concepts; prototypes will be constructed and tested. Experiments and instruments based on these development efforts will be proposed for flight.

**W89-70413** **199-80-92**
Ames Research Center, Moffett Field, Calif.
**ADVANCED TECHNOLOGY DEVELOPMENT - NEAR TERM FLIGHT HARDWARE DEFINITION**
G. H. Bowman 415-694-6273

The objective of this RTOP is to support the preliminary design, early development and testing of hardware required for projected flight experiments. New hardware will be identified through the analysis of scientific objectives and requirements described in the responses to the Announcement of Opportunity (AO), NASA Research Announcements (NRA), and through previous flight experiences. The newly identified hardware will undergo further detailed requirements definition, an assessment of available state-of-the-art components, a conceptual design, and finally, breadboarding and testing. After the prototype has been developed the Life Sciences Flight Experiments Program will assume the responsibility for developing the flight hardware.

**W89-70414** **199-90-71**
Lyndon B. Johnson Space Center, Houston, Tex.
**INTERDISCIPLINARY RESEARCH**
Carolyn L. Huntoon 713-483-3503

The Space and Life Sciences Directorate at Johnson Space Center is responsible for the development of a comprehensive biomedical research program in support of manned space flight. This broad, multidiscipline mandate to acquire new knowledge is directed toward the acquisition of definitive data regarding the effects of the space environment on life systems in order to define the critical physiological and psychological variables which must be integrated into the overall considerations of spacecraft designers and mission planners. The objective of the interdisciplinary research RTOP is to provide flexibility in the accomplishment of this goal. The responsibility for planning, implementing, and continually evaluating the life sciences programs at the Johnson Space Center includes the need to provide support for preliminary investigation of various alternative advanced research and technology efforts which might ultimately become part of an approved programmed RTOP assigned to the Center.

## Mission Operations and Data Analysis

**W89-70415** **399-41-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**HIPPARCOS VLBI**
R. A. Preston 818-354-6895

The ESA satellite Hipparcos will determine the positions, proper motions and trigonometric parallaxes of 100,000 optical stars with unprecedented accuracy. The Hipparcos observations will be tied to the JPL Very Long Base Interferometry (VLBI) celestial reference frame, which is composed of the radio cores of distant quasars and galaxies. This will allow Hipparcos studies of stellar and galactic dynamics to be directly linked to a nearly inertial reference frame, and will result in a unified optical/radio high precision celestial reference frame. The Hipparcos and VLBI reference frames will be tied together by stars which can be positioned directly in both frames. This proposal is for support to continue VLBI observations of a set of radio emitting stars from the Hipparcos catalog to determine their positions and proper motions directly in the VLBI frame. These VLBI observations will also be used to improve our understanding of the physics of the magnetosphere of these stars where the radio emission is thought to originate. Such an astrophysical study will not only be an interesting by-product of the investigation but is necessary to understand the degree of positional coincidence between the optical and radio counterparts of each star which directly affects the quality of the astrometric link.

## Space Physics Theory

**W89-70416** **431-03-02**
Goddard Space Flight Center, Greenbelt, Md.
**MHD TURBULENCE, RADIATION PROCESSES AND ACCELERATION MECHANISMS IN SOLAR AND MAGNETOSPHERIC PLASMAS**
M. L. Goldstein 301-286-7828

The objectives of this RTOP are: (1) to study magnetohydrodynamic (MHD) turbulence, radiation processes, and particle acceleration mechanisms in solar and magnetospheric plasmas; (2) to publish in the scientific literature and to present at professional meetings the significant results of such research; (3) to collaborate with and support theoretical research of graduate students, research associates, and coinvestigators from other academic institutions who work on the subject matter of this RTOP. Research on MHD turbulence will be carried out by M. L. Goldstein and A. Vinas of the Laboratory for Extraterrestrial Physics in collaboration with W. H. Matthaeus of the Bartol Research Institute and J. J. Ambrosiano of Berkeley Research Associates. Particle acceleration in solar flares will be studied by R. Ramaty of the Laboratory for High Energy Astrophysics and C. J. Crannell and D. S. Spicer of the Laboratory for Astronomy and Solar Physics. Shock acceleration research will be carried out by F. C. Jones of the Laboratory for High Energy Astrophysics, D. Eichler and D. C. Ellison of the University of Maryland, and M. A. Forman of the State University of New York.

## Space Physics SR&T

**W89-70417** **432-20-01**
Marshall Space Flight Center, Huntsville, Ala.
**SPACE PLASMA DATA ANALYSIS**
C. R. Chappell 205-544-3033
(432-36-55)

The objective of this RTOP is to advance the understanding of the physical processes which occur in core plasmas. This research involves analysis of data from spacecraft and laboratory investigations as well as theoretical modeling of plasma environments and processes. Included in this RTOP are coordinated tasks which involve: (1) the study of the ionospheric source of core plasma for the magnetosphere; (2) the study of role of multi-ion core plasmas in magnetospheric wave processes; (3) development of an empirical model of the core plasma composition, density, and temperature; (4) laboratory and space investigations of the interaction of plasma with natural or man-made bodies in space; and (5) modeling of the outflow characteristics of core plasmas and of their interactions with other plasma populations. The modeling work includes studies of core plasma in the ionospheres/magnetospheres of Earth and the outer planets.

**W89-70418** **432-20-03**
Goddard Space Flight Center, Greenbelt, Md.
**NSESCC FACILITY**
Melvyn L. Goldstein 301-286-7828

The objective of this RTOP is to support the operating budget of the NASA Space and Earth Sciences Computing Center (NSESCC) associated with very large-scale computational support of RTOP related research within the Space Plasma Physics program. The funding support will provide a total allocation of 1200 to 1500 Computing Units (CUs). The total allocation will be distributed to individual researchers both at Goddard and external universities, in accordance with the computational needs of the space plasma physics community.

**W89-70419** **432-20-04**
Goddard Space Flight Center, Greenbelt, Md.
**DUSTY PLASMAS IN THE MAGNETOSPHERES OF THE OUTER PLANETS**
T. G. Northrop 301-286-7516

The overall objective of this study is to gain an understanding of the sources, sinks and dynamics of charged particles (electrons, ions, and charged dust grains) in the magnetospheres of Jupiter, Saturn, earth, Uranus and pulsars. This work will apply plasma theory and the theory of charged particle motion to data taken by Pioneers 10 and 11, and by Voyagers 1 and 2. Included are studies of transport of charged dust grains in the rings of Saturn, Jupiter, and Uranus. Micron sized dust is observed in the vicinity of the rings of all three. Such dust constitutes a major consideration for the future Cassini mission orbiters at Saturn because it is a hazard to the spacecraft; but at the same time one wants to observe and analyze the dust. The gyrophase drift of dust in many environments dominates others, such as plasma drag drift and diffusion. Gyrophase drift takes place because the charge on a dust grain depends on its plasma environment and on its velocity through the plasma, both of which vary at the gyrofrequency. The non-zero capacitance of the grain introduces a time lag in the charge-discharge process and this in turn produces a radial drift. This drift does not take place for electrons or ions, because their charge is fixed. Calculations of gyrophase drift velocities have not to date taken account of photoemission in the presence of a plasma density gradient. We will do this. We will also find the drift of intermediate (micron to larger) grains. Present theory is inadequate for them because they do not satisfy the assumption of large charge to mass ratio, even though electromagnetic forces are comparable with gravitational forces on them.

**W89-70420** **432-20-05**
Goddard Space Flight Center, Greenbelt, Md.
**DETERMINATION OF CORONAL AND SOLAR-WIND PROPERTIES FROM ANALYSIS OF IONIC COMET TAILS**
Malcolm B. Niedner, Jr. 301-286-5821

The major objectives of this program are: (1) to use the extensive wide-field imagery of Halley's Comet resident at NASA-GSFC to calibrate the large-scale interaction of cometary plasma tails with the solar wind and IMF; (2) thereby allowing the use of Halley's and other comets as natural probes of the heliosphere in 3-D. The Halley images have been secured under the auspices of the Large-Scale Phenomena (L-SP) Discipline of the International Halley Watch, and the Investigator is the Discipline Specialist for L-SP. In addition to the plasma-tail imagery of Halley, simultaneous solar wind and IMF data are required for the calibration process, and several at least partial datasets, from the VEGA-1 and VEGA-2 magnetometers, the ICE and IMP-8 plasma experiments and magnetometers, etc., are available at the current time as a result either of collaborations between the investigator and spacecraft experimenters, or of being published in the literature. The study will examine all plasma structures in comet tails from the narrow ion rays on up to the dramatic disconnection events (DE's), but will focus more on the latter and other large-scale structures as a result of their more likely connection to the external solar wind and IMF (conditions internal to the comet may well be the cause of rays and other tail substructure). For example, from pre-Halley work there are unique and tantalizing clues afforded by DE's concerning the shape of the interplanetary current sheet (i.e., sector boundaries) to latitudes of 45 degrees and higher. The assumption is that frontside magnetic reconnection at sector boundary crossings is the cause of DE's (Niedner and Brandt 1978). The Halley imagery will be used to extend (or perhaps greatly modify) this past work.

**W89-70421** **432-20-11**
Goddard Space Flight Center, Greenbelt, Md.
**PRESERVATION AND ARCHIVING OF EXPLORER SATELLITE DATA**
R. A. Hoffman 301-286-7386

The NASA Explorer Project Scientists for the IMP Explorers, Dynamics Explorers (DE), and International Sun-Earth Explorers (ISEE) have proposed a set of projects whose general objective is to establish archives of spacecraft data for long-term access in a convenient form. The specific objectives include: (1) development of techniques and realistic cost estimates to recover data from old and possibly deteriorated magnetic tapes for subsequent transfer for archival to optical disks; (2) development of methods to transfer data from magnetic tapes to optical disks and to use the optical disks in an operational environment; (3) development of procedures and techniques for the NSSDC to acquire data processed at experimenters' facilities and utilized for analyses, and transfer of these diverse data sets to a common format on optical disks; and (4) production of the data sets which have been identified, and their dissemination to users. For objectives (1) and (3), candidate data sets from IMP and ISEE would first be identified, upon which detailed approaches would be developed for the subsequent work. With the diverse formats and time resolutions available, the feasibility of converting the data to a common format and consistent time resolution will be investigated. Appropriate investigators will be funded to prepare data for submission to the NSSDC. For objective (2), software will be developed to convert the DE tape telemetry data base from Sigma-9 format to optical disks running on DEC VAX computers. Operational procedures will be developed to transfer the data.

**W89-70422** **432-36-05**
Goddard Space Flight Center, Greenbelt, Md.
**SUPPORT FOR SOLAR-TERRESTRIAL COORDINATED DATA ANALYSIS WORKSHOPS (CDAWS)**
Robert E. McGuire 301-286-7794
(656-45-01)

As our understanding of solar-terrestrial systems such as the earth's magnetosphere and the heliosphere matures, many of the significant questions that remain concern global-scale, three-dimensional structure and dynamics. These questions are a major focus of the key space physics missions of the 1990s such as International Solar Terrestrial Physics (ISTP). The analysis of simultaneous data assembled from many instruments widely dispersed in space, with the analysis closely linked to theoretical models, is one essential element in the successful resolution of such questions. This RTOP is to support a continuing series of Coordinated Data Analysis Workshops (CDAWs) aimed at: (1) refining the organizational techniques and software tools to support the effective/efficient simultaneous analysis of the multiple data collections needed to address such global problems; and (2) the immediate exploitation of existing opportunities for fruitful collaborative research workshops, specifically the data collection that has resulted from the PROMIS (Polar Regions Outer Magnetosphere International Study) observational campaign. Specific activities expected under this RTOP include the conclusion of the current CDAW-8 research effort and the convening of CDAW-9 (CDAW/PROMIS).

**W89-70423** **432-36-20**
Marshall Space Flight Center, Huntsville, Ala.
**EXPERIMENTAL AND THEORETICAL STUDIES OF NATURAL AND INDUCED AURORAS**
M. R. Torr 205-544-7591

The purpose of this RTOP is to conduct studies to advance the knowledge of the physics of auroras, and to extend the ability to use the measurement of auroral emissions for the interpretation of magnetospheric phenomena. A primary objective is the modeling of auroral emissions in order to characterize the impact energy of the particles. Models describing the photochemistry of the principal auroral features will be completed with a two-stream auroral electron degradation code in order to conduct a detailed study of the expected behavior of the emissions. The second task addresses the fact that certain important cross sections needed for the interpretation of some of the emissions have not been measured. An example is the O(1D) emission at 6300 A. The collisional deactivation of O(1D) by O(3P) has yet to be measured in the laboratory. A simple but optimized experiment was designed to measure this reaction rate coefficient.

**W89-70424** **432-36-55**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**QUANTITATIVE MODELLING OF THE MAGNETOSPHERE/IONOSPHERE INTERACTION INCLUDING NEUTRAL WINDS**
M. Harel 818-354-4205

The coupling of the ionosphere/magnetosphere system is studied to evaluate the effect of neutral ionospheric winds on plasma convection in the magnetosphere, and the driving of these neutral winds by magnetospheric plasmas during substorms. In the first phase of this investigation, which has been completed, passive and interactive self-consistent models for the terrestrial ionosphere and magnetosphere were developed. These models combine the time-dependent Rice Convection Model with a storm-time neutral wind model developed by Dr. J. Forbes of Boston University. The models were tested for quiet-time and substorm periods during the Coordinated Data Analysis Workshop (CDAW) 6 and GISMOS events and yielded very realistic currents and electric fields at mid- and low-latitudes. The objective during this present phase of the study is to expand the storm simulation activity by extending the ionospheric grid to the equator and by inclusion of improved wind fields. Simulations of CDAW and GISMOS events will continue in collaboration with many other theoretical and experimental groups. The following steps are planned for FY89: (1) in collaboration with J. Forbes, we plan to incorporate new Thermospheric General Circulation Model (TGCM) wind models and refined polar cap boundary and potential distribution for additional runs of the CDAW and GISMOS storms. Results will be compared with satellite and ground-based observations and be extensively interpreted; (2) simulate the flywheel effect by freezing model neutral winds while computing E-field self-consistently; (3) improve and refine our self-consistent model by extending the grid to the equator; (4) develop a comprehensive user-friendly package in support of the model and take first steps to make the model available to other investigators; and (5) participate in future CDAW and GISMOS workshops.

**W89-70425** **432-36-55**
Marshall Space Flight Center, Huntsville, Ala.
**SPACE PLASMA SRT**
T. E. Moore 205-544-7633
(432-20-01)

The objectives of this and another closely related RTOP are to study the earth's plasma environment using instrumentation on spacecraft, sounding rockets, shuttle, and laboratory experiments. This RTOP is oriented toward the development of instrumentation technologies via the following tasks: (1) design and develop a low-energy ion mass spectrometer which operates differentially in energy, angle, and mass so as to measure the ion species distribution functions; (2) further develop the Differential Ion Flux Probe (DIFP) instrument to be used for the measurement of multiply-directed, low-energy ion streams. This technique was applied to laboratory wind tunnel studies, rocket flights into the aurora, and shuttle-based studies; (3) develop a low-energy electron analyzer suitable for the diagnosis of the spacecraft electron plasma environment, including thermal electrons, suprathermal components, photoelectrons, and the measurement of positive spacecraft floating potentials; (4) develop computer design tools for space plasma instrumentation and particle optics systems. These tools will numerically solve for the potential distribution in geometries of interest, and compute particle paths through the system, leading to rapid testing of proposed designs and reduced need for test hardware iterations.

**W89-70426** **432-36-55**
Goddard Space Flight Center, Greenbelt, Md.
**PARTICLES AND PARTICLE/FIELD INTERACTIONS**
Keith W. Ogilvie 301-286-5904

The object of this research is to increase the knowledge and understanding of non-thermal plasmas occurring in the interplanetary medium and magnetospheres of earth and other planets. This requires continuous improvement of measurement techniques, concentrating on advanced concepts of plasma detectors, ion mass discrimination at high energies, magnetometers and radio and plasma wave analyzers. Work is also under way to improve the theoretical description of plasma properties, and to improve techniques for the interpretation of the results of space plasma experiments, requiring corresponding improvements in numerical techniques and in methods of data display.

**W89-70427** **432-36-56**
Goddard Space Flight Center, Greenbelt, Md.
**PARTICLE AND PARTICLE/PHOTON INTERACTIONS (ATMOSPHERIC MAGNETOSPHERIC COUPLING)**
J. P. Heppner 301-286-8797

The objective is to develop experimental and theoretical approaches for investigating the processes which provide strong coupling between the neutral atmosphere, the collision dominated ionospheric plasma, and the collisionless magnetospheric plasma. Within the framework of this overall objective, specific sub-objectives are identified in terms of having: (1) key significance; (2) goals which are attainable with limited resources; and (3) close ties to future projects and programs. Emphasis is placed on electric fields and the associated transport and energization of particles that occur within the earth's magnetic and gravitational fields. Related topics include: electric fields in the earth-ionosphere cavity, the transformation of atmospheric ions to trapped radiation, auroral particle acceleration mechanisms, plasma instabilities producing ionospheric irregularities, etc. Improved instrumentation is being developed for low light level observations of tracer chemicals, measurements of low energy particles and electron temperature and density measurements. Properties of double probes in low plasmas are being studied. Models for the injection, diffusion, and transport of tracer particles are being developed for planning and interpreting future chemical release experiments.

**W89-70428** **432-36-58**
Goddard Space Flight Center, Greenbelt, Md.
**THEORETICAL STUDIES AND CALCULATIONS OF ELECTRON-MOLECULE COLLISIONS RELEVANT TO SPACE PLASMA PHYSICS**
A. Temkin 301-286-8091

The objective of this RTOP is to do calculations of electron scattering (primarily vibrational and rotational excitation within the ground electronic state) from molecules of atmospheric (terrestrial and planetary) and astrophysical importance. These include specifically e-N2, CO, O2. The atmospheric importance of N2 and O2 is obvious, for the most part, and has been further detailed in our previous RTOP. The basic calculational methodology is the non-iterative partial differential equation (PDE) technique, which in its two-dimensional (2-D) form has now been well developed, with the 15 state vibrational close coupling calculation of e-N2 scattering to be completed as the first item in this RTOP period. The main new undertaking will be the e-CO calculation. The main application of this cross section is relevant to the interstellar medium and molecular clouds. We will give a short recapitulation of the astrophysical relevance of CO as the tracer of H2, including where and under what conditions the process e+CO(n=0) yields CO(n greater than 0) can be expected to be of importance. The application of the non-iterative PDE technique to e-CO, by virtue of its similarity to N2, is expected to be straightforward and we expect to have preliminary results by the middle of the (three year) RTOP period. On the other hand application to e-O2 is more difficult because O2 is not a closed shell molecule. In principal the changes that are necessary are understood, but in practice we would expect this application to commence only toward the end of the RTOP period.

## Space Physics ATD

**W89-70429** **433-04-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**MERCURY ORBITER**
C. L. Yen 818-354-4899

The objective of this proposal is to advance the flight readiness of a low cost ballistic Mercury orbiter mission by expanding on the FY88 pre-Phase A study. The long term objective is to prepare for a 1997 ballistic Mercury orbiter mission. The FY88 study is aimed at determining the science requirements, the performance possibilities, and the development of a mission scenario and a flight system. In cooperation with a Mercury Science Working Team, the study has established a mission using two identical spacecrafts that will emphasize space physics objectives. The launch is planned for 1997. The deliverables of the FY88 study will be a preliminary mission and spacecraft design. The FY89 study will refine the proposed FY88 design concept and verify the viability of the concept with a more detailed and thorough analysis. Design problems which were not addressed previously will be investigated. The end product of the FY89 study will be a mission cost estimate plus a more definitive, revised, and improved conceptual mission design. A close liaison will be maintained with the science community and the design of the mission will be kept flexible to accommodate potential changes.

**W89-70430** **433-04-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**NASA-ISAS COOPERATIVE STUDIES**
S. J. Kerridge 818-354-0899

The objective of this RTOP is to support the NASA Space Physics Division (Code ES) in establishing cooperative interactions with Tokyo University Institute of Space and Astronautical Science (ISAS) with emphasis on a Comet Coma Sample Return (CCSR) Mission. The approaches are: (1) support programmatic and mission aspects of CCSR in establishing a joint NASA-ISAS program. Support necessary aspects of other agency involvement; (2) generate technical data supporting definition of elements of a CCSR mission likely to be the responsibility of NASA; (3) provide support to ISAS via consultants and advisors in selected science and engineering areas; and (4) support other potential cooperative ventures via joint planning meetings.

**W89-70431** **433-04-04**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**INTERDISCIPLINARY ATD STUDIES**
S. J. Kerridge 818-354-0899

The objectives of this RTOP are: (1) to assess further options of adding a tail probe to the Comet Nucleus Sample Return Mission (CNSR); and (2) to provide Code ES with ad hoc support on issues relevant to Space Physics Mission Planning. Approaches will be to: (1) continue Tail Probe design activities as in FY88; and (2) provide science, mission and spacecraft support as required for ad hoc activities.

**W89-70432** **433-04-07**
Marshall Space Flight Center, Huntsville, Ala.
**ADVANCED SOLAR OBSERVATORY DEFINITION**
William T. Roberts 205-544-0621
(443-04-06)

The sun represents a sample of astronomical matter lying figuratively at our doorstep in which many of the physical processes which operate on stellar and galactic scales can be studied at a level of detail that can be achieved in no other way. Examples of these fundamental processes include the release of energy by thermonuclear reactions, the generation of magnetic fields on stellar processes, the acceleration of particles to ultra-high energies, and the loss of mass through the solar wind. The Advanced Solar Observatory (ASO), as proposed, will contain a complement of instruments of such enhanced power and subtlety that our understanding of solar phenomena will be immeasurably advanced. The ASO will be developed on the Space Station in a modular approach. This modular design will allow the addition of new capability (EUV, soft X-ray, low frequency radio, and gamma ray and neutron) as they become available.

**W89-70433** **433-06-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**SOLAR PROBE ADVANCED TECHNICAL DEVELOPMENT**
J. E. Randolph 818-354-2732

This RTOP will support Starprobe advanced technical development studies including the following tasks: (1) reassessment of trajectory and mission design options such as multi-planet gravity assist and aero-gravity assist trajectories; (2) consideration of new spacecraft concepts using current spacecraft inheritance such as Mariner Mark 2 and developing in more detail the spin stabilized options that we briefly considered in the past; (3) new heat shield design concepts for three axis and spin stabilized spacecraft will be developed; (4) new spacecraft technology will be incorporated and new technology requirements will be identified; and (5) a revised program plan will be proposed consistent with possible collaboration with missions from other nations. A study team from the JPL technical divisions will consider the above objectives in the context of developing mission and system options leading to a phase A study in FY90 and a new project start in FY93.

## Space Physics Sounding Rocket Research

**W89-70434** **435-11-36**
Marshall Space Flight Center, Huntsville, Ala.
**NON-EQUILIBRIUM SPACE PLASMA INSTRUMENTATION SRT (DIFFERENTIAL ION FLUX PROBE DEVELOPMENT)**
N. H. Stone 205-544-7642
(432-36-55)
The objective of this RTOP is to evaluate plasma diagnostic techniques and develop space plasma instrumentation capable of diagnosing highly non-equilibrium plasmas that exist in nature and in the near environment of space vehicles. Three tasks are required to accomplish this objective: (1) continued development of the Differential Ion Flux Probe (DIFP); (2) development of a high throughput mass analysis technique; and (3) development of a combined ion mass and flux vector sensor. The proper and unambiguous diagnosis of non-equilibrium plasmas is essential to the success of future active space plasma experiments and a proper interpretation of space plasma data, in particular, data from sounding rockets and satellites immersed in regions of active particle ionization. This effort to extend the state of the art of space plasma instrumentation is directly related to ongoing NASA sounding rocket programs, space plasma physics/space shuttle missions (e.g., the Tethered Satellite TSS-1 mission), future NASA planetary and cometary probes, and DOD space test program flights.

**W89-70435** **435-11-36**
Goddard Space Flight Center, Greenbelt, Md.
**SOUNDING ROCKETS: SPACE PLASMA PHYSICS EXPERIMENTS**
J. P. Heppner 301-286-8797
The objective is to perform measurements and experiments that will lead to an understanding of the interactive processes that occur between neutral gases, plasmas, energetic particles, and electric fields in the atmosphere, ionosphere, and near-earth magnetosphere. Sounding rockets provide the only access for in situ measurements in the lower ionosphere (altitudes below 200 km) and middle atmosphere regions (30 to 90 km). Emphasis is also placed on trajectories and/or the low cost, quick reaction sounding rocket approach which permits program flexibility. Historically, this approach has logically been extended to include: (1) piggyback experiments on orbiting vehicles; (2) experiments involving sounding rocket flights in association with simultaneous satellite measurements in selected geometrical coincidence between trajectories; (3) flight testing of new instrumentation and measurement techniques; (4) shuttle flights of low cost, rocket type payloads; and (5) investigations of the electrodynamics of middle atmosphere (i.e., below 90 km) using sounding rockets for deploying payloads which descend via parachutes.

**W89-70436** **435-31-36**
Wallops Flight Center, Wallops Island, Va.
**SUPPORT OF OUTSIDE INVESTIGATORS**
L. J. Early 804-824-1611
The objective is to provide a streamlined administrative system for transferring monies to various science experimenters within universities and industry with approved grants or contracts for plasma physics experiments leading to a better understanding of the interactive processes of gases, particles, and fields in the atmosphere, ionosphere, and magnetosphere. Individual funding is accomplished upon approval of the research effort by the NASA Headquarters Science Discipline Chief. Emphasis is placed on studies which utilize sounding rockets to provide the platform for data collections. This is a pass-through arrangement for the Space Physics Division (ES), Office of Space Science and Applications to transfer monies to approved grantees.

## Technical Consultation and Support Studies

**W89-70437** **643-10-01**
Lewis Research Center, Cleveland, Ohio.
**SPECTRUM AND ORBIT UTILIZATION STUDIES**
James W. Bagwell 216-433-3502
The objectives of this RTOP are to: (1) provide technical consultation services support in the area of space communications services with particular emphasis on preparing for international meetings relating to the fixed-satellite service (FSS), the broadcast-satellite service (BSS), and the mobile-satellite service (MSS); (2) provide the technical basis and regulatory support needed to obtain sufficient orbit/spectrum to meet current and projected requirements of NASA and the United States; and (3) perform studies, develop analytical methods for spectrum management, conduct evaluations, identify technology status and needs, perform critical technology developments, perform measurements (where necessary) to determine sharing criteria, and evaluate alternatives that result in efficient and cost-effective use of the geostationary orbit/spectrum resource. Specifically, these activities will: (1) support planning for NASA and other government agencies communications needs; (2) support participation in the 1988 Space Services World Administrative Radio Conference (WARC) with primary emphasis on the FSS, and secondary emphasis on the BSS and the MSS; and (3) support domestic and international MSS planning. We will conduct the described activities within the framework and schedules of the applicable International Radio Consultative Committee (CCIR) Study Groups, the special preparatory committees established in the United States, and the national and international meetings called to support preparations for the conferences. Efforts planned are a combination of in-house and contract activities.

**W89-70438** **643-10-03**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**PROPAGATION STUDIES AND MEASUREMENTS**
F. Davarian 818-354-4820
(643-10-05; 650-60-15)
The objective of the Propagation Studies and Measurements Program is to support NASA's Communications and Information Systems Division through studies and experiments regarding the propagation effects in earth-space systems. The propagation effects in the earth-space environment must be understood and accounted for in the design and specification of space communication systems. Therefore, the goals of this RTOP are to quantify the propagation effects through field tests, develop prediction models and/or substantiate the existing ones for cases where no experimental data exist, and provide support to the International Consultative Radio Committee (CCIR) and regulatory bodies. The objectives of this RTOP are accomplished through a work plan consisting of three types of activities: (1) propagation measurements and experiments from about 0.5 GHz to the optical frequencies; (2) analysis and modeling of propagation effects; and (3) propagation assessment of communications techniques and evaluation of propagation models. The first activity involves flight experiments or their simulation. This activity is conducted through field tests as well as participation in the Mobile Satellite Experiment (MSAT-X), the Engineering Test Satellite V (ETS-V) Experiment, the Advanced Communications Technology Satellite (ACTS) Experiment, the Olympus Experiment, and other experimental programs. The second is conducted with the analysis and comparison of the results from the first with other data bases, and the publication of results. Simulation and modeling efforts are included in this activity. The third is typically CCIR contributions, surveys, and the propagation handbooks for earth-space paths. Collaboration and information exchange with domestic and

international laboratories with an interest in propagation studies will continue. The tasks of this RTOP will be carried out primarily at universities and government laboratories.

**W89-70439** 643-10-05
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**ADVANCED STUDIES**
A. Vaisnys 818-354-6219
(650-60-15; 643-10-03)

The objectives of this RTOP are to provide new system concepts and to identify key technologies leading to the growth of advanced communications satellite systems and the extension of existing space and terrestrial based communications services within the United States. The technical objectives of this RTOP for FY89 are: (1) to perform system concept design and analyses on integrated aeronautical, maritime and land mobile satellite systems; (2) to further refine the system concept designs of, and determine efficient channel access techniques for, future multiple-accessed, small terminal communications and interactive data network systems such as the Mobile Satellite System (MSS) and the Personal Access Satellite System (PASS); and (3) to assess the applicability of the state-of-the-art communications satellite technologies being employed on systems such as Advanced Communications Technology Satellite (ACTS), as well as identify enabling technologies for the above systems. With high frequency communications satellite projects such as ACTS progressing and PASS entering the conceptual design phase, as well as L-band satellites for aeronautical, maritime, and land mobile systems in various stages of development, this RTOP will develop concepts for more efficient frequency/orbit utilization, easier channel access, and cross-applicability of technology between various satellite systems. This RTOP will provide a system design for an integrated aeronautical, maritime and land mobile satellite system, and address the functional and operational requirements of each service, frequency sharing techniques, and system design issues to meet the substantially different requirements among these services. The main thrust of the technology study will be the identification of the critical technology and cost drivers for the high frequency bands for low data rate communications, including applications such as PASS. Existing small customer premises terminal technology and ACTS technology will be evaluated.

**W89-70440** 643-10-05
Lewis Research Center, Cleveland, Ohio.
**ADVANCED STUDIES**
James W. Bagwell 216-433-3502
(650-60-20; 650-60-21; 650-60-23; 643-10-01)

The objective of this RTOP is to establish the requirements rationale and provide a focus for NASA's communications technology program consistent with the overall goals, objectives and thrusts of NASA's Communications Applications Program and to support appropriate initiatives in the FCC, IRAC, CCIR or ITU for new space communications applications. The approach is to conduct in-house and contracted studies to: (1) assess current and future telecommunications needs and opportunities for NASA, other government agencies, and commercial applications; (2) assess applications, concepts and configurations to meet those needs and opportunities; (3) define technology developments and experiments needed to enable/realize new or enhanced space communications applications and systems; and (4) define and develop advocacy for suitable advanced communications technology development programs and experiments to be undertaken by NASA. The output from these studies will be used to address the technical, economic and institutional/regulatory feasibility of operational systems, and develop plans for guiding future communications technology development.

## Advanced Communications Research

**W89-70441** 650-60-15
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**MOBILE COMMUNICATIONS TECHNOLOGY DEVELOPMENT**
William Rafferty 818-354-5095
(643-10-01; 643-10-03; 643-10-05)

This is an on-going technology development program aimed at the efficient utilization of orbit, spectrum and equivalent isotropically radiated power (EIRP) for first and future generation mobile satellite systems (MSS). There are five major areas of technology concentration; in addition, there is a new advanced systems study area. The new study effort is directed to extending mobile communications to the personal level and will absorb the spacecraft antenna effort initiated in FY88. The core technology areas are: (1) vehicle antennas - the objective here is to develop low profile mechanically and electronically, steerable antennas which provide a moderate gain (10 dBic) and through directivity provide sufficient isolation as to permit multiple satellites to operate in the same frequency band without mutually interfering; (2) digital speech coders - the objective is to develop digital speech coders which can produce commercially acceptable voice quality with low complexity realizations at a 4800 bps rate; (3) digital modem - the goal here is to develop a bandwidth and power efficient modulation and demodulation (modem) technique which can support the above digital voice encoding schemes in a 5 kHz, satellite fading channel; (4) networking - this activity is to investigate multiple access and network management protocols standards which efficiently utilize the resources of an integrated voice and data mobile satellite network; (5) channel characterization - this task is directed at characterizing the mobile satellite channel through propagation experiments and modeling; and (6) personal communications study - this effort is aimed at identifying the required space and ground segment concepts and technologies to enable a personal access satellite system, i.e., access via a hand held unit. This system will permit greater freedom of satellite usage and will make extensive use of the technology base developed under this program and NASA's Advanced Communications Technology Satellite (ACTS) Ka-band program. The above activities are accomplished through in-house JPL efforts and a mix of industry and university contracts. A series of field experiments have been initiated, and are on-going, to validate MSS system concepts and operational equipment. The above technologies have been successfully developed to the breadboard level and are already being phased into the evolving U.S. MSS at the system definition level.

**W89-70442** 650-60-20
Lewis Research Center, Cleveland, Ohio.
**SPACE COMMUNICATIONS SYSTEMS ANTENNA TECHNOLOGY**
James W. Bagwell 216-433-3502
(650-60-22)

The objective of this RTOP is to conduct research and technology development on antenna systems and components for advanced space communication missions. Previous efforts have resulted in design, fabrication and testing of antennas and components based on both conventional and monolithic microwave integrated circuit (MMIC) technologies. Current efforts continue the study, design, fabrication and testing of advanced systems using MMIC devices for applications requiring increased performance and/or reduced weight and power costs. Requirements for future systems and critical device/component technologies will also be assessed. Supporting technologies such as MMIC packaging and characterization, microstrip radiating elements, applications of optics to arrays, and precision reflector system analysis will also be developed. Activities will be initiated to develop an intelligent antenna system. The emphasis will be on exploiting MMIC device technology for arrays where impact is both desirable and feasible in the near term and on investigating the future use of light wave technology in array feeds and arrays.

**W89-70443** **650-60-21**
Lewis Research Center, Cleveland, Ohio.
**SATELLITE SWITCHING AND PROCESSING SYSTEMS**
James W. Bagwell 216-433-3502
(650-60-20; 650-60-22; 650-60-23)
The objectives of this RTOP are to conduct research and technology development of components and subsystems for advanced communications satellite systems in the area of on-board message switching and processing, modems, codecs, and cost efficient implementation of earth terminal subsystems. Work focuses on the full range of spaceborne, ground and network control/management systems. Work under the RTOP is performed primarily under aerospace communications and electronics industry contracts and a portion through university grants. Work includes advanced proof-of-concept (POC) and focused technology development for: (1) bandwidth efficient combined modulation and coding concepts; (2) programmable digital modems; (3) multi-channel demux/demod/decoder; (4) flexible high speed codecs; (5) fault tolerant data distribution processors; (6) autonomous on-board master control; (7) radiation hardened, high speed, low power GaAs enabling components; (8) and cost efficient ground terminal controllers.

**W89-70444** **650-60-22**
Lewis Research Center, Cleveland, Ohio.
**RF COMPONENTS FOR SATELLITE COMMUNICATIONS SYSTEMS**
James W. Bagwell 216-433-3502
(650-60-23; 650-60-21; 650-60-20)
The objectives of this RTOP are to perform research and technology development of RF components for space communications including power amplifiers, low noise receivers, signal sources, microwave switches and other components identified as required for future applications/missions. Current efforts are aimed at developing and applying monolithic microwave integrated circuit (MMIC) technology to space communication systems and their related earth terminals. By means of both contracted and in-house efforts, develop analysis and synthesis techniques for the above space program components; apply the developed techniques to determine the basic characteristics of components meeting specified requirements; fabricate proof-of-concept components; and test and evaluate fabricated components.

**W89-70445** **650-60-23**
Lewis Research Center, Cleveland, Ohio.
**COMMUNICATIONS LABORATORY FOR TRANSPONDER DEVELOPMENT**
James W. Bagwell 216-433-3502
(650-60-20; 650-60-21; 650-60-22)
The objectives of this RTOP are to design, develop and operate a laboratory test facility to be used to test communication system components and subsystems, and to provide laboratory simulations of multibeam and multichannel satellite communications systems. To design, develop and test prototype ground terminal systems for use with the Advanced Communications Technology Satellite (ACTS) and other advanced communication satellites. The approaches are to design, develop and test 30 GHz uplink, frequency translator and 20 GHz downlink communications system, including transmitting and receiving ground terminals and satellite segment. Continuous and burst bit stream rates of nominally 27.5 Mbps to 220 Mbps will be used to modulate the links. End-to-end channel characterizations will be made. Software simulation results will be compared with the hardware simulation results. Upon completion, network control methods will be added and burst data transmissions will be tested and evaluated in both hardware and software. Specific testing in support of the ACTS Program including the development and testing of the Link Evaluation Terminal (LET) will be carried out.

**W89-70446** **650-77-00**
Lyndon B. Johnson Space Center, Houston, Tex.
**INTERSATELLITE LINK**
Kumar Krishen 713-483-0207
The objective of this task is to investigate space-to-space (orbiter to Advanced Communications Technology Satellite-(ACTS)) and direct space-to-ground (ACTS-to-ground stations) communications links in the 20/30 GHz frequency band. This frequency band has been proposed for the Space Station (SS) and is expected to be implemented in the growth phase of the SS. Its use will ease the traffic burden in the congested Ku-band frequency range. The proposed program will include a detailed study of the experiment plan and the orbiter test flight during the ACTS satellite life time. Preliminary JSC studies for the experiment configuration were conducted under Director's Discretionary funding. Under this RTOP a detailed configuration will be developed including system requirements, costs, schedules, and specifications for the orbiter and ground station hardware. The test flight program will be conducted under combined OSSA and OSF sponsorship. The overall feasibility of the communications links in the 20/30 GHz band using Low Earth Orbiter (LEO) will be demonstrated under this RTOP as a joint program between JSC and the responsible Center for ACTS, LeRC.

## Data Systems

**W89-70447** **656-11-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**DATA INTERCHANGE STANDARDS**
M. L. MacMedan 818-354-7004
(656-50-05)
The objective of this RTOP is to develop a supporting utility (DDP UTILITY) to enable users of the Consultative Committee for Space Data Systems (CCSDS) standard formatted data unit (SFDU) concept: (1) to write the corresponding Data Description Package; (2) to describe the contained format syntax in a precise language specifically designed for this purpose called Transfer Syntax Description Language; (3) to provide the user with access to an applicable data element dictionary which has been created and maintained for each scientific discipline for data interchange purposes; and (4) to allow the user to examine and analyze an externally obtained data description package. Use of such a utility is not merely to make it easier for originators of SFDUs to properly label and describe their data, but it also guarantees a high degree of uniformity in application of the structuring rules among diverse users. This is particularly true since many SFDU originators are in different disciplines, space agencies, and countries. Without such a utility, standardization would be much more difficult. Currently, format syntax is described for the control authorities in English, a language recognized as used imprecisely and which will not lead to future automation of the process. However, it is a way of temporarily documenting such descriptions until they can be rewritten in a better language. Traditional programming languages have been surveyed and were found to have flaws preventing adoption. Therefore, a major part of this task is to complete software development of the Transfer Syntax Description Language (TSDL) which was developed under the auspices of CCSDS, Pilot Land Data System, and the American Congress on Surveying and Mapping, and which is currently available in the form of a specification. This language would then be incorporated into the utility. The approach is to: (1) establish the requirements for the utility, such as the functions to be performed and degree of interaction with the user, and the form of output products; (2) develop the software architecture and flow chart for the functions

to be provided; (3) generate the source code including the incorporation of TSDL; (4) test and demonstrate the utility; (5) update the initial version based on selected user feedback; (6) distribute copies to users via the CCSDS Control Authorities; and (7) determine requirements for upgraded version (phase 2). The intent is to provide transportable software for the machines and systems most frequently used by scientific SFDU originators, and therefore initial development would be for IBM PC and VAX computers. It has been estimated that a software package to run on these two machines would satisfy over 90 percent of such users.

**W89-70448** **656-11-02**
Goddard Space Flight Center, Greenbelt, Md.
**STANDARDS FOR EARTH SCIENCE DATA**
D. M. Sawyer 301-286-2748

The objective is to provide practical mechanisms to facilitate the use of standards within NASA, and NASA related, data systems as called for in various reports from organizations such as ESADS, ADS, and the NRC Committee on NASA Information Systems. This work should lead to increased interoperability among the various data systems serving the space and earth science community. The approach is to provide a standards office at the National Space Science Data Center (NSSDC) that is capable of supporting a wide range of standards needed for the space and earth science community. This office is to be called the NASA Data Systems Standards Office (NDSSO), and its functions fall into three categories: standards education through standards information acquisition and dissemination; standards process mechanisms for the community to develop new recognized standards; and support offices for those standards needing additional support. This standards office will conduct its activities in a cooperative manner with the Consultative Committee for Space Data Systems (CCSDS). Other database will be available as a network service, and will be updated periodically. Policies and procedures for the validation of new standards will be defined. Support offices for the Standard Formatted Data Unit (SFDU) and the Common Data Format (CDF) will also be established. The SFDU support office will establish the NASA control authority and format registration service to serve a growing list of users, while the CDF support office will assist the many dozens of users who are acquiring and installing CDF software.

**W89-70449** **656-12-01**
Goddard Space Flight Center, Greenbelt, Md.
**FITS STANDARD SUPPORT OFFICE**
D. M. Sawyer 301-286-2748
(656-11-02)

The objective is to provide support in the use of the Flexible Image Transport System (FITS) format for data interchange among users and projects as called for in the ADS workshop reports. This includes a service organization that will assist users in using FITS, and that can validate FITS products to improve the degree of interoperability among systems exchanging FITS formatted data. It also includes using the experiences of the service organization as input to the evolution of the FITS standard, and coordinating with the Consultative Committee for Space Data Systems (CCSDS) Standard Formatted Data Unit (SFDU) effort to register FITS with a control authority. The approach taken is to use the services of the NASA Data Systems Standards Office (NDSSO) at NSSDC to assist a FITS expert in creating a single documented FITS specification, to disseminate this specification to requesters, and to coordinate with the SFDU effort in registering FITS with an SFDU Control Authority. Under the NDSSO, a FITS standard support office will be established to work with a FITS expert in the design and implementation of FITS validation software. This software will be used to validate and test FITS products produced by individuals and projects, and the experience gained will be folded back into the evolution of the standards through participation in the FITS Task Force.

**W89-70450** **656-13-40**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**NASA OCEAN DATA SYSTEM - TECHNOLOGY DEVELOPMENT**
J. Charles Klose 818-354-5036
(161-40-10; 656-50-05)

The objective of the NASA Ocean Data System (NODS) is to archive data sets from space-borne ocean viewing sensors, together with required supporting and metadata, and to distribute these data sets in convenient forms to the ocean research community. NODS will provide: a catalog of data sets relevant to ocean science; abstracts of documents relevant to catalogued and archived data sets; data at processing levels 0, 1, and 2 (swath-oriented), level 3 (gridded); browse files are small data subsets designed for quick, interactive browsing; the ability to select much of the NODS holdings by time, region, project, sensor, data level, and measurement type, as appropriate; the ability to display graphics or tabular data subsets at the user's terminal; the ability to transfer graphics or tabular data subsets to the user, either electronically to the user's computer or shipped as hardcopies, tapes or optical disks. Catalog, bibliography, data selection request, and browse file displays will all be available interactively. In the future it is expected that the functions described above, and others, will be performed in a distributed environment where specific data sets will be managed and distributed by the institutions which have a working knowledge of the data sets. In this context NODS will become a federation of cooperating open systems consisting of data centers connected via wide area networks such as the Space Physics Analysis Network (SPAN) or the NASA Science Network (NSN). An open system is a data system which interacts with other data systems using published protocols. A federation of such systems has no hierarchical structure, and no system wide control function. Rather, each participating system is a peer of the others, with respect to communications. Each NODS node specializes in particular data sets, and may support all or a subset of the NODS functions. Each node is independently managed and funded. The JPL node provides overall system engineering, development, and coordination. Newly created nodes will be offered JPL developed data set directory, catalog, and archive software, thus promoting cost efficiency and as much uniformity as possible within the network.

**W89-70451** **656-13-50**
Goddard Space Flight Center, Greenbelt, Md.
**PILOT LAND DATA SYSTEM**
Blanche Meeson 301-286-9282

The objective of this activity is to provide the land science community with a distributed data system to support their research. This data system, the Pilot Land Data System, will provide them with a means to determine what data is available and where it is located, help them to acquire that data, and finally, help them to access remote computer facilities where they might access the scientific data, process the data or display it. In FY89 we plan to pursue this objective by providing a land sciences directory and catalog to the available scientific data, and by providing access to the existing catalogs and archives of land science data. Moreover, we plan to begin implementation of a baseline land data system which has a high degree of portability and provides a basic level of functionality.

**W89-70452** **656-13-50**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**PILOT LAND DATA SYSTEMS**
E. D. Paylor 818-354-2867
(677-41-03; 656-13-40; 656-31-01)

The objective of the Pilot Land Data System (PLDS) project is to develop and implement a prototype state-of-the-art, data and information system to support research in the land related sciences that will lead to a permanent research tool. The capability is to be general, inter-center, and be based, to the extent possible, on existing technology. This particular task will: (1) develop and implement JPL's portion of PLDS; (2) continue PLDS system; and (3) specifically ensure that the PLDS is responsive to the needs of the scientists associated with the Land Processes Branch of NASA. PLDS is a multi-NASA center activity led by GSFC. JPL personnel will participate in the PLDS design and science teams. Liaison and coordination with other ongoing projects, such as Airborne Visible and Infrared Imaging Spectrometer (AVIRIS)/High Resolution Imaging Spectrometer (HIRIS) data processing, Synthetic Aperture Radar (SAR) data processing, hypercube, Earth Observing System (EOS) data and information system, and the other pilots will be maintained. The PLDS will be developed in a way which provides early capabilities to the Land Surface Climatology and Sedimentary Basins Projects, while providing generic capabilities and techniques having a broader use. Science requirements levied on the PLDS by these science projects are being used to functionally design the system in its initial phases. Major upgrades/modifications to the initial system will be based on requirements gathered from a broader scientific base, the Land Processes community of NASA. Each system component will be developed in parallel with the science projects, thus providing maximum utility of each component during the development/testing phase of the project. JPL participation in PLDS follows the PLDS work breakdown structure established by PLDS Project Management.

**W89-70453** **656-13-50**
Ames Research Center, Moffett Field, Calif.
**PILOT LAND DATA SYSTEM (PLDS)**
W. Likens 415-694-5596
(656-42-01)

The objective of the Pilot Land Data System (PLDS) is to explore issues in constructing a full-scale system for supporting all NASA land science data processing being carried out at NASA centers and associated universities. The approach is to link up existing computer facilities currently used in land science data processing. This work is managed by Goddard Space Flight Center. Ames Research Center (ARC) responsibilities are for establishment of a computer network, development of user documentation, and for appropriate system interface software and hardware. ARC is also responsible for development of the PLDS aircraft program data base node at ARC.

**W89-70454** **656-20-26**
Goddard Space Flight Center, Greenbelt, Md.
**MASSIVELY PARALLEL PROCESSOR SOFTWARE AND MAINTENANCE**
J. R. Fischer 301-286-3464

The objective of this RTOP is to enhance the Massively Parallel Processor (MPP) for the benefit of the NASA research community including the Headquarters approved members of the MPP Working Group. Since the beginning of FY86, the MPP Working Group, a pioneering team of computational scientists, has been provided the opportunity to implement and test their computational algorithms on the MPP. Their research endeavors span a very broad variety of applications. Based on their needs, the baseline MPP system software and the library of MPP applications subroutines will be further developed to improve system performance, robustness and ease of use. Also, the MPP User Support Office will distribute information to users and respond to their requests.

**W89-70455** **656-31-01**
Goddard Space Flight Center, Greenbelt, Md.
**COMPUTER NETWORKING**
Sol Broder 301-286-7088

The objectives of this RTOP are: (1) to plan and participate in the development of NASA Standard Initiator (NSI) and NSN project networks linking computers, workstations, peripherals and data sources inside GSFC and outside; (2) to provide ready access to the most appropriate computer tools for NASA-sponsored scientists inside and outside GSFC; (3) to provide leadership, expertise and assistance in developing workstations, interfaces, protocols and other aspects of modern computer networking to meet the needs of the present while investing constructively for the future and avoiding built-in obsolescence. This is a cooperative effort involving the computer users in the Code 600 laboratories, Code 500, other NASA Centers and outside scientists working on NASA projects. Computer networking development activities that are part of this RTOP include: expansion of the operational 10 Mbps GSFC local area network (LAN) to include more users over 500 user computers are already on-line; maintenance and upgrade of interfaces with the wide area networks (WANs) NSI (NSN and Space Plasma Analysis Network (SPAN)), NPSS, NSFnet, BITNET, and MILNET; specifications and installation of special project links; augmentation of the expert system based DFTNIC/NICOLAS to provide more comprehensive support to scientifically-oriented users of the networks; design, testbedding, and conversion to operation of new high speed LANs running at 100 Mbps and 1 Gbps.

**W89-70456** **656-31-03**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**INFORMATION SYSTEMS NEWSLETTER**
S. L. Dueck 818-354-5073

The objective of this RTOP is to inform the Space Science and Applications research and science community about Communications and Information Systems development and to promote coordination and collaboration between NASA offices and NASA centers by providing a forum for communication on a quarterly basis. The Communications and Information Systems Newsletter is produced quarterly and focuses on programs sponsored by the Communications and Information Systems Office in support of the Office of Space Science and Applications and includes articles of interest from other programs and agencies. Collaborative and coordinated Communications and Information Systems Office programs are encouraged by developing mechanisms and plans for coordination at specific Information Systems meetings (ESADS, EOS, PCDS, PLDS, PDS, NAIF, NODS, SAR, etc.) and at related workshops, conferences and meetings (NSN, PSCN, SAIS, Space Station, etc.). Technical and policy review are provided by JPL's Office of Space Science and Instrumentation and by NASA Headquarters.

**W89-70457** **656-31-05**
Goddard Space Flight Center, Greenbelt, Md.
**NASA CLIMATE DATA SYSTEM**
Mary G. Reph 301-286-5037

The NASA Climate Data System (NCDS) was first implemented in FY82 as the Pilot Climate Data Base Management System. In FY83, data manipulation utilities and graphics tools were added to the initial catalog, inventory, and data access capabilities and direct support for scientific researchers began. During FY84, this support was expanded to meet the needs of specific user groups within the Space and Earth Sciences Directorate (formerly the Applications Directorate) of Goddard Space Flight Center (GSFC). In FY85, this support was also provided for several researchers outside of GSFC, including university scientists. During FY86, a transition plan from the pilot system development phase to the operational research support phase was initiated in conjunction with the Earth Science and Applications Division. This transition continues while the NCDS expands its direct support of specific universities and specific science projects and its data holdings. During FY89, NCDS will test ideas for improving the system, while continuing support for specific science user groups (in particular, several universities, the International Satellite Cloud Climatology Project (ISCCP) and the First ISCCP Regional Experiment (FIRE)), sharing the operations and maintenance of the computer facility on which the NCDS resides, maintaining system software and databases, and supporting additional data sets. Included in these improvements are methods to better support increasing needs of the current users and an expanding user community, as well as to meet some of the requirements for supporting interdisciplinary earth science, such as is envisioned for the Earth Observing System (EOS) era.

**W89-70458** **656-42-01**
Goddard Space Flight Center, Greenbelt, Md.
**LAND ANALYSIS SOFTWARE**
Yun-Chi Lu 301-286-4093
(656-13-50)

The objective of this RTOP is to develop a portable, comprehensive, distributed image analysis system for use across microcomputer based workstations, minicomputers, and supercomputers to accommodate various levels of computational capabilities and port the Land Analysis System (LAS) to other overseas users. The approach will be to implement selected LAS functions on a supercomputer; improve the portability of LAS by removing VAX/VMS dependencies; use the Transportable Applications Executive (TAE) for a standard user-friendly interface to allow access to image processing environment by geographically and scientifically diverse users throughout the multi-disciplinary science community; create a software link between microcomputer workstations, minicomputers, and supercomputers; downsize LAS so that it may be implemented on a microcomputer; continue user support through the support office; and implement LAS on computers for U.N. users overseas. A new transportable distributed LAS image processing system, independent of machines and operating environments and including at least 150 image processing functions and an improved Catalog Manager, will be developed and released to COSMIC. It will be an expansion of the FY88 portable version but will include at least 80 more functions than the earlier one.

**W89-70459** **656-43-01**
Goddard Space Flight Center, Greenbelt, Md.
**GENERIC VISUALIZATION OF SCIENTIFIC DATA**
Lloyd A. Treinish 301-286-9884

This RTOP includes development of computer-based scientific data systems, particularly in computer graphics. Five basic thrusts emerge as being relevant to the ability of a researcher to understand and visualize the complex relationships inherent in any of the multi-dimensional space or earth science data sets that NASA develops with near-term applications, which are: (1) development of correlative visualization and analysis techniques for multiple parameter/dimensional data sets; (2) development of rendering algorithms; (3) establishment of a prototype, portable, operational environment for the visualization of scientific data; (4) distribution of data visualization tools to the scientific community; and (5) utilization of visualization tools on candidate science problems/data sets. In FY89, the strategy is to begin to expand the prototype of an operational, portable end-to-end system for non-programmers developed in FY88 to support correlative data visualization and analysis with limited capabilities using candidate data sets.

**W89-70460** **656-43-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**IMAGE ANIMATION LABORATORY**
K. J. Hussey 818-354-4016
(677-43-21)

This task will develop the visualization technology to allow integration of scientific data from several disciplines for the construction of multi-dimensional images and animations at the highest useful spatial resolution. The purpose of this is to assist scientists in their research. Earth scientists, planetologists and astrophysicists must think in several dimensions to solve many of their problems, yet most data are represented in two dimensions. Tools will be developed to properly combine and then visualize multidisciplinary data in several dimensions. This work will be done in close cooperation with scientists whose data is being visualized. The first product of this task will be a high-quality three-dimensional crustal-scale geologic block diagram using purely geophysical data. LANDSAT Thematic Mapper (TM), digital terrain elevation data (DTED) and seismic reflection profiles (SRPs) will be integrated and visualized. Attention will be given to the generalization of techniques so that similar three-dimensional models may be constructed from comparable data sets. A task team will be assembled consisting of the scientists whose data is to be visualized, a visualization specialist and an image processing/computer graphics programmer to formulate a visualization plan consistent with achievable technology and scientific validity/utility. A crustal-scale geologic block diagram visualization team has met and will proceed in the following manner. The various geophysical data sets will be coregistered by extending existing techniques and development of new ones. We have produced a preliminary product that demonstrates the feasibility of the objective, and many of the challenges to be encountered. The registration and display of the image and digital elevation data can be achieved by extension and refinement of techniques used in making L.A. and Miranda: The Movies. The incorporation of the seismic data is a particular technical challenge for several reasons, including conversion of the seismic waveforms into pixel format in a manner which does not distort the information content from real information. These problems are solvable. We are collaborating with geophysicists at USC to aid in work on the seismic data.

**W89-70461** **656-44-06**
Goddard Space Flight Center, Greenbelt, Md.
**SISC COMPUTER FACILITY SUPPORT**
G. N. Wolford 301-286-7093

The objective of this RTOP is to maintain the computer facility which is utilized by the staff of the SISC for information sciences and applications development sponsored by the Information Systems Office (Code EC). The approach will be fixed-level costs associated with hardware. Systems software maintenance will be obtained for the facility through a number and variety of service contracts, (operations costs will be recovered through a chargeback technique). A baseline effective and reliable SISC computer facility (CF) will be made available.

**W89-70462** **656-44-10**
Goddard Space Flight Center, Greenbelt, Md.
**TAE MAINTENANCE AND SUPPORT**
Martha R. Szczur 301-286-8609

Under this RTOP, enhancements to the Transportable Applications Executive (TAE) will be made to satisfy user requirements and to provide functions that will be needed to support advanced telescience for space station information processing systems. To maintain TAE's system integrity and the currently established high level of reliability, this RTOP will contribute to the TAE maintenance and configuration control, which will be done when necessary and/or routinely. We will continue close contact with the TAE user community and maintain a catalog of potential enhancements. Those features that are of high priority to the user community and fit within the TAE scope and philosophy will be developed for new releases of TAE. We will also continue contributing to user support through the TAE Support Office (TSO). The TSO has been a highly successful component of TAE development and acceptance. The staff of this office provide immediate response to questions and problems of TAE users and programmers within and outside of GSFC. They compile and edit a tri-annual newsletter, coordinate TAE user conferences and workshops, give TAE demonstrations and tutorials, consult on installation and usage of TAE, and develop utility programs to run under TAE. Users, from scientists to programmers, actively use and rely on the TSO services. Development and maintenance of TAE software to support common interface and procedures for use on diverse computing systems and to support advanced telescience applications for space station information processing systems will take place.

**W89-70463** **656-44-11**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**NAVIGATION ANCILLARY INFORMATION FACILITY**
C. H. Acton 818-354-3869
(656-80-01; 155-20-70)

This RTOP develops and tests prototype software technology which will be used to facilitate the preparation, archiving, distribution and user access to navigation and related geometric information required for full interpretation of the science data returned from instruments onboard planetary spacecraft. The work is in response to recommendations of the NAS CODMAC report, and is particularly relevant as instrument complexity, data volume and interest in correlative analyses grow. If FY89 Navigation Ancillary Information Facility (NAIF) will continue the development and testing, within the context of the Planetary Data System (PDS), of those functions which will provide scientists improved access to and informed use of the geometric and allied ancillary data needed for better understanding of science instrument datasets. Included will be delivery of planned NAIF portions of PDS Version 1.0 capabilities, focusing on providing access to restored Voyager Survey Probe Infrared Celestial Experiment (SPICE) kernels and allied toolkit software. NAIF will also continue development and testing of Image Navigation and C-Smithing technologies in support of PDS science and testbed nodes. Data from the Voyager Neptune encounter will be used in testbed experiments. NAIF will also pursue opportunities to promote common, easy access to fundamental geometry data and algorithms across a widening discipline community.

**W89-70464** **656-45-01**
Goddard Space Flight Center, Greenbelt, Md.
**COORDINATED DATA ANALYSIS WORKSHOP (CDAW) PROGRAM**
Robert E. McGuire 301-286-7794
(442-36-05)

As understanding in various areas of solar-terrestrial and earth science disciplines matures, the most significant questions that remain tend to be large or global scale. This RTOP will extend the development of organizational techniques and software tools to support the effective and efficient analysis of the data sets needed to address such global problems. The analysis of simultaneous data assembled from many instruments widely dispersed in space is essential to the successful resolution of these kinds of problems and anticipates requirements of significant new NASA programs such as the Earth Observing System (EOS) and International Solar Terrestrial Physics (ISTP). Key elements of the proposed Coordinated Data Analysis Workshop (CDAW) program include: (1) development of new and enhanced software tools to allow the more effective collection and collaborative analysis of data; and (2) organization of new workshops, with emphasis both on extending the range of scientific disciplines to which CDAWs have been applied and innovative techniques in organizing and assembling such workshops and databases. Specific activities under this RTOP include work to define new CDAWs in earth science, astrophysics and solar-terrestrial physics, and various technical initiatives to allow better user access to the accumulated databases.

**W89-70465** **656-45-04**
Goddard Space Flight Center, Greenbelt, Md.
**CENTER OF EXCELLENCE FOR SPACE DATA INFORMATION SCIENCES (CESDIS)**
Milton Halem 301-286-8835

The objectives of this RTOP are to establish and operate at GSFC a Center of Excellence for Space Data and Information Sciences (CESDIS) which will consist of a consortium of university, industry, and government scientists engaged in research addressing NASA's long-term Space and Earth Sciences data and computational problems. This RTOP will support a contract with the Universities Space Research Association (USRA) to administer, coordinate and manage the award of grants to participating universities, to negotiate appointments of industrial and government associates to CESDIS, to conduct periodic peer review of CESDIS by the USRA Council, and to act as the interface between NASA and CESDIS.

**W89-70466** **656-50-01**
Goddard Space Flight Center, Greenbelt, Md.
**NASA MASTER DIRECTORY**
James R. Thieman 301-286-9790
(656-80-03)

The objective of this RTOP is to continue the development and population of a Master Directory to NASA and other institution earth and space science data systems and data sets. Brief information on the potentially useful data systems and data sets will continue to be entered in the directory and more network links to the data systems or catalogs containing further information about the data will be established. The directory will be evaluated in actual usage by the science community and modifications to the directory hardware, software, procedures, information content, etc., will be made in accordance with the outcome of that evaluation. By the beginning of FY89, the currently operating Build 0 of the NASA Master Directory (MD) will be modified to yield a more fully functional Build 1 and the dataset population will be increased so that it is reasonably comprehensive in most disciplines. At that point the existence of the directory will be publicized for use by the general science community and a six-month actual usage evaluation period will begin. During the six months the data set population of the directory database will continue to be increased and additional network links to useful data systems will be established. Testing of modifications necessary to increase interoperability among data systems will also take place during the evaluation period. These include the changes needed to support automated ingest of directory-information via the Directory Interchange Format (DIF) and the automatic passing of a user's search interests to another data system as the user is connected to that system. Build 2 will be put in place by the end of FY89 and should include the modifications resulting from the interoperability testing as well as the changes required in response to the consensus of the evaluation. It is likely that adequate response to anticipated criticisms will require an upgrade in the hardware/software technology used in the Master Directory.

**W89-70467** **656-50-02**
Goddard Space Flight Center, Greenbelt, Md.
**ESADS LEXICON DEVELOPMENT**
Joseph H. King 301-286-7355

The objective is to develop a widely accepted lexicon of relatively high level terms to facilitate the development and utilization of data systems in a multidisciplinary environment. The basic approach is to develop a draft lexicon with the involvement of the Data Systems Lexicon Working Group, to distribute this draft widely through the communities of potential users, to finalize the lexicon, and to gain approval and use of the lexicon.

**W89-70468** **656-50-05**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**ESADS INTEROPERATIONS**
J. W. Brown 818-354-3614
(656-80-03)

The objective of the Earth Science and Application Division Systems (ESADS) Interoperations RTOP is to address some of the priority issues identified by the ESADS committee and the ESADS Program Plan. This is a continuation of a multi-year effort which is intended to facilitate the implementation of ESADS objectives within the existing data systems at JPL. Tasks under this RTOP are chosen to complement the existing work going on within the data systems, and to emphasize those areas which have been identified as ESADS priorities, but which may not otherwise have been included in the individual data systems' plans. Special attention is given to those areas which involve coordination among the data systems. This RTOP addresses several items identified as priorities for FY89 in the ESADS Program Plan: (1) catalog interoperability requirements and standards; (2) data system modifications for catalog interoperability; (3) data system architecture and modeling; (4) ESADS implementation coordination; (5) accounting requirements; and (6) guidelines for Project Data Management Plans and guidelines for data submission.

**W89-70469** **656-55-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**EOS ADVANCED DATA SYSTEMS DEVELOPMENTS (IDACS)**
Wallace Tai 818-354-7561

The overall objective of this RTOP is to conduct system design of a Data Access and Distribution System (DADS) for JPL high-rate instruments and other facility and PI instruments and to support detailed requirements analysis for the Earth Observing System (EOS) Information Management Center (IMC). An integrated, multi-instrument approach to defining the system architecture of the DADS will be taken in the context of JPL's multi-instrument data and control system, i.e., IDACS. The requirement definition of the IMC will be conducted in a team fashion, by working with GSFC EOS DIS personnel and phase B study contractors, based on the operation scenarios defined in the IDACS System Operation Concept Document and IDACS Functional Requirements Document completed in FY88.

**W89-70470** **656-62-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**SYNTHETIC APERTURE RADAR DATA SYSTEMS**
J. C. Curlander 818-354-8262

Microwave remote sensing of earth and planetary surfaces using synthetic aperture radar (SAR) is undergoing a substantial amount of development in both the U.S. and abroad. NASA SAR systems in various stages of development include: Airborne DC-8 SAR, the Shuttle Imaging Radar (SIR-C), the Magellan Radar Mapper and the Earth Observing System (EOS) SAR planned for the mid-1990's. Currently, the existing digital SAR data handling facilities cannot adequately meet anticipated needs to produce high quality products in a timely fashion. The need for development of high speed autonomous systems is driven not only by the science community but the expected cost of hands-on data processing operations. Besides the SAR image formation processing system, a number of issues in the end-to-end data system need to be investigated to facilitate future mission design and implementation data throughput while maintaining product quality. Primary issues are: (1) data management from level 0 through the catalog/archive; (2) formulation and implementation of multi-mission standards (i.e., data formatting, interfacing and distribution); and (3) data quality assessment. An optimal resolution of these issues will greatly enhance the cost effectiveness of the overall SAR system for science applications and provide a sound basis for development of a true multi-mission data network. The overall objective of this RTOP is to develop, evaluate, and demonstrate end-to-end data system concepts and data processing techniques to facilitate and automate transmission, processing and analysis of data gathered by future spaceborne and airborne SAR sensors. The primary emphasis is data system development for OSSA SAR missions with consideration of other U.S. and international remote sensors currently in development or planning stages. The general approach to the development of data system elements for SAR missions is phased as follows: (1) conduct end-to-end data system development planning; (2) identify needed subsystem elements that require new research and development; (3) integrate subsystems and conduct system operations experiments; and (4) upgrade existing systems to meet new requirements.

**W89-70471** **656-62-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**CONCURRENT PROCESSING TESTBED - SCIENCE ANALYSIS**
J. E. Solomon 818-354-2722

The objective of this task is the design and implementation of high-performance concurrent processing environments for science analysis of Earth Observing System (EOS) era remote sensing image data. A major element of this objective is the implementation of a concurrent image processing testbed which utilizes both Multiple Instruction Multiple Data (MIMD) and Single Instruction Multiple Data (SIMD) concurrent architectures, together with the implementation of a concurrent image processing executive software system. A second major element is the development of science analysis tools, for both computation and visualization, which can be used to provide an efficient scientific computing environment for the end-user. The final major element of this objective is the implementation of a prototype high-performance science analysis workstation which incorporates advanced concurrent computing technology and provides an environment which allows the science user to access, merge, analyze, and display EOS-era data sets such as those produced by the High Resolution Imaging Spectrometer (HIRIS), Moderate Resolution Imaging Spectrometer (MODIS), Synthetic Aperture Radar (SAR), etc. The approach to be taken in this work consists of the following elements: (1) implementation of concurrent testbed with hypercube (MIMD) and systolic array (SIMD) technology coupled with high-performance workstation host; (2) concurrent image processing executive (CIPE) implemented with system layer, applications layer, and user interface layer; (3) development of application-specific concurrent algorithms and software for large-scale multi-sensor, multispectral image analysis and interpretation; (4) development of data and analysis visualization tools; (5) hardware/software integration into a demonstration prototype science analysis system.

**W89-70472** **656-80-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**PLANETARY DATA SYSTEM**
J. T. Renfrow 818-354-6347
(656-11-01; 656-13-40; 656-13-50; 656-44-11; 155-20-70)

The overall objective of this RTOP is to conduct evaluations of methodologies, standards, and technologies which can be used in solving the data problem of the planetary science community and to do these evaluations within science testbeds which are run by working planetary scientists. The detailed objectives of this RTOP are to: (1) develop and evaluate system concepts and also appropriate technologies to support the archiving and accessing of planetary science data by the planetary science community; and (2) develop and demonstrate the efficacy of data administration, data format, and data nomenclature standards for use across the full spectrum of future planetary missions and data restoration activities. To meet these objectives a three fold approach will be used to: (1) develop system components and applicable technologies to test and validate functional and performance requirements and serve as testbeds for technology. These system and technological components will be developed in such a way that the ability to incorporate these components into the operational Planetary Data System (PDS) is maximized; (2) have the scientists involved in the project actually use the testbeds to perform science functions; and (3) develop, validate, and demonstrate data standards in the development of optical disks and planetary science data catalogs and data bases.

**W89-70473** **656-80-03**
Goddard Space Flight Center, Greenbelt, Md.
**CATALOG INTEROPERABILITY**
James R. Thieman 301-286-9790
(656-50-01)

The objective of this RTOP is to investigate, define, and implement a unified approach to developing and interconnecting data systems so that users may rapidly obtain information about data of interest, and to enable efficient distribution of up-to-date information about data throughout the systems. In an effort coordinated by the NSSDC, representatives from participating data systems work together to complete several steps to: (1) determine, together with scientists/users, requirements for interoperability; (2) develop and implement interconnections so that a user may search, starting with a directory, for data sets or data systems of interest and choose to be transferred through computer networks to the places where further information is available; (3) develop a common directory interchange format for passing information among the data systems for input and update of directory level information; (4) assist a user in searches among the data systems by automated transfer of information describing the user's requests; and (5) to determine, document, and implement, as fully as possible, a set of guidelines or recommendations on the concepts and capabilities of an interoperable data system.

**W89-70474** **656-85-03**
Ames Research Center, Moffett Field, Calif.
**NASA SCIENCE INTERNET (NSI)**
W. P. Jones 415-694-6482
(656-31-01; 656-85-03)

The principal objective of the NASA Science Internet (NSI) program is to consolidate and integrate communications requirements among Office of Space Science and Applications (OSSA) projects. Cost effective intercomputer networking will be developed between sites and will utilize new technology and communications resources for which OSSA is the sponsoring office. The development of the Pilot Land Data Systems will be continued. Two networks will be used to support OSSA science disciplines and flight projects: the NASA Science Network (NSN) which uses TCP/IP protocols and the Space Physics Analysis Network (SPAN) which uses DECnet protocols. The centralized coordination of these existing operational networks is to be accomplished at Ames Research Center, Moffett Field. In addition, Ames will manage the interfacing of these networks with other agency communications systems and oversee the establishment of R and D network operations. NSI Site Managers and Technical Liaisons will be identified at each science site that is connected to the operational networks for the purpose of supporting the network configuration management, computer security, operations, utilization monitoring, and network user services.

**W89-70475** **656-85-03**
Goddard Space Flight Center, Greenbelt, Md.
**SPACE PHYSICS ANALYSIS NETWORK (SPAN)**
Valerie L. Thomas 301-286-4740

This RTOP provides for Space Physics Analysis Network (SPAN) growth, reliable network performance monitoring, DSUWG support, data analysis coordination, network management, user support, security support, internetworking, protocol migration and network programming support. The number of nodes accessible by SPAN has increased from about 150 to about 1,400 registered nodes and a DECnet internet of 6,000. The SPAN Network Information Center (SPAN-NIC), which provides on-line information and help and has staff to answer questions via phone or in person, was established to support this wide area network. SPAN has been a valuable quick reaction capability resource for cometary encounters, Coordinated Data Analysis Workshops (CDAWs), orbital debris studies, supernova research and the ozone hole investigations.

## Climate Research

**W89-70476** **672-00-00**
Langley Research Center, Hampton, Va.
**CLIMATE RESEARCH**
John T. Suttles 804-865-2977

Objectives are to conduct studies of aerosol and cloud processes and to develop improved satellite-based observations of the earth's radiation budget. The following approach will be used to: (1) continue 48-inch ground-based and airborne Lidar measurements to extend the climatology of aerosol distributions and conduct cirrus and stratospheric polar cloud experiments; (2) conduct analysis of satellite data (GOES, LANDSAT and AVHRR) and surface observations to define spatial, seasonal, and diurnal variation of cloud radiative properties as part of International Satellite Cloud Climatology Project (ISCCP) and First ISCCP Regional Experiment (FIRE) investigations; (3) combine satellite, surface, and airborne measurements with theoretical studies to investigate cirrus and marine stratocumulus cloud systems for Project FIRE; (4) study characteristics of cirrus clouds using Lidar, radiometric, and laboratory measurement techniques and integrate results with satellite observations as part of FIRE cirrus field experiments; (5) implement a coordinated program of satellite algorithm intercomparisons and validation studies for surface radiation budget components; (6) develop and validate techniques for deriving global surface radiation parameters from satellite data and models; (7) investigate statistical relationships between radiation and meteorological quantities such as water vapor and clouds; and (8) develop, evaluate, and apply techniques for retrieval of radiation flux divergence within the atmosphere and use with surface flux data to study climate processes.

**W89-70477** **672-10-00**
Goddard Space Flight Center, Greenbelt, Md.
**CLIMATE DATA BASE DEVELOPMENT**
Otto W. Thiele 301-286-9006
(672-20-00; 672-30-00; 672-40-00; 672-50-00)

The objectives are to develop, demonstrate and make available for use space acquired global data sets for climate research applications. Approaches are to: (1) develop climate related data sets from NASA research satellites and from operational satellites where such data are needed by NASA and NASA supported climate researchers; and (2) incorporate such data into a climate data cataloging and data base management system (e.g., the NASA Climate Data System) to insure maximum access to NASA satellite climate data by users. The expected results are to: continue adding Nimbus-7 data products and the International Cloud Climatology Project (ISCCP) data sets to the climate data system; incorporate the solar data base into the climate data system; continue providing user access to climate data sets; and maintain communication links to participating universities.

**W89-70478** **672-10-02**
Goddard Inst. for Space Studies, New York, N.Y.
**GLOBAL CLOUD CLIMATOLOGY (ISCCP OPERATIONS)**
William B. Rossow 212-678-5567

The objectives of this RTOP are to develop and apply techniques of extraction of cloud optical properties to satellite observations to produce cloud climatology data sets. The approach is to participate in the International Satellite Cloud Climatology Project (ISCCP) as the Global Processing Center to produce a seven year global cloud climatology. The original project data collection period has been extended to seven years. We will participate in data and analysis comparisons to validate the global climatology. The expected results will be complete processing of first five and one half years of radiance data and document quality; complete processing of the first six years of correlative data and document quality; complete processing of first three years of cloud data; and document analysis procedures. We will continue comparisons to pilot study and field experiment data to validate results and complete first intercomparison between ISCCP and ground-based cloud climatology.

**W89-70479** **672-20-00**
Goddard Space Flight Center, Greenbelt, Md.
**CLIMATE PROCESSES**
Otto W. Thiele 301-286-9006
(672-10-00; 672-30-00; 672-40-00; 672-50-00)

The objectives of this RTOP are to extract information on climate and climate related parameters from satellite data, and develop techniques for remote sensing of climate parameters, including the development of methods for extracting cloud cover and radiation parameters from existing satellite images in support of the International Satellite Cloud Climatology Project (ISCCP) and the First ISCCP Regional Experiment (FIRE). Approaches are: (1) participate in field experiments such as FIRE and conduct theoretical studies to develop methods for remote sensing of cloud parameters; collect aircraft remote sensing data on a variety of cloud types to achieve a better understanding of the radiative properties of clouds; (2) develop algorithms for determining cloud cover amount, cloud height, cloud absorption within clouds, and cloud type from multichannel satellite images; and (3) utilize microwave data from Nimbus-7 Scanning Multichannel Microwave Radiometer (SMMR) to produce maps of sea surface temperature, atmospheric water vapor, atmospheric liquid water, and surface winds; conduct analyses of the data to determine their validity; explore potential use of the data to estimate energy and moisture exchange between the oceans and the atmosphere.

**W89-70480** **672-22-06**
Goddard Inst. for Space Studies, New York, N.Y.
**EXPERIMENTAL CLOUD ANALYSIS TECHNIQUES**
William B. Rossow 212-678-5567

The objectives of this RTOP are to: (1) test cloud analysis algorithms, particularly that used by the International Satellite Cloud Climatology Project (ISCCP) as its operational algorithm, for cases which present difficult problems such as the polar regions, and develop new cloud algorithms; and (2) develop analysis methods to infer cloud-radiative feedbacks from the ISCCP data. The approach is to: (1) test ISCCP results in polar regions against other satellite cloud algorithms and multi-spectral radiative analysis of Advanced Very High Resolution Radiometer (AVHRR) data; (2) test ISCCP results by radiative model comparison to First ISCCP Regional Experiment (FIRE) observations of cirrus and marine stratus clouds; and (3) develop methodologies to infer cloud-radiative feedbacks from ISCCP data by comparison to climate model simulations and radiative model development. The expected results are: (1) completion of first comparison of several cloud algorithms in the polar regions; (2) completion of comparisons of radiative analyses of cirrus and marine stratus clouds covering a wide range of spatial resolutions, viewing geometries, and portions of the spectrum; and (3) completion of first comparison of ISCCP-derived, Earth Radiation Budget Experiment (ERBE) and climate model radiation budgets.

**W89-70481** **672-22-99**
Ames Research Center, Moffett Field, Calif.
**RADIATIVE EFFECTS IN CLOUDS FIRST INTERNATIONAL SATELLITE CLOUD CLIMATOLOGY REGIONAL EXPERIMENT**
F. P. J. Valero 415-694-5510

The interaction of radiation with clouds plays a fundamental role in the earth's energy budget. The objective of this work is to study the measurement and modeling of the interaction of radiation and clouds, including radiative flux divergence profiles, optical depths, total/diffuse radiation field and particle size distributions in stratus and cirrus clouds. It is a fundamental objective of this work to validate satellite-acquired radiative data. Measurement will be made using aircraft as instrument platforms during the First International Satellite Cloud Climatology Regional Experiment (FIRE) deployments. From the above measurements, the significant radiative energy parameters are determined and used in radiative transfer modeling to validate model prediction.

**W89-70482** **672-30-00**
Goddard Space Flight Center, Greenbelt, Md.
**CLIMATE MODELING AND ANALYSIS**
Otto W. Thiele 301-286-9006
(672-10-00; 672-20-00; 672-40-00; 672-50-00)

The objectives of this RTOP are to develop climate modeling capabilities, to guide the design of the observing system, to optimize analysis techniques for the utilization of space-acquired data, to carry out studies of physical processes important to climate, and to assess climate predictability. The approach will be to: develop semi-empirical methods for understanding, detecting, and predicting climate change; improve the GLA General Circulation Model (GCM) for use in seasonal cycle predictability studies; develop efficient radiative transfer routines for use in climate models; conduct studies of the sensitivity of climate to radiative forcing using the seasonal version of the GLA multi-layer energy balance model (MLEBM); develop planetary boundary layer (PBL) parameterization methods for global models; study blocking events to identify dynamical predictors; and conduct extended range climate forecast and predictability experiments.

**W89-70483** **672-31-03**
Goddard Inst. for Space Studies, New York, N.Y.
**GLOBAL CLIMATE MODELING**
James Hansen 212-678-5619

The objectives of this RTOP are to develop and apply climate models to support NASA's Climate Program, particularly carrying out basic research which helps define observing systems requirements for monitoring, analysis and prediction of long-range climate change. We will develop climate modeling capability appropriate for analysis of long-range climate. Principal areas of model development are in the areas of moist convection and clouds, ground hydrology and numerical methods. The approach involves testing more realistic or accurate representations of these physical processes or numerical schemes, using the previously developed Model 2 as a control for these experiments. We will use the current Model 2 for climate studies aimed at obtaining a better understanding of global climate sensitivity and projections of transient climate change during the next 10 to 50 years. This includes experiments in which the global greenhouse is forcing changes at a realistic rate on decadal time scales.

**W89-70484** **672-31-99**
Ames Research Center, Moffett Field, Calif.
**AEROSOL FORMATION MODELS**
O. B. Toon 415-694-5971
(672-32-99)

The objective of the work is to play a role in NASA studies of water clouds and their effects on the radiation balance. A three-dimensional tracer transport model has been developed. A radiation code suitable for use in multi-dimensional models has been developed. A model of cirrus cloud microphysics has been developed. Also a model of tropospheric cloud condensation nuclei physics and chemistry has been developed for use in exploring cloud formation processes and their impact on cloud radiative properties.

**W89-70485** **672-32-01**
Goddard Space Flight Center, Greenbelt, Md.
**NEAR IR LARGE APERTURE INTEGRATING SOURCES STUDIES**
Bruce W. Guenther 301-286-5205

The objectives of this RTOP are: (1) to provide laboratory calibration capability for atmospheric and aerosol studies by remote sensing investigations in the near infrared portion of the reflected solar spectrum, improve absolute accuracy of these calibrations, track calibration accuracy and precision of ground calibrations; (2) provide calibrations in near IR accurate to 10 to 15 percent, devised plan for improved calibrations throughout the range 400 to 2500 rm with special emphasis on the near IR; (3) implement and document improved ground calibrations of large aperture integrating sources, design, fabricate and test Lens-less Absolute Spectrometer capable of calibration characterizations which represent improvements of a factor of five to ten; and (4) comparison of CNES Spherical and NASA Hemispherical Large Aperture Integrating Sources, 1, as Determined with a Laboratory Spectroradiometer, B. Guenther, M. Leroy and J. Henry and Comparison of CNES Spherical and NASA Hemispherical Large Aperture Integrating Source, 2, As Determined with the SPOT-2 Satellite Instruments, submitted for publication to the Remote Sensing of Environment.

**W89-70486** **672-32-99**
Ames Research Center, Moffett Field, Calif.
**CLIMATE MODELING WITH EMPHASIS ON AEROSOLS AND CLOUDS**
J. B. Pollack 415-694-5530
(672-31-99; 672-22-99)

A coordinated set of theoretical, laboratory, and field investigations of the chemical and radiative properties of clouds and natural (e.g., volcanic) and man-made atmospheric aerosol particles is conducted in order to assess their impact on regional and global climate. The field investigations are intended to provide complementary information on clouds and aerosols to that being obtained from spacecraft platforms (e.g., SAM, SAGE 2 and SME) so as to insure that a comprehensive set of properties is gathered for climatic analyses. The theoretical and laboratory tasks are directed at interpreting and utilizing the data sets to perform the desired climatic assessments. The centerpiece of the field investigations is a set of coordinated experiments which are flown together on appropriate aircraft platforms. Both theoretical modeling and laboratory studies are used to define the mechanisms of aerosol and cloud formation to provide hypotheses that can be tested by the field investigations and to ultimately provide predictive tools. Theoretical investigations involving radiative transfer, dynamics, and formation are utilized for making the climate assessments, including simulations with a three-dimensional climate model.

**W89-70487** **672-40-00**
Goddard Space Flight Center, Greenbelt, Md.
**CLIMATE OBSERVATIONS**
Otto W. Thiele 301-286-9006
(672-10-00; 672-20-00; 672-30-00; 672-50-00)
The objectives of this RTOP are to: (1) study ways of using available satellite data to measure or infer climate parameters (e.g., ocean/air heat flux, sea surface temperature, soil moisture, etc.); (2) evaluate spaceborne techniques for precipitation measurements; and (3) determine changes in solar size and relate to changes in solar luminosity which in turn relates to the total energy available to the earth/atmosphere system. Approaches are to: (1) investigate instrumentation and sampling options for important climate parameters such as global precipitation, radiation and ocean characteristics; (2) analyze solar eclipse data and model relationship between radius and luminosity changes; and (3) make direct solar diameter measurements and model changes in size, shape and surface temperature to changes in total solar flux.

**W89-70488** **672-50-00**
Goddard Space Flight Center, Greenbelt, Md.
**CLIMATE PROGRAM SUPPORT**
Otto W. Thiele 301-286-7208
(672-10-00; 672-20-00; 672-30-00; 672-40-00)
The objective of this RTOP is to provide program support to NASA Headquarters and Goddard for a broad based NASA climate program which in turn involves a substantial contribution to the National Climate Program. Approaches are to: (1) develop recommendations for climate program initiatives in connection with NASA, GSFC climate research; (2) provide planning support for global satellite climate data base development, especially a global cloud climatology under the International Satellite Cloud Climatology Project (ISCCP) and the First ISCCP Regional Experiment (FIRE); (3) provide representation to the National Climate Program Office as required in connection with NASA's role as lead Agency for solar and earth radiation monitoring and research; (4) develop planning strategies for physical processes studies with particular emphasis on cloud and earth/atmosphere radiation processes; (5) provide support for annual National Climate reports to Congress, annual science review, etc.; and (6) arrange for ad hoc science working groups, advisor panels, etc.

## Stratospheric Air Quality

**W89-70489** **673-00-00**
Langley Research Center, Hampton, Va.
**STRATOSPHERIC AIR QUALITY**
William L. Grose 804-865-4789
The objective of this RTOP is the application of remote sensing technology and measurements for environmental monitoring of the stratosphere. Data analysis techniques and theoretical model studies will be used to improve the understanding of the stratosphere and potential changes to its composition and structure. Specific tasks include: (1) analysis of global satellite data sets to detect natural and/or anthropogenically induced trends of temperature and constituents; (2) interpretation of transport processes in the stratosphere using constituent and temperature data from satellite based experiments; (3) development and evaluation of orbital analyses, instrument modeling, and sampling simulations to define mission concepts for advanced satellite experiments; (4) maintain a pilot electronic data base consisting of stratospheric trace gas data from both measurements and models to facilitate rapid dissemination of data to the scientific community and support data and model intercomparison activities; (5) study the distribution and variation of odd nitrogen in the stratosphere using satellite data sets in conjunction with radiative and photochemical models; and (6) investigate stratospheric dynamics and transport processes using a 3-D circulation/transport model and global sets of satellite data.

**W89-70490** **673-41-12**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**STRATOSPHERIC CIRCULATION FROM REMOTELY SENSED TEMPERATURES**
L. S. Elson 818-354-4223
The objective of the research is to develop an improved quantitative understanding of the large scale circulation of the lower stratosphere in the 15 to 30 km region. Included in the topics addressed are both free and forced waves along with the zonally-averaged component of the circulation. A major theme of the investigation is to examine traditional scaling approximations which have been applied to the stratosphere. Such approximations have been based mainly on tropospheric applications and are not always appropriate for stratospheric problems. When an approximation is found to be inappropriate, an alternative approach is developed. The technique employed maximizes the use of high quality satellite data which provides both global coverage and good vertical resolution. For these applications, limb observations (Nimbus-7 Limb Infrared Monitor of the Stratosphere--LIMS) have been found to be superior to other data sets. By inferring the circulation from the observations, the results are less dependent on modeling assumptions. The use of data also allows the selection of dominant processes from among competing theoretical models.

**W89-70491** **673-41-44**
Goddard Space Flight Center, Greenbelt, Md.
**ANALYSIS OF UPPER ATMOSPHERIC MEASUREMENTS, THE TEMPORAL BEHAVIOR OF STRATOSPHERIC OZONE, AND THE ULTRAVIOLET SOLAR IRRADIANCE**
R. D. Hudson 301-286-5485
The objectives of this RTOP are: (1) to enhance the understanding of the behavior of stratospheric composition over time scales of the 27-day solar rotation period, the annual cycle, and the 11-year solar cycle and to delineate the driving mechanisms of these variations; (2) to develop models of the variability in the ultraviolet solar irradiance which can be used to predict atmospheric responses for comparison with measurements; and (3) to analyze aspects of radiation transfer related to the penetration of biologically relevant solar wavelengths to the earth's surface. The approaches are to conduct analyses of data obtained by satellite-based remote sensors using models of latitudinal, zonal, and temporal variability and theoretical models of radiation transfer and photochemical production, loss and transport; assemble long term climatological data sets for the study of annual and interannual variations and their driving mechanisms, plus responses to solar activity; and collect and analyze a long term ultraviolet solar irradiance data base to better define possible mechanisms of solar variability.

**W89-70492** **673-41-51**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**SME OZONE AND MST RADAR**
M. A. Allen 818-354-3665
Vertical ozone profiles for various local times during a 24-hour diurnal cycle retrieved from radio emission data will be compared with the results of an updated photochemical model to test the adequacy of current model descriptions of upper atmosphere chemistry. The 1-D photochemical model will be used to develop parameterizations of HOx mesosphere chemistry for inclusion in a 2-D model.

**W89-70493** **673-42-99**
Ames Research Center, Moffett Field, Calif.
**ANALYSIS OF TROPOSPHERE-STRATOSPHERE EXCHANGE**
L. Pfister 415-694-5491

The overall goal of this work is to improve our understanding of the role of small scale motions in stratosphere-troposphere exchange in the tropics. Specifically, analysis will be made of aircraft, radiosonde, and satellite data from the 1980 NASA field experiment in Panama and the 1987 NASA field experiment in Australia to: (1) examine the structure of ozone, temperature, and water vapor within, around, and above cumulus anvils; (2) establish the presence, during the experimental period, of various potential mechanisms of exchange, such as direct injection by cumulus, gravity wave fluxes, and turbulent fluxes; and (3) evaluate quantitatively, if possible, the mass of air transferred by these mechanisms during specific transport events.

**W89-70494** **673-61-00**
Marshall Space Flight Center, Huntsville, Ala.
**UPPER ATMOSPHERIC THEORY AND DATA ANALYSIS**
G. S. Wilson 205-544-1628

The objectives of this RTOP are to perform fundamental studies aimed at improving our understanding of the dynamics of earth's upper atmosphere. The approach is to combine analytical and numerical models of atmospheric dynamical flow with trace gas measurements made from space to understand the structure and evolution of the upper atmosphere.

**W89-70495** **673-61-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**MESOSPHERIC THEORY**
R. W. Zurek 818-354-3725

The goal of this task is to better understand the interaction of photochemistry and mass transport in the terrestrial upper atmosphere. The approach is to develop in collaboration with Y. Yung (Caltech), M. Allen (JPL/CIT) and D. Crisp (JPL/CIT) a 2-D interactive model containing coupled chemistry and transport relevant to the stratosphere and mesosphere. This model will be used to simulate and interpret the observed distributions of photochemically important atmospheric trace constituents observed from airborne and spaceborne platforms.

**W89-70496** **673-61-07**
Goddard Inst. for Space Studies, New York, N.Y.
**CLIMATOLOGICAL STRATOSPHERIC MODELING**
David Rind 212-678-5593

The objectives of this RTOP are: (1) contributions toward understanding the impact of potential climate perturbations on the stratosphere; (2) assessment of the effect of any alterations in stratospheric dynamics on the impact of anthropogenic releases on stratospheric ozone; and (3) better understanding of the expected changes to be observed in the next several decades. The approach is 3-D modeling of the troposphere/stratosphere/mesosphere system to delineate climate change influence on the stratosphere. Results will be saved for use with photochemical models. The expected results are an estimate of the effects of climate perturbations for the next several decades as well as further into the future on ozone sensitivity to anthropogenic perturbations.

**W89-70497** **673-61-99**
Ames Research Center, Moffett Field, Calif.
**STRATOSPHERIC DYNAMICS AND PARTICULATES**
R. E. Young 415-694-5521
(672-31-99)

The objectives of this research are to increase our understanding of the dynamics, thermodynamics, and composition of the earth's stratosphere, and to investigate the mechanisms by which trace species are exchanged between troposphere and stratosphere. The research will involve a combination of theoretical and observational studies. Global and mesoscale circulation models will be used to investigate transport and exchange processes. Satellite data analysis will be used to characterize wave and transport phenomena in the stratosphere. Meteorological and diagnostic analysis will be conducted in support of aircraft measurement programs, such as the Troposphere-Stratosphere Exchange experiment. The studies in particulates are: (1) to construct numerical models of stratospheric aerosols and to compare simulation with observations in order to learn more about stratospheric dynamics and chemistry; and (2) to construct numerical models of polar stratospheric clouds and compare simulations with observations in order to learn more about processes occurring in the Antarctic ozone hole.

**W89-70498** **673-62-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**PHOTOCHEMICAL MODELING**
D. Crisp 818-354-7971

Radiative heating rates provide a direct coupling between the radiance field, and the stratospheric thermal structure, composition, and dynamical state. Because of this, net radiative heating rates obtained from a radiative transfer model can be used to determine the advective component of the 2-D transport circulation at these levels of the atmosphere. A description of this circulation is essential in state-of-the-art 2-D chemical tracer transport models. We have developed an efficient, accurate atmospheric radiative transfer model to compute solar, thermal, and net radiative heating rates for the terrestrial stratosphere. This model accommodates all known sources of extinction at levels below 65 km including absorption, emission, and multiple scattering by gases, aerosols, and clouds. We will couple this model with the Caltech 1-D Chemical Model and the Caltech/JPL 2-D Chemical Tracer Transport Model to conduct a series of numerical experiments to study the ozone budget, and to diagnose the seasonally varying distribution of other important trace gases in the stratosphere.

**W89-70499** **673-62-02**
Goddard Space Flight Center, Greenbelt, Md.
**UPPER ATMOSPHERE RESEARCH - THEORETICAL STUDIES**
P. D. Guthrie 301-286-5830

The objectives of this RTOP are to: (1) provide the framework for developing and understanding an organized, solid body of knowledge of the physics, chemistry, and dynamics of the earth's upper atmosphere; (2) analyze data from upper atmospheric flight programs; and (3) predict and assess the effects of natural and man-related perturbations on the atmosphere. The approaches are to: continue to develop and utilize a hierarchy of models of upper atmospheric photochemistry and radiation ranging from simplified models to the incorporation of chemistry into a global general circulation model; and utilize field measurement data to elucidate the controlling mechanisms for atmospheric composition and variations. Expected results are: improved photochemical models; and the improved understanding of the coupling between chemistry and transport.

**W89-70500** **673-62-99**
Ames Research Center, Moffett Field, Calif.
**THEORETICAL INVESTIGATION OF STRATOSPHERIC PARTICULATES**
O. B. Toon 415-694-5971

The objective of the work is to contribute to NASA's Upper Atmosphere Theory Program in the area of quantifying the importance of heterogenous chemistry. A sophisticated model of polar stratospheric clouds has been developed and used to study the properties of ice clouds. The model is being extended to investigate nitric acid clouds and ice clouds as well as their interactions.

**W89-70501** **673-63-00**
Goddard Space Flight Center, Greenbelt, Md.
**APPLICATION OF STRATOSPHERIC MODELLING TO DATA INTERPRETATION**
J. R. Herman 301-286-7821

The 1-D photochemical model is to be used to interpret composition data (NO2, N2O5, HNO3, O3, ClONO2) obtained during the midnight to sunrise time period from the Fourier

Transform Spectrometer flown on September 15 to 16, 1986 at Palestine, Texas. The use of the time dependent 1-D model with complete photochemistry is essential for the interpretation of the measured time dependent composition especially near sunrise. The mode is to be upgraded in its treatment of the Schumann-Runge band absorption and photolysis rates in accordance with M. Nicolet's latest results. This will make necessary a change in the radiative transfer treatment currently employed in the model. The results should be an improved odd oxygen production rate, and a more accurate assessment of the interaction of net ozone production rates balanced against chlorine destruction. The model is also to be used in support of the next flight of the spectrometer emphasizing time dependence through sunrise and sunset with increased accuracy. Time dependent composition changes of several strongly coupled species are necessary to verify chemistry assumptions concerning the nitrogen oxide storage molecules (e.g., N2O5, ClONO2).

**W89-70502** **673-64-04**
Goddard Inst. for Space Studies, New York, N.Y.
**STRATOSPHERIC CHEMISTRY IN A GCM**
Michael Prather 212-678-5625

The proposed research emphasizes the 3-D transport of chemically active species in the stratosphere. Work will center on the development of the 21-layer chemical transport model for the stratosphere. The tasks are: (1) 21-layer tracer model: development and validation of stratospheric chemical tracer model based on experience with similar tropospheric models. The chemical model will be limited to photolytic destruction of species such as chlorofluorocarbons (CFCs) and N2O completed. Comparison will be made with observations (in preparation); (2) stratospheric chemistry: parameterization of a complete ozone chemistry for use in the stratospheric tracer model, applying limited, linearized ozone chemistry to study the Antarctic ozone hole; and (3) perturbed atmospheres: relying on the 21-layer GCM simulation of CO2 and O3 perturbations to the stratospheric circulation, using chemicals to assess the impact on lifetimes of long-lived tracers and on ozone.

**W89-70503** **673-64-05**
Goddard Space Flight Center, Greenbelt, Md.
**STRATOSPHERIC CIRCULATION MODELING WITH CHEMISTRY**
Marvin A. Geller 301-286-5002
(673-41-00)

The objectives of this RTOP are to: (1) provide a framework to understand the natural stratosphere and its response to external perturbations; and (2) enhance the understanding of the two-way interactions between troposphere and stratosphere. The approach will be to develop computer models of the troposphere-stratosphere system and compare results to observations. Expected results are improved understanding of the stratospheric radiative-chemical-dynamic system.

## Space Processing Science and Spacelab Payload Development

**W89-70504** **674-21-05**
Lewis Research Center, Cleveland, Ohio.
**ELECTRONIC MATERIALS**
Fred J. Kohl 216-433-2866
(674-22-05; 674-24-05; 674-25-05; 674-26-05; 674-27-05; 674-28-05)

The plan for FY89 of this task is to continue an in-house cooperative project with Westinghouse Research Laboratories and to manage a contract with Westinghouse to study the growth kinetics of physical vapor transport (PVT) processes. The objectives of this project include achieving a quantitative understanding of the PVT process, identifying convective effects, and obtaining optimal process parameters for desired crystal structure properties.

**W89-70505** **674-21-06**
Langley Research Center, Hampton, Va.
**MORPHOLOGICAL STABILITY AND KINETICS**
A. Fripp 804-865-3777

Morphological stability, i.e., the capability of retaining the interface shape during growth, is a necessary requirement for the growth of high quality (homogeneous) crystals. An understanding of the requirements for morphological stability allows one to maximize the rate for high quality crystal growth. This is particularly important for optimal use of the limited experimentation time available for materials processing research in space. The development of morphological stability theory for crystal growth from vapors is hampered by the scarcity of quantitative experimental observations. A research program is proposed to secure definitive experimental data for the kinetic and fluid dynamic conditions that lead to the loss of morphological stability in vapor growth. These studies will be performed on materials that should allow for the observation of instabilities on non-faceted and faceted parts of the same interface. This will provide a unique opportunity to compare isotropic (well understood) and anisotropic stability models.

**W89-70506** **674-21-08**
Marshall Space Flight Center, Huntsville, Ala.
**ELECTRONIC MATERIALS**
S. L. Lehoczky 205-544-7758

In any crystal growth system, an important problem is that the compositional and/or thermal fluctuations in the fluid phases cause compositional inhomogeneities and defects in the growing crystal. Where these fluctuations are caused by convection and sedimentation, they can be reduced in low gravity. Therefore, the major objectives of this crystal growth program are to: (1) understand the role of gravity and determine limitations in earth's gravity; (2) determine and demonstrate advantages to be obtained by growing crystals in space; and (3) apply the findings to help solve problems in the growth of electronic and detector crystalline materials. The types of growth that will be explored in this program include melt, solution, vapor, and float zone growths. Crystal growth by solidification from the melt is the most widely used technique for high technology single crystalline materials. The success of the technique depends on the control of the composition, temperature, and morphology of the solidification interface. Advantages of the solution growth technique include the control it provides over the temperature of growth and viscosity. In the vapor approach there are two distinct mechanisms for growing crystals: (1) the physical vapor deposition, and (2) chemical vapor deposition (CVD). Finally, floating zone crystal growth is accomplished by supporting a polycrystalline rod at both ends, melting a portion of it with a moving heater, and growing a crystal behind this zone.

**W89-70507** **674-22-05**
Lewis Research Center, Cleveland, Ohio.
**COMBUSTION SCIENCE**
Fred J. Kohl 216-433-2866
(674-21-05; 674-24-05; 674-25-05; 674-26-05; 674-27-05; 674-28-05)

The objective of the Combustion Science program is to obtain an understanding of fundamental combustion phenomena where low-gravity analysis and experimentation can be of use in: (1) isolating the gravity related mechanisms; (2) determining the influence of mechanisms normally obscured by gravitational effects; (3) creating unique system configurations that provide favorable symmetries or boundary and initial conditions; or (4) determining the controlling mechanisms of low-gravity systems for in-space applications such as spacecraft fire safety. The Microgravity Combustion Science Discipline Working Group provides advice to focus the effort on those areas of Combustion Science where maximum benefit can be anticipated through low-gravity research.

Principal Investigators from the academic and industrial communities and from NASA LeRC are chosen to develop analytical or numerical models of selected combustion problems. Using the results of theoretical analysis, a Principal Investigator defines and performs normal-gravity and low-gravity experiments to obtain scientific data within the constraints of ground-based laboratories. Experimental and theoretical results are reconciled and evaluated to determine if together they provide an accurate model of the combustion phenomena under study. When the limitations of ground-based laboratories preclude conclusive testing of theoretical analysis, the Principal Investigator defines experiments requiring the long-duration low-gravity environment of space. The Principal Investigator performs additional analyses and ground-based experiments to determine the nature and feasibility of the apparatus required for the space experiment and a specification of the data to be obtained using the apparatus. The Principal Investigator prepares a Science Requirements Document and participates in the preparation of a Conceptual Design of a space experiment which together summarize the justification and feasibility of that experiment.

**W89-70508** **674-23-08**
Marshall Space Flight Center, Huntsville, Ala.
**BIOTECHNOLOGY**
R. S. Snyder 205-544-7805

The long-range objective is to utilize the environment of space to separate, purify or crystallize, and analyze biological products. The intermediate objectives are to develop the required technology and to expand the base of knowledge involved with processing biologicals in space; to identify, evaluate, and select the most promising processes; and to explore new areas of separation technology. Separation and purification procedures which have been found to produce inadequate results on the ground because of gravity-dependent problems will be investigated. More specifically, this program will: (1) determine possible advantages of the low-gravity environment for separation, purification, crystallization, and characterization of biomedical materials; (2) design, develop, manufacture, and test experiment apparatus to conduct experiments in low gravity; (3) apply ground/flight knowledge to the improvement of bioprocessing procedures on earth; (4) develop broad and strong collaborative interactions with research scientists; and (5) identify and explore new techniques of separation or bioprocessing that might be enhanced by low gravity.

**W89-70509** **674-24-04**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**COLLISION AND COALESCENCE OF FREE DROPS**
T. G. Wang 818-354-6331

The objective of this RTOP is to study four aspects of the collision and coalescence of free drops: time-dependent deformation, film drainage, final rupture of the film, and drop stability after coalescence. The results of the investigations will be used to verify existing linear theory and to provide the necessary insight for further theoretical development of the subject. The deficiencies of the existing theory, which disregards non-uniformity of the air-film drainage, irregularity in the surface of separation, rotational energy, and oscillation energy, are exemplified by inconsistent results appearing in the literature. In the coming years, the experimental technique and procedures, data acquisition and processing will be developed in ground-based immiscible systems and in the low gravity environment provided by KC-135 flights. These results will be used to provide detailed definition of the approved space flight experiment, Collision and Coalescence of Free Drops, by T. G. Wang, D. D. Elleman, and E. H. Trinh, and will determine the appropriate hardware to obtain the optimum results from the space experiments.

**W89-70510** **674-24-05**
Lewis Research Center, Cleveland, Ohio.
**FLUID DYNAMICS AND TRANSPORT PHENOMENA**
Fred J. Kohl 216-433-2866
(674-21-05; 674-22-05; 674-25-05; 674-26-05; 674-27-05; 674-28-05)

The objective of the activities covered by this RTOP are to expand our understanding of the fundamental fluid physics/fluids transport phenomena and the effects of gravity on those phenomena through studies which exploit the unique conditions that prevail in a reduced gravity environment. The pursuit of this understanding is directed to a wide range of scientific endeavors of interest to the general fluids community as well as specific applications such as supporting the design and development of advanced technologies/techniques for space-based materials processing and fluid management systems. Because of the wide range of applications and the large disparity of fluid processes/conditions encountered in these applications, the strategy used to address as many critical fluids issues as possible is to concentrate on a much smaller set of reasonably self-contained research topics or areas of fundamental understanding. At LeRC the topics/areas of interest include: (1) phase transitions (first order and second order); (2) multicomponent coupled transport flow; (3) magneto/electro hydrodynamics; (4) multiphase flow; and (5) capillary phenomena. In general, idealized simple systems are chosen for initial modeling and experimental work before proceeding studies of more application specific configurations and conditions. Principal Investigators from academic institutions, industry, other Government agencies and NASA LeRC are currently involved in a variety of research focused on providing a foundation of fundamental understanding of low-gravity fluid behavior/phenomena. Emphasis in the early stages of any of the research programs is on analytical/numerical modeling and normal gravity laboratory tests to provide predictive capabilities. When possible, these efforts are followed by low-gravity testing in ground-based facilities to provide more specific data for further model refinement. While the available low-gravity test time available in the ground-based facilities impose limitations on the amount of applicable data that can be obtained, in many cases a significant amount of valuable insight can be obtained in the fluid processes and/or phenomena of interest. This is particularly true when scaling analyses can be exploited with confidence. When the capabilities of the ground-based low-gravity facilities are exhausted or found to be inappropriate, efforts then are directed toward the development of science requirements and conceptual designs for space flight experiments.

**W89-70511** **674-24-06**
Langley Research Center, Hampton, Va.
**PACE FLIGHT EXPERIMENTS**
Joseph C. Moorman 804-865-3661

The basic purpose of the Physics and Chemistry Experiments in Space (PACE) program is to facilitate the utilization of space as a laboratory in which to carry out basic research in the areas of physics and chemistry. There are 15 experiments that have been supported in the program in the areas of fluid physics, critical phenomena, combustion, soil mechanics and relativity. The objective of this RTOP is to provide the continuing support to these 15 experiments required to facilitate their development through the conceptual design phase and to support them through the flight development phase with science peer reviews and science peer advocacy.

**W89-70512** **674-24-08**
Marshall Space Flight Center, Huntsville, Ala.
**FLUID DYNAMICS AND TRANSPORT PHENOMENA**
S. L. Lehoczky 205-544-7758

The objective of this RTOP is to develop experimental and theoretical methods for the study of the effects of gravity on the behavior of fluids undergoing phase transformations. Of particular interest are the quantitative effects of boundary conditions on the nature of the heat and mass transfer processes that accompany the solidification of materials. Multi-dimensional fluid dynamic and heat transfer codes, such as needed to model combined thermocapillary buoyancy-driven flows, will be developed and measurements will be performed to obtain quantitative comparisons between calculated and actual velocity fields as functions of relevant fluid dynamic parameters. A system of transport equations will be developed through numerical modeling, and a steady two-dimensional combined thermocapillary buoyancy-driven flow will be established.

**W89-70513** **674-25-04**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**METALS AND ALLOYS**
D. D. Elleman 818-354-5182

The Metals and Alloys Research and Technology Operating Plan consists of four tasks. The Electrostatic Containerless Processing Technology task objective is development of the science and technology base required for containerless positioning and manipulation of various materials using electrostatic and electrophoretic forces. Experimental and theoretical investigation is being conducted for the following systems: a focused radiator furnace and a hot wall furnace for the heating of low density samples up to 2000 C both in a vacuum and in a gaseous environment; investigation of charge gain/loss mechanism in a vacuum and in a gaseous environment using both the indirect heating technique and the hot wall furnace technique; development of an intelligent, self-adapting feedback control system; and completion of highly charged, rotating drop dynamics experiment using electrostatic-acoustic hybrid system. The Containerless Studies of Nucleation and Undercooling task objectives are to utilize containerless manipulation technologies to perform: undercooling and heterogeneous nucleation experiments on low melting pure metals and alloys and organic compounds and glass formers; and measurements of the physical properties of undercooled melts. Experimental methods are based on acoustic levitation techniques using gaseous and liquid hosts. The Metallic Glass Research in Space task objective is to develop an experiment to determine thermodynamic properties of bulk metallic glasses over the entire undercooling region. The primary scientific objective is to measure the specific heat of undercooled bulk metallic glass systems. Other objectives include measurements of the rate of homogeneous nucleation and the evaluation of crystal-melt interfacial tension and, in the long term, development of metallic glasses into a viable industrial and commercial material. The Multimode Acoustic Research task objectives are: to develop theoretical acoustic models of new multimode classes of acoustic levitation; to provide experimental validation of these models; and to investigate novel methods of sample levitation, manipulation and heating. These new levitation principles, coupled with advanced heating techniques, provide us with alternative methods for positioning and manipulating molten materials, which may lead to rapid cooling, separation of levitation and rotation capabilities, and the selection of arbitrary axes of rotation. The ultimate goal of this task is to enhance multimode levitation techniques for use in high temperature acoustic levitators.

**W89-70514** **674-25-05**
Lewis Research Center, Cleveland, Ohio.
**METALS AND ALLOYS**
Fred J. Kohl 216-433-2866
(674-21-05; 674-22-05; 674-24-05; 674-26-05; 674-27-05; 674-28-05)

The objective of this product is to conduct fundamental research on the solidification of metals and alloys in order to improve our understanding of phenomena such as macrosegregation, dendritic growth models, and undercooling. The ultimate goal is to use this understanding to improve current or develop new theories, models and improved ground-based materials/processes. The near-term targets are: (1) to determine the role of gravity-driven convection on the problem of macrosegregation in commercial alloys, with initial tests being conducted on Pb-Sn model alloys leading towards a series of shuttle flight experiments; and (2) to investigate the effects of containerless processing in order to understand the influence of undercooling on resulting alloy microstructures and to evaluate the potential of bulk undercooling as a solidification process. This effort will consist of a phased approach: ground-based research program in laboratories, flight hardware definition, development and space experiments. This program builds on the extensive OAST research and technology base in the areas of solidification processing and evaluation of advanced high temperature alloys which exists at the Lewis Research Center. This program involves focused joint LeRC/university/industry cooperative/advisory efforts.

**W89-70515** **674-25-08**
Marshall Space Flight Center, Huntsville, Ala.
**METALS AND ALLOYS**
R. S. Sokolowski 205-544-7796

Control of the solidification of metals and alloys is keyed to gravitational effects such as buoyancy-driven convection. Thus, the objectives of the study are to: (1) identify various aspects of solidification phenomena that may be affected by gravity-driven flows; (2) devise and conduct critical experiments in increased gravity as well as in space; and (3) impact the field of metallurgy by fundamental knowledge through devising better control strategies. Multicomponent metallic systems involve a first-to-freeze component which nucleates and begins to grow, causing the composition ahead of the solidification front to change dramatically. Where it is unfeasible or undesirable to provide controlled gradients for a planar solidification front, dendritic growth results. Thus, concentration is one of the more fundamental problems involved in the formation of dendrites. Directional solidification affords a degree of control because unidirectional thermal gradient can be imposed and growth rate regulated. Another important class is the monotectic alloys which have a region of immiscibility. Finally, nucleation and rapid solidification of deeply undercooled melts will be pursued by containerless melting and solidification.

**W89-70516** **674-26-04**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**GLASS RESEARCH**
G. F. Neilson 818-354-6365

The objective of this RTOP is to establish the scientific framework for the identification and evaluation of potential flight experiments pertaining to the preparation and processing of glasses in a microgravity environment by means of ground-based experimentation and mathematical modeling. In September of FY88, all activities under this RTOP will be transferred, along with the equipment being employed at JPL for the work, to the University of Arizona. At the beginning of FY89, the equipment will be set up and made operable at the University of Arizona. The research activities under this RTOP for FY89 will be accomplished individually or collaboratively by G. Neilson and M. Weinberg, as indicated. Also, one activity will be continued by G. Smith for his thesis research. The specific goals for FY89 are: (1) to continue the experimental analysis of sodium borosilicate gel and gel glass microstructure; (2) to study the feasibility of conducting a glass immiscibility flight experiment; (3) to begin conducting an investigation of gel glass phase separation in the nonclassical immiscibility region; (4) to conduct a computer analysis of complex T-T-T diagram behavior and calculation of volume fraction crystallized for comparing ground-based and microgravity glass crystallization behavior; and (5) to continue the experimental study and theoretical analysis of crystal nucleation as a function of temperature in lithium diborate glass.

**W89-70517** **674-26-05**
Lewis Research Center, Cleveland, Ohio.
**GLASSES AND CERAMICS**
Fred J. Kohl 216-433-2866
(674-21-05; 674-22-05; 674-24-05; 674-25-05; 674-27-05; 674-28-05)

The objective of this program is to identify and initiate fundamental research in the areas of glasses and ceramics wherein microgravity related phenomena play an important role. The study of the effects of gravity on the combustion synthesis of ceramic and alloys has been completed. Phase immiscibility in glasses has been initiated as an in-house research effort. Research involving glass foaming, order disorder transitions of ceramic slips and agglomeration of ceramic powders is under way at universities. A follow-on proposal to the initial efforts in foam formation and destruction and ceramic powder agglomeration are anticipated. A new effort in fiber growth has been proposed for initiation via an NRC fellow.

**W89-70518** **674-26-08**
Marshall Space Flight Center, Huntsville, Ala.
**GLASSES AND CERAMICS**
E. C. Ethridge 205-544-7767

The objectives of this activity are to: (1) explore novel techniques and applications for containerless processing of glasses and refractory materials; (2) understand the limitations imposed by the gravitational field; and (3) evolve meaningful flight experiments which extend processes beyond gravity limitations. For example, with metals research the recent attention drawn to containerless processing by the Microgravity Science and Applications (MSA) program has served to focus these activities and demonstrated their usefulness to a wide variety of research disciplines. In this manner, the technology of containerless processing is emerging from isolated experimenters investigating individual research tasks to a concerted multidisciplinary effort to develop better techniques and apply them to a variety of research topics. A developing scientific community is utilizing state-of-the-art ground-based levitation experiments to process many metal systems. The difficulty in levitating and melting glasses and ceramics in one-g has limited the development of this discipline. Focused heating techniques need to be developed and implemented on the 34 and 100 m drop tubes in order to be able to containerlessly solidify glasses and refractory oxides and stimulate interest in the community of glass and ceramic scientists.

**W89-70519** **674-27-05**
Lewis Research Center, Cleveland, Ohio.
**MICROGRAVITY MATERIALS SCIENCE LABORATORY**
Fred J. Kohl 216-433-2866
(674-21-05; 674-22-05; 674-24-05; 674-25-05; 674-26-05; 674-28-05)

The objective of this project is to operate and maintain a dedicated, well equipped Microgravity Materials Science Laboratory (MMSL). This laboratory provides visiting scientists, from industry and universities as well as those from within the government, access to experimental equipment either configured to simulate flight hardware, to emulate microgravity processing, or to otherwise help define the effects of gravity on materials processing. The availability of this experimental equipment and engineering support provided by the MMSL staff will help the scientists obtain a better understanding of their materials experiment behavior in a 1-g environment. Laboratory staff aid in definition of future space flight hardware and cooperate with Space Experiments Division in developing specifications for hardware construction. The laboratory is a site for visiting scientists to conduct experiments as precursors to the use of other ground-based microgravity facilities, such as the drop towers and research aircraft, or in preparation to qualify an experiment for space flight.

**W89-70520** **674-28-05**
Lewis Research Center, Cleveland, Ohio.
**GROUND EXPERIMENT OPERATIONS**
Fred J. Kohl 216-433-2866
(674-21-05; 674-22-05; 674-24-05; 674-25-05; 674-26-05; 674-27-05)

The objective of the Learjet/drop tower support effort is to provide the manpower, equipment and facility support necessary to perform reduced gravity experiments. Experiments are conducted to support both principal investigator studies and LeRC in-house studies in fluids and combustion science.

**W89-70521** **674-28-08**
Marshall Space Flight Center, Huntsville, Ala.
**GROUND EXPERIMENT OPERATIONS**
M. B. Robinson 205-544-7774

This RTOP covers work in the area of defining, developing, and conducting experiments using the low-gravity capabilities of the drop tube, drop tower, KC-135, and F-104 aircraft. Such experiments may be in themselves complete investigations to develop new knowledge or to prove theories, or they may serve as precursors for more extensive experiments to be conducted in space. This RTOP also includes studies and experiments to define the effects of various levels and durations of acceleration perturbations on microgravity experiments.

**W89-70522** **674-29-04**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**MICROGRAVITY SCIENCE AND APPLICATIONS PROGRAM SUPPORT**
R. H. White 818-354-6786

The objective of this RTOP is to provide detailee support to NASA's Microgravity Science and Applications Division (MSAD), Code EN. Detailee(s) would provide the scientific management of broad-based programs in basic and applied research related specifically to one or more of the following areas: metals and alloys, glasses and ceramics, bioprocessing, and/or combustion science in a microgravity environment. Responsibilities would include managing the ongoing program in these areas, evaluating incoming proposals for new efforts in the assigned areas, and participating in the overall programmatic planning for the science goals of the MSAD program.

**W89-70523** **674-29-08**
Marshall Space Flight Center, Huntsville, Ala.
**CONSULTING AND PROGRAM SUPPORT**
B. G. Bass 205-544-7756

The objectives of this RTOP are: (1) to provide the necessary management and support manpower to implement the Microgravity Science and Applications (MSA) research and technology development effort; and (2) to provide the MSA program with an effective means of interacting with the various scientific communities involved for the purposes of: making them aware of the research opportunities offered by the MSA program; stimulating their interest and active involvement in the program; gauging their response to the scientific results being obtained by the program; identifying research areas on which the program should concentrate; initiating in-house research activities in selected optics pertinent to the MSA program; and evaluating the ongoing research effort. MSFC will ensure the necessary professional and supporting manpower to implement the MSA research and technology development effort. Also, the stated objectives will be met by actively involving the various research communities in the MSA program through working groups, seminars and workshops, science reviews, and a visiting scientist program. In addition, scientific goals and accomplishments of the program will be documented and disseminated to the science communities in the form of a published bibliography and catalog of tasks.

## Geodynamics Research and Technology Development

**W89-70524** **676-10-10**
Goddard Space Flight Center, Greenbelt, Md.
**SOLID EARTH DYNAMICS**
Steven C. Cohen 301-286-8826

The objectives of this RTOP are to conduct research and provide support for research relating to the solid earth, its dynamics, structure and interior composition. The approach will be to: (1)

pursue research aimed at determining the lithosphere's present state and evolution and its physical properties; (2) determine the large-scale structure and magnetization contrast between the continental and oceanic lithosphere using MAGSAT data; (3) conduct studies of the measurements and systems necessary for future geophysical and geodetic measurements of the earth and planets; (4) determine the relationships between petrogenesis and tectonics; (5) provide technical and administrative management for grants and contracts in geodynamics; (6) prepare and exercise geodynamics management data base; (7) develop finite element models of earth dynamic processes including continental rheology; (8) study end-to-end Geodynamics Laser Ranging System requirements; (9) study lithospheric flexural rigidity in Australia based on gravity-topography coherence; and (10) study mantle convection and its relationship to observed gravity anomalies.

**W89-70525** **676-10-11**
Goddard Space Flight Center, Greenbelt, Md.
**SATELLITE GEODETIC TECHNIQUE DEVELOPMENT**
David E. Smith 301-286-8826

The objectives of this RTOP are to develop space geodetic techniques for the analysis of spacecraft data in support of geodynamic quantities, including the earth's gravity field, dynamics, and crustal motions. Techniques will be developed to assess the value of potential spacecraft missions for geodynamics. Particular attention will be placed on the value of Gravity Probe B for improving our knowledge of the gravity field of the earth, on the advantages of combined laser and Global Positioning System (GPS) solutions for crustal motions, and the contribution that Lageos 3 in a polar or complementary orbit to Lageos 1 could make to satisfying long-term objectives in the solid-earth science program.

**W89-70526** **676-40-02**
Goddard Space Flight Center, Greenbelt, Md.
**GEOPOTENTIAL FIELDS (MAGNETIC)**
Robert A. Langel 301-286-6603

The major objectives of this RTOP are to develop more accurate and reliable models of the earth's main magnetic field and its temporal variation, to study the physical processes in the core which are responsible for generation of that field, and to conduct studies preparatory to proposed missions. The approach includes both collection of all suitable data types and the development of new analytic techniques. New observatory, repeat and survey data are being added to our data set as they become available. During the past year, new analysis techniques were applied to the derivation of Definitive Geomagnetic Reference Fields (DGRF) for 1945, 1950, 1955 and 1960. Data from the DE-2 satellite was combined with MAGSAT and other data to derive and publish a model for 1980 to 1983. The usefulness of data from other satellites (DE-1, DMSP F-7, AMPTE) is being investigated. A new formalism for error analysis is now operable and publication is under preparation. Arrangements have been made with EDIS/NOAA for reduction of the vast marine magnetic data set for use in main field modeling. A formalism for external field analysis is being incorporated into the field modeling procedure, as is a spline representation for secular variation. Models with a priori based on the physics of the core (Stochastic Inversion) will be explored. Models of the fluid velocity at the top of the core will continue to be explored assuming steady motion and/or geostrophy and, for the first time, flux diffusion. Future geodynamics related missions will likely explore regions of space at altitudes lower than previously possible. Planning for such missions is made more precise if the nature of the magnetic fields to be encountered can be estimated. Models of external fields can be determined so as to match existing data and then utilized to predict the nature of the fields in unexplored areas.

**W89-70527** **676-40-10**
Goddard Space Flight Center, Greenbelt, Md.
**GRAVITY FIELD AND GEOID**
Barbara H. Putney 301-286-6018

The objectives of this RTOP are to develop a model of the earth's gravity field based upon satellite tracking and altimetry and surface gravity data. The computed geopotential model, the interim field, will be used as the a priori model at the beginning of the Topography Experiment (TOPEX) and other gravity missions. We will develop state-of-the-art geodynamic software systems; perform research through the interpretation of geopotential signals; evaluate flight concepts for a cryogenic gravity gradiometer using the Spartan configuration; study the scientific benefits of a number of small geodetic/geodynamic spacecraft for improvement of knowledge of the earth's interior, surface layers, and rotational dynamics; and determine analytic theory for simulations of high degree and order gravity field for increased resolution of the gravity field. Essential elements for the development of the interim field are: improvement methods of incorporating surface gravity data; development of techniques for extensive use of altimeter data; improvement of accuracy of models used in orbit determination; and optimization and development of the necessary software programs. The gradiometer flight test study has been started to determine attitude and control requirements by modeling typical instrument configurations. For the mini-Lageos study, the main emphasis will be the time changing gravity field. Analytic software has been evolving to determine the high resolution sensitivities of the gravity field.

**W89-70528** **676-59-10**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**GRAVITY FIELD MISSION STUDIES**
D. Sonnabend 818-354-7593

The objective of this work is to continue the development of a technique for operating sensitive instruments, primarily gravity gradiometers, aboard the Space Transportation System (STS) vehicle (Shuttle). The technique provides either active vibration isolation or intermittent drag free operation of the payload instrument, with minimum impact on Shuttle systems or operations. The payload would be encased in a conducting shell, and set free inside a set of eddy current forcing coils. In the vibration isolation mode, the payload position is continuously fed back to the forcing coils, using arbitrary frequency shaping. In the semi drag free mode, the coils are operated only briefly, when collision with the coils is imminent. Previous studies have shown that normal Shuttle disturbances, including air drag, rotation, and crew motion can all be accommodated, and have determined the special requirements associated with cryogenic payloads. Work is presently underway to demonstrate single axis operation in the laboratory, and to examine the possibility of remote identification of the instrument parameters in the laboratory and in flight. Work is also underway to determine rotation corrections to floated gradiometers by dynamic estimation.

**W89-70529** **676-59-31**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**GPS-BASED MEASUREMENT SYSTEM DEVELOPMENT AND DEPLOYMENT**
W. G. Melbourne 818-354-5071

A Global Positioning System (GPS) based measurement system for sub-centimeter geodesy is being developed and demonstrated in California, Mexico, the Caribbean and South and Central America. The broad objective is to achieve baseline accuracies of 2 cm or better in the local vertical and less than 1 cm in each horizontal component over distances up to transcontinental lengths. A second objective is to reduce the capital equipment and field operations costs by an order of magnitude. Current costs are already an order of magnitude less than very long baseline interferometry (VLBI) and satellite laser ranging (SLR) systems. These technology advances will enable high accuracy low cost measurements to be made with dense arrays that sample crustal deformation with high resolution in time and space. This will enable key geodetic experiments in regions of tectonic interest. Among the problems to be addressed are: (1) the question of the direction and rate of relative motion between the North American and Caribbean plates; (2) the subduction of the Cocos plate beneath Central America; (3) the spreading rate across the Galapagos spreading center; (4) the spreading rates in the Gulf of California; (5) the nature of strain in southern California; and

(6) uplift and deformation in the Long Valley caldera associated with magma injections. System development will continue to build on the successful demonstrations and technology development conducted in the FY85 to 1988 time frame. A GPS data processing software system (GIPSY) is now fully operational; work continues to simplify its use. Improved strategies for data analysis and experiment planning have led to significant improvements in system accuracy that is now approaching 1 cm in the horizontal components. Improved field equipment, including the Rogue advanced GPS receiver, antenna/backplane systems for reduced multipath and water vapor radiometers, is now beginning to be deployed in field experiments. The CASA UNO experiment involved the first use of a global GPS fiducial network for generating highly accurate GPS satellite ephemerides. New strategies for data analysis and experiment design are being employed to further improve system accuracy.

**W89-70530** **676-59-32**
Goddard Space Flight Center, Greenbelt, Md.
**LASER RANGING DEVELOPMENT STUDY**
Thomas W. Zagwodzki 301-286-5199
(676-10-10; 692-20-10; 584-01-31)

The long term goals of this RTOP are: (1) to develop automated millimeter accuracy satellite laser ranging (SLR) systems; and (2) to provide supporting analyses and technology tradeoff studies in support of a combined geodynamics/altimetry mission of the Geodynamics Laser Sensing System (GLRS) instrument on the Earth Observing System (EOS). Under Automated Millimeter Accuracy Systems, the technical strategy is to use dual wavelength, subnanosecond pulse laser transmitters and picosecond resolution streak camera technology to remove centimeter level range uncertainties caused by atmospheric refraction effects. Under GLRS Ranger/Altimeter, earlier system studies of the Geodynamics Laser Ranging System (GLRS) will be updated to provide a preliminary assessment of the engineering impact of an additional, high duty cycle altimetry mission. Different altimetry missions vary in their data type (e.g., simple mean range vs. return waveforms for surface roughness investigations) and data volume which can impact transmitter energy and lifetime specifications and receiver design. We will investigate the GLRS instrumental changes dictated by a combined two color geodynamics/altimetry mission and also potential improvements to the instrument made possible by recent technological advances in the areas of laser pumping, high speed photodetectors and spacecraft navigation.

**W89-70531** **676-59-33**
Marshall Space Flight Center, Huntsville, Ala.
**SUPERCONDUCTING GRAVITY GRADIOMETER**
S. H. Morgan 205-544-0614

The objective of this RTOP is to develop a full vector, three-axis super-conducting gravity gradiometer for space flight applications. The instrument will be designed to have a measurement sensitivity of 1/10,000 eotvos units (1 eotvos unit = 10 to the ninth power per second squared) in an orbital environment and exhibit a measurement time constant consistent with the current requirements of geodynamics research. The final functioning sensor unit will be constructed and tested in a manner consistent with a proto-flight approach to a possible precursor Shuttle flight test.

**W89-70532** **676-59-44**
Marshall Space Flight Center, Huntsville, Ala.
**SUPERCONDUCTING GRAVITY GRADIOMETER (SGG) SHUTTLE PAYLOAD STUDY**
S. H. Morgan 205-544-0614
(676-59-33)

The objective of this RTOP is to conduct a Phase A study for a prototype flight of a full vector, three-axis superconducting gravity gradiometer (SGG). This instrument is being developed under a separate RTOP (676-59-33). The SGG instrument will be designed to have a measurement sensitivity of 1/10,000 eotvos units (1 eotvos = 10 to the ninth power per second squared) in an orbital environment. The precursor flight test will validate the flight performance of the instrument, the design and operation in space of the Experiment Module as well as the analytic predictions of the instrument error model, and will assess the performance of automated instrument control and data handling/analysis.

**W89-70533** **676-59-45**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**GPS POSITIONING OF A MARINE BUOY FOR PLATE MOTION STUDIES**
T. H. Dixon 818-354-4977

This RTOP is intended primarily to perform a system analysis and demonstration of the use of GPS (Global Positioning System) receiver technology for determining the location of an ocean surface platform with respect to the GPS reference frame. The development of a system for measuring the location of benchmarks on the ocean floor with respect to an acoustic transmitter on the surface platform is being performed under other Geodynamics Program-sponsored research, by F. N. Spiess of Scripps Institution of Oceanography. The combined objective of these two RTOPs is to precisely tie ocean floor benchmarks to an earth fixed reference frame. GPS-based systems have been developed for high precision, cost-effective geodetic measurements under the NASA Geodynamics Program. Current proof-of-concept receivers have demonstrated baseline measurements with few cm accuracies. If this level of performance can be maintained in a system used at sea, it will be adequate for obtaining an absolute position for the surface element(s) of an acoustic sea floor benchmark system. Moreover, the instantaneous positioning data for the surface element of the array obtainable with GPS may enable us to put limits on the sound velocity variation in the upper 100 m of water measured. Variability in this layer is expected to be a major error source. Some developments in the system design are required to use GPS technology for sea floor geodesy, including antenna design and kinematic positioning of a wave-tossed platform. Preliminary sea trials with the SERIES GPS receiver and over-water tests with TI-4100 receivers with modified antennas have been used to gain engineering information. Based on these results, we are ready to deploy the system for preliminary tests at sea. These are tentatively planned for March, 1989, in conjunction with sea trials of the in-water, acoustic portion of the system conducted by F. N. Spiess.

**W89-70534** **676-59-75**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**ADVANCED MAGNETOMETER**
E. J. Smith 818-354-4110

The objectives of this RTOP are: (1) to operate the helium magnetometer in a scalar mode and demonstrate that it can meet the requirements of future investigations to study secular changes in planetary magnetic fields and to detect crustal magnetic anomalies; (2) to evaluate the magnetometer performance in a hybrid mode in which it alternates (rapidly) between scalar and vector operation; (3) to optically pump helium using a laser rather than a lamp excited by an electrodeless discharge and evaluate the consequences for the magnetometer performance; (4) to investigate the possible use of a solid state semiconductor laser in a space flight magnetometer including fiber optics to transmit the pumping radiation between the electronics and sensor; and (5) to gain experience with the He3 nuclear precession magnetometer and evaluate its possible use on spacecraft.

**W89-70535** **676-59-80**
Goddard Space Flight Center, Greenbelt, Md.
**MAGNOLIA/MAGNETIC FIELD EXPLORER**
G. W. Ousley, Sr. 301-286-8073
(676-59-10)

The objectives of this RTOP are to conduct system definition studies for a Magnolia/Magnetic Field Explorer (MFE) mission. The studies will be based on the MAGSAT-A concept and will build on the studies completed by APL. The studies will produce the U.S. inputs for a definition phase spacecraft design with the French Centre National d'Etudes Spatiales (CNES) that could serve as the basis for a joint cooperative program. The French CNES is cooperating with NASA in this study activity which could lead to a joint mission on the Ariane launch vehicle.

# Land Processes Applied Research and Data Analysis

**W89-70536** **677-12-03**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**ERS-1 FOREST ECOSYSTEMS STUDIES**
J. B. Cimino 818-354-8225

Multitemporal measurements of forest ecosystems may be critical in resolving ambiguous interpretations of microwave backscattering from architecturally complicated forest canopies in the presence of spatial and temporal variability in scene characteristics. It is postulated that multitemporal microwave observations can be utilized to separate weather related scene variance from phenologic development. In addition, changing seasonal environmental conditions may be useful for enhancing or subduing certain components of the radar backscatter. These postulations are based primarily on multitemporal observations using truck-mounted scatterometers and some airborne imaging studies. The key questions to be addressed are: (1) what are the magnitudes of seasonal variation in the microwave backscattering coefficient as a function of wavelength and polarization vectors (with emphasis on C-band VV) in response to naturally occurring temporal variability in monospecific forest stands which are characteristic of the temperate deciduous and coniferous forests and boreal forests; (2) how are these variations in the backscatter coefficient quantitatively related to specific forest stand and environmental properties via the relevant scattering mechanisms; (3) how can this information be connected to quantities of ecological interest, biomass in particular; (4) can synthetic aperture radar (SAR) data be adequately calibrated (in both a relative and an absolute sense) to permit use of the data in conjunction with microwave scattering models, to permit its use in multitemporal comparisons and to permit site to site comparisons of globally distributed forests; (5) if so, what are the most cost and time efficient techniques and how can they best be implemented with orbital sensors such as ERS-1; (6) given the observed temporal variations in backscatter and the associated calibration limitations, what ecologically useful information can be inferred from multitemporal SAR observations via change-detection retrieval. To address the above question, in the pre ESA Remote Sensing Satellite 1 (ERS-1) era, we will use a series of airborne SAR data sets; specifically seasonal coverage (at least two: winter and summer) acquired over the ERS-1 test sites (Bonanza Creek Experimental Forest) in Alaska. Duke Forest and Michigan Biological Station). Ground truth measurements collected simultaneously with the overflights will be used in conjunction with existing radar models (Ulaby, Richards and Simonett) to determine which of the canopy properties are contributing to the backscatter at all wavelengths and polarizations.

**W89-70537** **677-20-10**
Ames Research Center, Moffett Field, Calif.
**REMOTE SENSING OF A BIOGEOCHEMICAL CYCLE: THE MANGANESE CYCLE IN A FRESHWATER LAKE**
R. C. Wrigley 415-694-6060
(677-21-35)

The objective of this work is to understand the biogeochemical cycle of manganese in Oneida Lake, N.Y., using remote sensing approaches to extend process level models to the entire lake. The basic approach is first to determine how the microbial mediation of the manganese biogeochemical cycle in Oneida Lake can be detected remotely, and then to use remote sensing to extend the knowledge of those processes.

**W89-70538** **677-21-22**
Ames Research Center, Moffett Field, Calif.
**ESTIMATING REGIONAL METHANE FLUX IN HIGH LATITUDE ECOSYSTEMS**
L. A. Morrissey 415-694-5896

The objective of this work is to develop a regional estimate of methane flux for select areas in the Alaskan arctic tundra and taiga by using ground observations and simulation studies in coordination with land surface stratifications based on remote sensing. Initial ground observations will determine the magnitude and variability of methane flux along select environmental gradients known to affect the biogeochemical processes related to methanogenesis. Net methane flux will then be estimated within spatial ecological strata derived from Landsat Multispectral Scanner Subsystem (MSS) and NOAA Advanced Very High Resolution Radiometer (AVHRR) data. Various estimation approaches of regional flux based on AVHRR and AVHRR/MSS strata will be assessed through sensitivity analyses on the precision of these estimates. Ground flux measurements coupled with multitemporal AVHRR data will provide the basis for an assessment of the seasonal variability of methane flux for Alaskan arctic tundra ecosystems. The significance of high latitude ecosystems in the global methane budget will be addressed through atmospheric modeling using existing photochemical models developed at NASA Ames. By comparing calculated and published latitudinal distributions of atmospheric methane, it will be possible to infer whether assumed seasonal source strengths in the high latitudes are reasonable.

**W89-70539** **677-21-24**
Goddard Space Flight Center, Greenbelt, Md.
**COMPLEMENTARY USE OF LASER INDUCED FLUORESCENCE (LIF) AND PASSIVE REFLECTANCE IN DETECTION AND STUDY OF FOREST STRESS**
Emmett W. Chappelle 301-286-6638

Experimental correlations have been found between laser induced fluorescence (LIF) changes and changes in vegetation vigor as the result of environmental stress, especially in areas subject to acid deposition. Evidence has been obtained that relates these fluorescence changes to biochemical responses, primarily photosynthesis, to the stress factors. Further, it has been indicated in red spruce that changes in certain fluorescence bands can be related to certain passive reflectance bands. The objective is to obtain the necessary data sets, including LIF measurements, reflectance data, and relevant ancillary data, to provide a basis for the use of LIF, not only in the detection and study of forest stress, but also for the interpretation of reflectance changes. These studies which will be done in collaboration with Dr. Rock at the University of New Hampshire will involve measurements on samples collected at selected sites in New Hampshire and New York. Fluorescence and reflectance measurements will be performed in our laboratories along with analysis of chlorophyll, elemental mineral analysis, and possibly the measurement of photosynthetic rates. Suitable analyses of the data will be subsequently made. Data sets will be obtained which allow the validation of the use of fluorescence and reflectance in the detection and understanding of forest dieback, and which will be of value of other investigators studying this problem.

**W89-70540** **677-21-31**
Ames Research Center, Moffett Field, Calif.
**FOREST EVAPOTRANSPIRATION AND PRODUCTION**
D. L. Peterson 415-694-5899
(677-21-35; 199-30-72)

The objectives of this RTOP are to determine evapotranspiration (ET) and net primary productivity (NPP) for a large regional coniferous forest, to test theories necessary for efficient partitioning and aggregation of a forested landscape to support regional level estimations. The approach is to implement an appropriately modified version of DAYTRANS/PSN, an existing physiologically based model simulating ET and NPP at the conifer stand level, for initially a small watershed and later a 2600-square-kilometer basin in western Montana. Variables relating



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to key processes controlling energy, carbon and water exchange will be derived from remote sensing, digital terrain, in-place measurement, and soil data. The variables, to be interrelated in a geographic information system, are: (1) site physical properties (slope, aspect, elevation, soil) obtained by automated partitioning of the terrain into hydrologically meaningful landscape units; (2) surface meteorological conditions including radiation balances, canopy/air temperature, humidity, precipitation; and (3) vegetation characteristics, leaf area index and total biomass. Estimates of ET and NPP will be validated using independent hydrological yield measurements and productivity estimates from ground sampling.

**W89-70541** **677-21-32**
Goddard Space Flight Center, Greenbelt, Md.
**GLOBAL INVENTORY MONITORING AND MODELING EXPERIMENT**
Compton J. Tucker 301-286-7122
(199-30-99)

The objective of this work is to develop the techniques and scientific basis for studying terrestrial renewable resources at regional, continental, and global scales with multilevel satellite remote sensing data. Satellite data will be obtained at spatial resolutions of 30 m, 80 m, 1 km, 4 km and 15 km for selected local areas (30 and 80 m), regional test sites (1 km), continental test areas (4 and 8 km), and the entire planet (15 km). These data will be analyzed to provide high temporal frequency vegetation biomass and condition information for assessing productivity, land cover mapping, deforestation, insect and disease upsurges, and other large-scale vegetation information of interest to global science questions such as the earth's radiation budget, the carbon cycle, and the hydrological cycle. Expected results are: (1) the understanding of large-scale vegetation response and its relationship to atmospheric and climatic phenomena; (2) estimates of grassland biomass production across entire continental ecological zones; (3) global estimates by continent of land cover types and how these vary with time; (4) improved documentation of tropical forests; (5) understanding the coupling of directional reflectance and atmospheric effects; (6) developing the computer-related software to process large volumes of coarse resolution satellite data and handle multilevel satellite data from the same target; and (7) determination of desert boundaries and desert spatial extent.

**W89-70542** **677-21-35**
Ames Research Center, Moffett Field, Calif.
**BIOGEOCHEMICAL CYCLING IN TERRESTRIAL ECOSYSTEMS**
D. L. Peterson 415-694-5899
(199-30-72; 677-21-31; 199-30-62)

The objectives of this research are to develop and use theoretical models and empirical studies to derive biochemical information from leaf and canopy spectra; to relate these measurements to ecosystem productivity and nutrient cycling for temperate and tropical gradients; and to incorporate these findings into developing ecosystem process models. The approach will be to develop decomposition and biophysical models of leaf spectral characteristics accounting for biochemical properties; apply these techniques to canopy models to understand the canopy chemistry in empirical remote sensing studies using visible to shortwave spectral sensors (e.g., airborne visible/infrared imaging spectrometer (AVIRIS)); and design, conduct and compare gradient studies of ecosystem nutrient cycling using established methods and incorporate in ecosystems models combining water-carbon-nutrient processes and interactions and test for generality.

**W89-70543** **677-21-36**
Goddard Space Flight Center, Greenbelt, Md.
**BASIC LAND SYSTEM STUDIES**
David L. Toll 301-286-9256
(677-92-22)

The objective of this RTOP is to provide the broad range of programmatic and technical supporting activities necessary for the conduct of basic studies of the land surface as a system, including those in support of the International Satellite Land Surface Climatology Program (ISLSCP). An active satellite data base will be built for use by ISLSCP investigators. Meetings/workshops will be conducted to discuss analysis techniques, present research results and plan future directions of basic land system studies such as those for ISLSCP. Supporting research will be conducted, including bidirectional reflectance field measurement experiments in the U.S. Documentation describing the results of the meetings/workshops will be prepared, printed, and distributed to interested parties. NOAA AVHRR and LANDSAT MSS and TM data sets of interest to ISLSCP investigators will be purchased and distributed, as appropriate, and retained in a local data base for future use. Test measurements acquired during the field campaign will be analyzed, and results will be used to refine field experiment data acquisition techniques.

**W89-70544** **677-21-37**
Goddard Space Flight Center, Greenbelt, Md.
**LAND INFLUENCE ON THE GENERAL CIRCULATION - STUDIES OF THE INFLUENCE OF ANOMALIES IN THE BIOSPHERE ON CLIMATE**
Yogesh C. Sud 301-286-7408

The SiB-GLA General Circulation Model (GCM) has produced very realistic rainfall that agrees well with observations. A set of four summer runs with the SiB model will be compared with a corresponding set of four control runs with the standard model to isolate the effect of vegetation on climate. Four July simulations for 1979, 1980, 1981 and 1982 have already been made with the standard GLA GCM. The corresponding four runs with SiB model are in progress; the two sets will be analyzed to determine the effects of realistic vegetation parameterization on the simulated global circulation and rainfall. Due to weaknesses in the cloud radiation interaction, which essentially results from inaccurate non-precipitating cloud cover, the net radiation at the ground is inaccurate. This problem will be addressed. It is evident from the analysis of a few runs that the GLA GCM has a robust climatology. Initial and preliminary indications are that the SiB model improves global evaporation and rainfall patterns. This result will be interpreted physically and analyzed for statistical significance in different regions. The effect of improving the fractional cloudiness parameterization will also be analyzed. These two results are pre-cursors to in-depth studies of biosphere atmosphere interactions to understand the biogeophysical effects of deforestation and desertification mechanisms.

**W89-70545** **677-21-40**
Goddard Space Flight Center, Greenbelt, Md.
**FOREST ECOSYSTEM DYNAMICS**
James A. Smith 301-286-7282

The overall objective of the research is to use forest pattern and process models, soil models, and radiative transfer models, combined with ground-based and satellite observations to understand the dynamics of boreal forest ecosystem evolution over a variety of temporal and spatial scales. Two major tasks are involved: (1) the synthesis and organization of available knowledge of forest ecosystem dynamics into a comprehensive modeling framework; and (2) the classical problem of appropriately scaling up our knowledge of ecosystem processes as we move from the site to the local to the regional and ultimately to global perspectives. Remote sensing will play a particularly crucial role in solving this latter problem. Key results of this effort will be advancement of state-of-the-art theoretical models applicable to evaluation and refinement with global satellite observational capabilities and compilation of appropriate measurement sets useful for the design of larger scale field measurement efforts along climatic or environmental gradients.

**W89-70546** **677-22-00**
John C. Stennis Space Center, Bay Saint Louis, Miss.
**USE OF REMOTE SENSING TECHNOLOGY FOR DEVELOPING A WATER QUALITY DECISION SUPPORT SYSTEM**
Richard L. Miller 601-688-1904

The primary objective of the proposed project is to develop an efficient, cost effective methodology for assessing the effects of nonpoint source nutrient loadings on estuarine water quality. This methodology will be developed in three stages, consisting of geographic information system (GIS) database assembly, watershed modelling of nonpoint source loadings, and development of a phytoplankton-nutrient dynamics model of Perdido Bay. The study area for this project is the Perdido Bay and the Perdido River drainage basin located on the Alabama/Florida border in the northern Gulf of Mexico. This effort will provide the general framework and analytical approach for assessing water quality in watershed-estuarine systems.

**W89-70547** **677-22-27**
Goddard Space Flight Center, Greenbelt, Md.
**HYDROLOGY**
R. J. Gurney 301-286-5480
(677-22-28)

The objectives of this RTOP are: (1) to determine remote sensing capabilities for observing net radiation, surface temperature, soil moisture, snowpack properties and vegetation over land; (2) to develop models that are calibrated using these remotely sensed data to estimate hydrological fluxes, such as rainfall, evapotranspiration and runoff, soil moisture profiles and soil hydraulic properties; (3) to examine the spatial integration of these estimated variables and parameters using remotely sensed data. The approaches are: (1) remotely-sensed data to determine these variables will be obtained from field, aircraft and spaceborne measurements; (2) physically based models to use these data to infer the hydrological fluxes and parameters will be written and calibrated using these data and will be used to investigate the spatial variability of these quantities. Expected results are: (1) Special Sensor Microwave Imager (SSM/I) data set for vegetation and snow volume will be produced to continue Scanning Multichannel Microwave Radiometer (SMMR) data set; (2) surface model for decadal global hydrological cycle model will be tested; (3) experiment conducted in Botswana to test energy balance modelling in tropical savanna grasslands.

**W89-70548** **677-22-28**
Goddard Space Flight Center, Greenbelt, Md.
**HAPER AND FIFE PLANNING**
R. J. Gurney 301-286-5480
(677-22-27)

The objectives of this work are to determine the capability of extracting quantitative estimates of land surface parameters from satellite radiance observations. These parameters include components of the surface energy balance such as albedo, latent and sensible heat fluxes, surface temperature and insolation. Approaches are: (1) analyze existing satellite data, e.g., NOAA Advanced Very High Resolution Radiometer (AVHRR), Nimbus Scanning Multichannel Microwave Radiometer (SMMR), and LANDSAT Multispectral Scanner (MSS) for land surface parameters; and (2) analyze data from coordinated field experiments in which satellite, aircraft and surface determinations of land parameters are intercompared. These efforts are part of the International Satellite Land Surface Climatology Project (ISLSCP). Expected results are: (1) data from the Hydrologic and Atmospheric Pilot Experiment (HAPEX) will be analyzed to estimate regional evaporation during the experiment; (2) an eight year set of data from Nimbus-7 SMMR will be used to understand soil moisture mass balance and vegetation over the Sahel zone of Africa; and (3) data from the First ISLSCP Field Experiment will be analyzed to estimate regional evaporation during the experiment.

**W89-70549** **677-22-29**
Goddard Space Flight Center, Greenbelt, Md.
**FIRST ISLSCP FIELD EXPERIMENT**
Forrest G. Hall 301-286-2974
(677-22-27; 677-92-22; 677-21-36)

The objectives of this RTOP are: (1) to better understand the interaction between vegetated land surfaces and the atmosphere, specifically how the surface vegetation, topography and soils control the magnitudes of the components of the surface energy budget; (2) to better understand how the relationships which express these controls scale from a point to an area level; (3) to better understand how to use satellite remote sensing to monitor the components of the surface energy budget. Approaches are to acquire simultaneous satellite (AVHRR, SPOT, LANDSAT, etc.), aircraft (spectral, material and energy flux through the atmospheric boundary layer) and surface observations of radiometric, atmospheric, meteorological, hydrological and biophysical parameters of vegetation and soil at sufficient temporal and spatial resolution and over a large enough area to permit proper comparison of satellite derived quantities with actual surface conditions. Expected results are improved weather and climate forecasting; improved understanding of how vegetation modifications affect the global climate; improvement in interpretative techniques; a refinement in ground measurement techniques and improvement in methodology to permit the further execution of experiments on a variety of land surfaces.

**W89-70550** **677-24-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**JPL REMOTE SENSING SCIENCE PROGRAM**
D. L. Evans 818-354-2418

The goal of the Remote Sensing Program is to develop basic knowledge of electromagnetic radiation interactions with terrestrial materials for the purpose of deriving or inferring land phenomena from satellite acquired remotely sensed observations. This RTOP covers research designed to: (1) develop and validate theoretical models of EM/land interactions; (2) develop methods to separate the atmospheric and surface components of remotely sensed measurements; (3) identify and specify land biophysical parameters which may be derived or inferred from remotely sensed observations and develop methods which may be used for this purpose; and (4) incorporate this knowledge in discipline-specific studies through communication and collaboration with other Land Processes investigators.

**W89-70551** **677-24-01**
Ames Research Center, Moffett Field, Calif.
**REMOTE SENSING SCIENCE PROGRAM**
J. G. Lawless 415-694-5900

The objective of this project is to investigate the information in the polarized light scattering characteristics of leaves and plant canopies. The effect of the atmosphere on polarized light from plant canopies will be investigated. The approach involves studies conducted at three levels; laboratory, field, and aerospace. In the laboratory and field phases of the research, both single leaves and plant canopies will be measured allowing comparison of their spectral polarized light scattering properties and their physiological and morphological characteristics. The aerospace portion of the research will be conducted with the aid of a specially modified polarization scanner which will be flown on the ER-2. Targets of known light scattering characteristics will be measured on the ground and from the ER-2, thereby allowing the effect of the disturbing atmosphere to be better understood and modelled.

**W89-70552** **677-24-01**
Goddard Space Flight Center, Greenbelt, Md.
**REMOTE SENSING SCIENCE PROGRAM**
Harold Oseroff 301-286-9538

The Remote Sensing Science Program is conducted to improve the general scientific understanding of the energy emitted or reflected from an earth surface target, through the intervening atmosphere as measured by a remote sensing system. It is designed to provide a foundation upon which new, more advanced satellite and aircraft remote sensing instruments and interpretive techniques can be developed. At its heart is developing an understanding of the physical processes whereby radiant energy is emitted or reflected from earth land surface targets and the relationships of the measurable radiant energy to important biophysical attributes and processes. Goddard Space Flight Center responsibility includes the project management and several of the fundamental research tasks. Seeking new research and evaluating proposals; monitoring continuing studies; and conducting workshops, progress review meetings and conference technical sessions, as well as performing the necessary procurement activities will be continued in a manner similar to previous years. Continued advancement of the state-of-the-art of theoretical models that predict radiant energy response from earth surfaces and improvement in empirical characterizations that lead to the formulation of mathematical process models, which relate reflected and emitted radiation to scene attributes, are expected from this effort.

**W89-70553** **677-24-02**
Goddard Space Flight Center, Greenbelt, Md.
**LEAF BIDIRECTIONAL SCATTERING AND ABSORPTION STUDIES**
Thomas W. Brakke 301-286-3851

A three year research effort is proposed to develop model abstractions and corresponding calculational procedures to estimate individual leaf spectral bidirectional reflectance and transmittance distribution functions as a function of leaf type, morphology and basic constituents. An experimental data base to support model development and validation and to document leaf scattering profiles will be developed concurrently. Modeling efforts will begin with three published abstractions: (1) the simple flat plate model that represents the leaves as a series of layers with different optical properties; (2) a six compartment flow Markov transition matrix model with individual probabilities calculated from leaf constituent dimensions and absorbing properties; and (3) a Monte Carlo ray tracing model utilizing primarily geometric optics to trace interactions among the major internal leaf components. The data base will be developed using a laboratory goniometer with illumination providing a few discrete wavelengths at high angular resolution using visible and near infrared laser sources. Individual leaf spectral scattering functions will be documented and related to leaf structure and spectral absorption features. The incorporation of such leaf scattering functions into canopy reflectance models should increase their realism by supplanting the simplistic assumption of Lambertian scattering behavior for leaves.

**W89-70554** **677-29-12**
Goddard Space Flight Center, Greenbelt, Md.
**TOPOGRAPHY FROM SEASAT AND GEOSAT OVERLAND ALTIMETRY**
Herbert Frey 301-286-5450

The objectives of the RTOP are as follows: to determine the accuracy and quality of topography derived from SEASAT and GEOSAT overland altimetry on a global basis; to develop techniques to selectively combine data from SEASAT and GEOSAT overland altimetry; and to produce a uniform, high quality global topographic data set in both gridded and profile form and make this data set available to the scientific community for both global and regional studies. The approach will be as follows: to evaluate the extent of the attitude and acquisition problems experienced by GEOSAT in terms of amount of useable overland data recoverable from this mission; to retrack selected portions of the GEOSAT overland altimetry data and merge this with the data already produced by us from SEASAT; to produce global and continental-scale topographic maps after removal of the geoid and correction for slope-induced error; to evaluate the accuracy of these by cross-over analysis on a continent-by-continent basis and by detailed comparison of the profile data with existing high quality topographic contour maps produced locally for each continent; to produce contour maps derived from the satellite altimetry maps for each continent along with maps showing quality of the mean values derived for each grid point, and make these maps as well as the profile data available on magnetic tape for other users. The expected results are a global topographic data set of uniform, high quality derived from a single type of measurement, referenced to a common base with knowledge of both the intrinsic accuracy and its variability with region.

**W89-70555** **677-41-03**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**MULTISPECTRAL ANALYSIS OF SEDIMENTARY BASINS**
H. Lang 818-354-3440

The primary objectives of this RTOP are to: (1) refine geological understanding of the formation and evolution of the Wind River/Bighorn Cordilleran Foreland Basin area, Wyoming; (2) evaluate combined utility of remote sensing conducted at visible-microwave wavelengths for mapping strata, defining stratigraphic sequences and modeling facies, delineating geologic structures and inferring tectonic regimes, determining Quaternary soil/terrace genesis and stratigraphy; (3) compare lithologic and structural information from remotely sensed data with that obtained from conventional field mapping, borehole and geophysical data; (4) use results to test geophysical crustal models and to develop strategy for integrating remote sensing and conventional data for quantitative basin analysis; and (5) apply methods developed in Wyoming to west central Mexico. The approach is to perform the following as a collaborative effort by investigators from Geology and Cartographic Groups at JPL and 10 other organizations: acquire and coregister remote sensing data from orbital and airborne systems and conventional data to define stratigraphic units, map facies and determine their physical and mineralogical attributes in order to infer environments of deposition and paleogeography, and map structure in order to infer tectonic evolution. Field and laboratory studies of geological, spectral and botanical conditions will be performed to support analysis and interpretation of remote sensing data. In FY89, we will organize a workshop to include individuals with expertise in basin analysis and modeling, and individuals with detailed knowledge of the stratigraphy and structure of the study areas. The workshop will provide an opportunity to identify critical gaps in current understanding of basin evolution and topical geological problems in the study areas, and assess utility of geological information derived from remote sensing for addressing these problems. Workshop results will be published and used to refine the experimental plan for subsequent fiscal years.

**W89-70556** **677-41-07**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**REMOTE SENSING OBSERVATIONS OF GEOMORPHIC INDICATORS OF PAST CLIMATE**
T. G. Farr 818-354-9057

The goal of the proposed research is to use remote sensing data to extend local records of climate change over the last 2 million years throughout the arid southwestern United States and other arid regions of the earth. The specific objectives are as follows: (1) to determine the extended spectral signatures of desert piedmont surface of different ages using multisensor remote sensing data in areas where these surfaces have been dated; (2) to determine the effects of surficial modification processes on extended spectral signatures in areas where the types, rates, and magnitudes of modification processes and their changes with time have been determined so that the results of (1) may be extended to surfaces of different age in other areas; (3) to use this information to correlate and map the distribution and ages of geomorphic indicators of climate change on desert piedmont surfaces over the southern Great Basin (Mojave Desert, eastern California, and southern Nevada); and (4) to develop a regional chronology of climate change based on the maps and ages. The first year of this study will concentrate on the development of extended spectral signatures of dated type-surfaces at several sites and an evaluation of how surficial modification processes affect these signatures. Sites will include Death Valley, Owens Valley, and Cima volcanic field, Chicago Valley, and Vidal Valley, California; Kyle Canyon, Spring Valley, and Yucca Valley, Nevada; and others, as field data become available. The second year will concentrate on the use of the signatures to correlate and map geomorphic surfaces throughout the southern Great Basin. Detailed comparisons will be made between our maps of past land conditions and those derived by others with GCM. This proposal covers the continuation of a basic research effort at JPL on Rock Weathering in Arid

Regions. It represents the efforts of two researchers in the Radar Science Group.

**W89-70557** **677-41-29**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**MULTISPECTRAL ANALYSIS OF ULTRAMAFIC TERRAINS**
M. J. Abrams 818-354-0937

Ophiolites are the on-land occurrences of oceanic crust, obducted onto the continents during collision or caught up in suture zones marking the loci of paleo-oceans. They provide the only opportunity to study directly the processes of oceanic crust formation, emplacement, and metamorphism; and they provide indicators of past tectonic assembly of continental fragments. The objectives are to use a combination of remote sensing data, field work, and laboratory analyses to address geologic problems related to crustal evolution. In the Semail ophiolite in Oman, Thematic Mapper data have been used to: identify sea-floor faults, emplacement faults, and post-emplacement structures to understand the deformational processes involved in oceanic crust obduction; and to determine the Quaternary fan history of the coast as it relates to regional tectonics. Field work will be done to verify these findings, refine conclusions, and reinterpret data. In addition, we will examine distribution of alteration in dike/volcanic sequence to determine 3-D pathways of seafloor fluid circulation. In Tibet, Thematic Mapper and Spot data will be used with field work and dating to determine: the tectonic history of the Karakoram fault, one of the major tectonic features related to the collision of India with Asia; the history of the Bangong-Nujiang suture zone, the site of a Jurassic ocean closure which was reactivated as a strike-slip fault during Indian-Asian collision; and to synthesize this information into tectonic models for deformation of Tibet.

**W89-70558** **677-43-09**
Goddard Space Flight Center, Greenbelt, Md.
**ARCHEAN SUBPROVINCES**
Robin Bell 301-286-3621

The objectives of this RTOP are as follows: (1) to utilize knowledge gained from remote and ground datasets, and to determine whether evidence supports the hypothesis that the Quetico/Wabigoon Archean subprovince boundary marks a major tectonostratigraphic boundary; (2) to document the relationships between forest assemblages, soil and rock type and spectral signatures in a Boreal ecosystem study area (in support of 3); (3) to assess usefulness of a multidisciplinary approach (multi-technique/multi-scale) to a regional tectonic problem. Should evidence suggest that the subprovince boundary marks an ancient suture zone, the implication is that modern plate tectonics theory is applicable to the Archean geodynamics regime (in support of 1). Petrological and geochemical laboratory analyses will continue on rock samples returned from study area, and, along with soil textural and geochemical analyses, will be used to quantify any parent rock geochemical-soil-vegetation associations documented through vegetation field mapping data. Ground truth collected during FY87/88 will be used in remote sensing data analyses directed towards refining knowledge of lithologic nature and distribution patterns with a focus on ultramafic rocks. Ultramafic laboratory analyses will yield information on tectonic setting along and across the fault zone.

**W89-70559** **677-43-21**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**USGS NATIONAL MAPPING PROGRAM: COLORADO PLATEAU-BASIN AND RANGE TRANSITION**
M. J. Abrams 818-354-0937

This RTOP is in collaboration with the U.S. Geological Survey National Geologic Mapping Program project: Basin and Range-Colorado Plateau Transition, P. I. Dr. Robert Scott. The study area in Nevada/Utah/Arizona provides an opportunity to study the tectonic and magmatic evolution of an area of extreme contrasts in compression, magmatism, and extension; and to elucidate the transition between two major geologic provinces. Secondary objectives are to: determine kinematic relationships of strike slip and high angle faults in an extensional terrain; define the limits of the eastward-migrating Sevier thrust belt; study the relationship between Holocene volcanoes and an active earthquake belt. Our contribution to this project is to provide processing and interpretations of Thematic Mapper imagery and aircraft data for the 40 participating field geologists. Our data will be integrated with field mapping, will be used as base maps, and will help determine areas for detailed field mapping and sampling. Two TM scenes will be obtained covering the 8 half-degree quadrangles which are being mapped over the next five years, at a scale of 1:100,000. Processing will be done to enhance the display of lithologic and structural information. In the second year, aircraft data (TIMS and AVIRIS) will be acquired over critical areas for stratigraphic definition. This work will be done in collaboration with Drs. Podwysocki and Rowan at the USGS, Reston, and will re-establish a long-standing professional collaboration between NASA/JPL and the USGS.

**W89-70560** **677-43-21**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**REMOTE SENSING STUDY OF THE TECTONICS OF THE SOUTHWEST**
R. Blom 818-354-4681

The objectives of this RTOP are to apply state-of-the-art remote sensing methods and data to tectonic problems of the southwestern U.S. We are concentrating on study of neotectonic features related to the current strike slip regime, and on detachment terranes from the preceding extensional orogen. Neotectonic objectives include the following: the accommodation of strike-slip motion across the Mojave and Borrego Deserts are in question. Using remote sensing imagery, geophysical data sets and field work we will locate and document strike-slip faulting in these areas. We will also evaluate terrane rotations in portions of the Mojave where conventional field methods are difficult and tedious to use. Extensional tectonics objectives include the following: previous work has concentrated on distinguishing upper and lower plate rocks. In cooperation with our collaborators, this work will continue in selected areas and we will work on regional synthesis. The concentration will be on extracting information from remote sensing data sets within the upper and lower plates. Upper plate rocks, where sedimentary, contain the extensional history. Lower plate rocks record the history of their uplift. Work to date indicates that useful information on both plates can be extracted from remote sensing data sets when coupled with field and laboratory work. Our approach consists of acquisition, processing and analysis of remote sensing data followed by field and laboratory work. This work will be carried out in cooperation with our collaborators who are working on parallel tasks funded by NASA, NSF and other agencies. LANDSAT Thematic Mapper images, especially when registered to panchromatic SPOT images, and SEASAT radar data have proven most useful. Advanced remote sensing data from AVIRIS and the DC-8 SAR are also being requested for particular study areas.

**W89-70561** **677-43-24**
Goddard Space Flight Center, Greenbelt, Md.
**TOPOGRAPHIC PROFILE ANALYSIS**
James B. Garvin 301-286-6565

This project will quantitatively analyze high-resolution topographic profiles obtained from aircraft laser altimetry, in order to explore and define fundamental wavelengths associated with dynamic surface processes such as volcanism and coastal erosion. Heretofore unavailable topographic data will be acquired, processed, and interpreted by means of a Goddard Space Flight Center (GSFC) aircraft laser altimeter (1 to 10 m footprints, approximately .5 m vertical precision) and, will for the first time, permit exploration of the spectral topographic (and slope) properties of coastal erosion and active volcanism. Data has or will be obtained from the GSFC aircraft laser altimeter (developed by J. Bufton of Code 674 and colleagues) for selected targets including youthful volcanics (SP flow/cone, Surtsey) and coastal erosion features (Delmarva barrier islands and Nauset/Monomay at Cape Cod). High resolution (spatial and vertical) topographic profiles will subsequently be analyzed by means of classical spectral analysis and interpreted. Dominant wavelengths associated with specific terrains and processes will thus be defined; such data can then be used as boundary conditions in mechanical models for certain landforms. Major FY89 activities will emphasize coastal erosion by means of establishing a database of transverse beach profiles.

**W89-70562** **677-43-25**
Goddard Space Flight Center, Greenbelt, Md.
**STUDIES OF VOLCANIC SO2**
Louis S. Walter 301-286-2538
(673-41-20)

The goals of this RTOP are as follows: (1) to expand understanding of volcanic processes; (2) to examine the geochemistry of sulfur; and (3) to investigate SO2 emissions as precursors for predicting violent eruptions. Its objectives are: (1) the quantitative determination of volcanic SO2 emissions; (2) determination of temporal variations of such emissions; (3) global tracking of volcanic SO2 clouds; and (4) definition of requirements for future sensors and missions for SO2 measurements. Data from this work will also be useful in studies of the atmospheric chemistry of sulfur and related compounds. The approach taken will be to improve empirical algorithms for quantifying low levels of SO2 emissions; establish accuracy of SO2 measurements using the Total Ozone Mapping Spectrometer data through comparison with data from ground and aircraft measurements; estimation of global volcanic emission of SO2 and rate of deposition in the oceans and definition of future sensor/system requirements based on observational characteristics determined in this study.

**W89-70563** **677-43-25**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**REMOTE SENSING OF VOLCANIC FEATURES**
D. C. Pieri 818-354-6299

Under this RTOP, we plan to continue acquisition and analyses of multispectral data on active and emplaced volcanic features with attention to the thermal infrared (e.g., Thermal Infrared Multispectral Scanner-TIMS; Inframetrics 525). In particular, we are investigating the relationship between remote data (e.g., TIMS, Airborne Imaging Spectrometer-AIS, Zeiss, radar) and the spectral-physical characteristics and processes of active and emplaced volcanics (e.g., composition, surface texture, formation parameters). Underway currently is a morphology/process-model/spectral comparison of Hawaiian and Italian volcanic shields, as well as thermal analysis of high-risk calderas in New Mexico and Italy. We are drawing on data and techniques already acquired and proven by the JPL Geology Group, plus ongoing work in theoretical and applied volcanology by the author and other JPL co-workers. Ultimately we hope to utilize these techniques from earth orbit to address basic volcanological problems, as well as global habitability and societal risk concerns, particularly with regard to high-energy explosive volcanic events.

**W89-70564** **677-43-26**
Goddard Space Flight Center, Greenbelt, Md.
**COASTAL PROCESSES - NILE DELTA**
Patrick T. Taylor 301-286-5412

The objectives of this RTOP are to assess and evaluate the rapid changes in coastal morphology occurring at the mouth of the Nile Delta. These changes result from both active erosion of the sediment-starved delta and coastal subsidences. The latter results from sediment loading and increasing sea level. Before the completion of the Aswan High Dam in 1964 approximately 80 to 100 million tons of sediment were deposited annually on this delta; since then the sediment load has been effectively zero. Rapid and significant erosion of the delta has been the result of this change in sedimentation. Our plan is to chart, in detail, these patterns of coastal change with the ultimate goal of producing a predictive model. The approach will be to inventory all remote image data bases (14 years of Multispectral Scanning, 4 years Thematic Mapping, 1 year Speed Position and Track) to establish chronology of coast line change. We also plan to precisely register data to best available geodetic control. Where possible, we will compare consecutive images to establish precise yearly changes. Using annual changes, we will establish a pattern of coastal change. For ground truth information we will consult Smithsonian Institution Egyptian Drilling Program (Dr. D. J. Stanley) and SIO Southeastern Mediterranean project (Dr. D. L. Inman). We expect to consult with other university (e.g., Delaware), government (e.g., Code 623, 624, and NSTL) and other groups working in this region. For example, IWACO, a Dutch company, under contract to the Netherlands AID and working for the Egyptian Irrigation Board. IWACO is also working with the USDA. Using information from the different images we will attempt to evaluate the relative sand/silt ratio in unvegetated regions of the delta.

**W89-70565** **677-43-27**
Goddard Space Flight Center, Greenbelt, Md.
**EAST AFRICAN RIFT TECTONICS AND VOLCANICS**
James R. Heirtzler 301-286-5213

The collection of geological, geophysical, and remote sensing datasets, in digital form, for the entire east African Rift will permit the understanding of recent tectonic development of this first order continental rifting process. When one notes the similarities to the undersea parts of the worldwide rift system, one will be able to study typical rifting processes and their continued development on dry land and with remote sensing techniques. Various geophysical data sets, including topographic, magnetic, volcanic, seismic and heat flow, will continue to be put in compatible digital formats. Geological maps will continue to be collected. Remote sensing tapes will be inventoried and selective images processed and printed. We anticipate that initial study will be directed at three geographic areas and these results used as guides to much of the entire rift system.

**W89-70566** **677-43-27**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**AFRICAN TECTONICS**
T. H. Dixon 818-354-4977

The objectives of this RTOP are: (1) to understand processes and rates of late Precambrian continental evolution and growth in Northeast Africa-Arabia; (2) understand development and evolution of Tertiary-Recent Red Sea rift in context of a propagating rift model in heterogeneous lithosphere; and (3) to evaluate utility of various remote sensing data sets in the region for attacking the above problems. The approach will be to: (1) generate regional image mosaics; (2) obtain, process and interpret detailed remote sensing images in key areas; (3) perform field mapping and ground verification studies in selected areas; and (4) generate quantitative models constrained by above data.

**W89-70567** **677-43-28**
Goddard Space Flight Center, Greenbelt, Md.
**MID-OCEAN RIDGE VOLCANISM IN SW ICELAND**
James B. Garvin 301-286-6565

The subaerial expression of mid-ocean ridge (MOR) basaltic volcanism occurs uniquely in the Reykjanes region of SW Iceland. This project is intended to explore the various volcanic eruption styles by means of advanced remote sensing techniques and petrologic data. The prime emphasis will be on the causes for variations in lava flow morphology, on the fracture mechanics of tectonic fissures, and on the origin of small Icelandic lava shields. The synergisms of airborne laser altimetry, SAR, and thermal IR data will be explored. Airborne laser profiles of the microtopographic characteristics of the most youthful lava field in SW Iceland, together with DC-8 SAR and ground observations, will be used to quantify variations in surface texture, deformation wavelengths, and to assess lava yield strengths. Comparisons with data for older flows related to lava shields and with lavas on Surtsey will be investigated.

**W89-70568** **677-45-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**EVOLUTION OF VOLCANIC TERRAINS**
A. B. Kahle 818-354-7265
(677-80-23; 677-43-25)

The long-range goals of this project are twofold: (1) to study the historic and prehistoric eruption histories of a number of young volcanic centers including frequency and nature of eruptions, current potential for eruption, and changes in volumes, rates and chemistry; (2) to develop and evaluate the use of weathering histories of lava flows to infer paleoclimatic conditions. The specific objectives this year are: (1) map selected historic and prehistoric flows on Hawaii, in collaboration with personnel from the USGS HVO (Lockwood); (2) study very young flows on Hawaii (1984 Mauna Loa, 1985 Puu'Oo) to determine degree of separability of units based on initial states, using remote sensing techniques, and to determine the very early weathering changes; (3) quantify weathering characteristics for a number of dated flows of varying compositions in different climatic settings in Hawaii, Italy and the western U.S. as determined by remote sensing; and (4) initiate study of the TransMexican Volcanic Belt in collaboration with Dr. Michael Sheridan and students of Arizona State University. Our approach is to first establish the physical basis for both compositional mapping and the determination of age relationships using remotely sensed data from volcanoes where the eruptive history and composition are well documented (in Hawaii). We will then test and continue the development of these relationships in other well known volcanic areas of different composition, eruptive styles, and weathering regimes (western U.S. and Italy). We will then extend the work to poorly known volcanic areas globally. One first such area will be the TransMexican Volcanic Belt. Others and future years may include Icelander, S. American or Alaskan volcanics as opportunities and scientific rationale are identified.

**W89-70569** **677-45-03**

Goddard Space Flight Center, Greenbelt, Md.

**SOURCES OF MAGNETIC ANOMALY FIELD**

Patrick T. Taylor 301-286-5412

The objectives of this RTOP are to study the short wavelength magnetic anomaly field recorded at satellite altitude and to interpret these data in terms of crustal geology and tectonics; and to develop and improve anomaly reduction and analysis methods for use with the MAGSAT data and future near-earth magnetometer missions (e.g., GRM or Tether). The approach will use methods and techniques previously developed to reduce and interpret MAGSAT data, i.e., computing anomaly maps for significant geologic and tectonic regions. These data are interpreted with reference to the geometry and the contrasting magnetization. Geologic inferences or interpretations are made from the parameters which produce the most plausible match with the observed field. Higher order interpretation methods permit us to make inferences as to the character and mode of magnetization; that is, we determine if remanent magnetization is important or if the means of magnetization is induced for TRM or VRM. Petrologic character is used to determine possible source-rock types. Unlike other geologic interpretation, we have made use of the vector components (north-south, east-west and vertical) to aid in source region isolation and magnetization studies. This RTOP represents an integrated interpretation approach to the study of MAGSAT data.

**W89-70570** **677-45-06**

Goddard Space Flight Center, Greenbelt, Md.

**DETERMINATION AND INVERSION OF CRUSTAL MAGNETIC FIELDS**

Robert A. Langel 301-286-6603

The basic objective of this program is to isolate crustal fields from the core and external fields and to model the isolated crustal fields in terms of geophysical parameters. This requires understanding the nature and limitations of satellite magnetic field data, collection of and comparison with data from aeromagnetic and ship magnetic surveys, and evaluation of the effects of external fields. Consequences of satellite data limitations for interpretation are to be investigated. The approach consists of: (1) the development of suitable data selection and filtering criteria; (2) estimating or modeling external fields and correcting the data where possible; (3) collecting and collating alternative data for comparison and joint analysis; and (4) developing and evaluating analyses techniques.

**W89-70571** **677-45-09**

Goddard Space Flight Center, Greenbelt, Md.

**MAGNETIC PROPERTIES OF CRUSTAL MATERIALS**

Peter J. Wasilewski 301-286-8317

For a number of years, the Goddard rock magnetism facility conducted pioneering works on xenoliths, tectonically exposed crustal sections, and other sample sequences. Out of this research a magnetic petrology paradigm emerged. Synergism between petrologists and the Goddard rock magnetism facility is a requirement and is achieved because of the mutual benefits to be derived. The principle objective is to formalize magnetic petrology and to demonstrate the effectiveness of the approach in enhancing the usefulness of magnetic anomalies for geoscience research and to provide the scientific basis for future satellite magnetometer missions in orbit at altitudes lower than MAGSAT. A team of petrologists will conduct conventional petrographic examination of specific sample sets chosen to elucidate specific geologic contexts such as, for example, prograde and retrograde metamorphism. The one exception is that oxide petrology is emphasized. This results in a more complete petrography and ensures a basis for direct integration with magnetic property studies. The same samples are then studied in the magnetic properties laboratory. The resultant petrography and magnetic properties are then subject to geologic synthesis. This will allow us, for example, to realistically model the magnetic structure of the downgoing oceanic crust at a convergent margin.

**W89-70572** **677-46-02**

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

**CHARACTERIZATION OF GEOLOGIC SURFACES USING MULTIPARAMETER AND INTERFEROMETRIC RADAR DATA**

D. L. Evans 818-354-2418

The ability to characterize the physical nature of the earth's surface and cover is fundamental to many Earth Science investigations. For example, the Committee on Earth Sciences of the National Research Council Space Science Board recommended that one of the key objectives of this kind requires large scale mapping of both composition and morphology. While many sensors have become available in the past decade that make this sort of mapping possible, data analysis and interpretation tools have not been developed to the extent required to meet this objective. Specifically, while the role of radar in geologic remote sensing has been outlined in several documents, the detailed strategy for using SAR data in geologic process studies is not well-established. In addition, while the importance of high resolution land surface topography (up to 10 cm height 30 m horizontal resolution accuracy) for geologic mapping has been stressed by several NASA planning committees, methods for acquisition and reduction of these data in a routine manner need to be developed. The goal of this proposed research is to establish a quantitative link between geologic parameters and information derived from multiparameter synthetic aperture radar (SAR) measurements. The specific objectives of the proposed research are: (1) to develop quantitative methods to extract and interpret geologic characteristics such as surface roughness and geometry, subsurface conditions, and vegetation density from multiparameter radar images; (2) to develop and implement data analysis tools for interpretation of SAR data alone and in conjunction with data acquired with other sensors using transportable workstation software that can be distributed to other investigators analyzing airborne and spaceborne SAR data; and (3) to develop tools for derivation and analysis of high resolution topographic (1 m) and topographic change (1 cm) information using radar interferometry data from both airborne and spaceborne platforms.

**W89-70573** **677-80-03**

John C. Stennis Space Center, Bay Saint Louis, Miss.

**MULTICENTER AIRCRAFT SCHEDULING DATABASE**

K. D. Cashion 601-688-1930

The objective of this RTOP is to establish an integrated, multicenter low/medium altitude aircraft/sensor mission scheduling system database. The purpose of the database would be to add insight, disperse information, and enhance understanding, but not transfer any present organizational responsibilities. A straightforward PC-based system would be established to maintain a catalog of simplified mission requests. The database could be queried by mission managers, funding offices, peer review panels, etc. This database would make all mission opportunities visible to all interested parties and thereby satisfy some of the needs of the overall community of remotely sensed data users. The database would list desired missions, their level of approval, and priority; sensor and platform location, status, and schedule; and a matrix listing mission requirements and the least necessary (the most cost-effective method) to meet each mission's requirements.

**W89-70574** **677-80-06**
Ames Research Center, Moffett Field, Calif.
**RESOURCE OBSERVATION APPLIED RESEARCH AND DATA ANALYSIS-GENERAL SUPPORT**
J. G. Lawless 415-694-5900

The objective of this work is to provide general support to NASA's science program in Terrestrial Remote Sensing. This RTOP will insure that supplementary support is provided for the operation of Ames Research Center's (ARC) Image Processing Laboratory (IPL). Additionally, support will be provided for planning activities related to Terrestrial Remote Sensing Program usage of ARC's science applications aircraft. The approach will be to provide support to the IPL in the form of funding for ongoing computer equipment replacement and upgrades. Support for aircraft use planning will be provided by allotting staff support necessary for regular meetings of the Land Aircraft Science Management Operations Working Group (LASMOWG).

**W89-70575** **677-80-09**
Goddard Space Flight Center, Greenbelt, Md.
**LANDSAT DATA**
Stuart Locke 301-286-5411

The objectives of this RTOP are to provide data processing and analysis support for the Landsat and further the earth resources investigations programs. This support intends to conclude the efforts begun in 1984 when NASA Headquarters issued an Announcement of Opportunity soliciting LANDSAT Thematic Mapper investigations. The support will continue for NASA research personnel and their collaborators who are substantially involved in the use of LANDSAT and other earth resources image data. Documentation of final results from the currently concluding investigations program will be included as an integral part of this RTOP task. It is proposed that a browse capability with complete LANDSAT archives be maintained, and expanded to encompass other earth resources data. While the Landsat Final Results Workshop is currently scheduled for August, 1989, investigators will be permitted use of processing and analysis facilities until contract closeout, which may be as late as the end of December, 1988. In-house and Headquarters-sponsored NASA investigators and their collaborators will be assisted in their efforts to use LANDSAT and other earth resources data for research through facilities furnished through this RTOP. As the formal Landsat investigations approach conclusion, substantial effort will be made to document results, significant accomplishments, and conclusions in a widely disseminated comprehensive publication. It is proposed that the Browse Facility be continued, to provide NASA earth resources data users the opportunity to communicate their data requirements to knowledgeable, technically oriented people who can provide cogent analysis of data sources, costs, availability, acquisition parameters, and predictions of test site coverage success.

**W89-70576** **677-80-19**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**LAND PROCESSES ADVANCED STUDIES/DVS**
D. J. McCleese 818-354-2317

The objective of this task is to support the NASA Land Processes Branch in the development and scientific use of remote sensing techniques to study land processes phenomena as they shape our biologic and geologic environment. The approach will consist of three aspects: (1) invite distinguished scientists in the field to spend some time (a few weeks to a few months) at JPL to work with JPL scientists; (2) support new ideas and approaches to the level of allowing the submission of viable proposals for peer review; and (3) organize symposia on Advances in Earth Observation from Space.

**W89-70577** **677-80-20**
John C. Stennis Space Center, Bay Saint Louis, Miss.
**REPLACEMENT OF SSC REMOTE SENSING AIRCRAFT**
K. D. Cashion 601-688-1930

The objective of this RTOP is to create a more cost-effective, low/medium altitude aircraft remote sensing program NASA-wide by upgrading the Stennis Space Center (SSC) aircraft program. The approach taken will be to replace the present SSC Gates Learjet Model 23 with a Gates Learjet Model 35 or 36. The Model 35/36 will be modified to utilize dual, existing scanners as well as an aerial camera. By doing so many missions presently performed by larger, slower aircraft with a larger crew complement can be performed by a smaller, faster aircraft with fewer crew members. Overall flexibility of scheduling missions, acquiring data, and utilizing SSC aircraft will be greatly enhanced with substantial savings in overall SSC aircraft funds over the next three-to-five year period.

**W89-70578** **677-80-22**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**IMAGE PROCESSING CAPABILITY UPGRADE**
R. Alley 818-354-6363

The objective of this RTOP is to upgrade the facilities available to the geology group for image processing and analysis of samples. The current operational image processing computer system consists of the group's VAX 11/750 computer, 1.2 gigabytes of disk storage, 1 tri-density high-speed tape drive, 1 medium density tape drive, an interactive color image processing workstation, as well as the TAE-VICAR2 and DIPIX image analysis software package. The VAX 11/750 is on a network which also includes the JPL PLDS microvax (PLDSJ1), the AVIRIS VAX and AVIRIS Sun workstation. Upgrades to the geology group's facilities that are required this year include additional disk storage, a high-density tape drive, as well as maintenance services for the group's VAX computer. The approach to be taken in this project consist of the purchase of maintenance services as well as additional disk space and a high capacity digital storage device (high-density tape or optical disk). The high capacity storage device will help both the computer system as well as the facilities because of the smaller space requirement for offline storage.

**W89-70579** **677-80-23**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**THERMAL IR OPERATIONS**
A. B. Kahle 818-354-7265

The main objectives of the proposed research are: (1) to develop, implement and test new algorithms for TIMS data analysis; (2) to maintain the current level of support of the TIMS user community including aid in use of TIMS data and laboratory and spectroscopic support; (3) to encourage more widespread use of TIMS data and expand collaboration with researchers who are using TIMS data; (4) to continue calibration and documentation of the TIMS instrument; and (5) to investigate the utility of TIR imaging spectrometer via TIIS (Thermal IR Imaging Spectrometer). We will continue to refine methods to derive quantitative physical units from the TIMS data; the objective is to produce accurate surface radiance images on a routine basis. We will make detailed comparisons of image results with data from laboratory and field instruments. We will also begin working on algorithms integrating TIMS data with those acquired by the TIIS instrument and other high resolution thermal infrared scanners, and determine how to best utilize these data sets. Our approach for derivation of accurate surface radiance determinations will involve first the implementation of LOWTRAN7 to replace LOWTRAN6. Topographic information will be integrated into the model. Various approaches to atmospheric corrections will be implemented and compared to the base model results, including utilizing natural blackbodies such as vegetation and water bodies. With the accurate surface radiance values, we will examine, along with scientists from CSIRO, Australia, different ways of separating the effects of emissivity from the effects of temperature. Present level of support to other TIMS users will be maintained, including calibration, documentation, spectroscopic and image analysis support. Modification of the AIS to TIIS will continue.

**W89-70580** **677-80-25**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**IMAGING SPECTROMETER OPERATIONS**
G. Vane 818-354-2851

The general objective of this RTOP is to routinely collect, process and distribute calibrated AVIRIS data for two dozen NASA investigators conducting research in earth remote sensing. The spectral region of interest is the 0.41 to 2.45 micrometer region, sampled at approximately 10 nanometers spectral sampling interval. The specific objectives covered by the six tasks under this RTOP include: (1) overall coordination of AVIRIS operations; (2) maintenance of the AVIRIS instrument; (3) complete spectral, radiometric and geometric calibration of the AVIRIS system; (4) routine performance evaluation of the system; (5) archival and retrieval processing of high density flight tapes; (6) timely distribution of data products to investigators; (7) support to investigators visiting JPL to use the AVIRIS computer facility for data analysis' (8) upgrades to the Spectral Analysis Manager (SPAM) software; (9) completion of the AVIRIS system for long-term operations; and (10) operation and maintenance of PIDAS in support of AVIRIS investigators, and partial payback of the JPL loan for the purchase of PIDAS from Caltech. The approach to meeting these objectives is based on utilizing the expertise of a selected number of individuals who were instrumental in the development of the AVIRIS and PIDAS systems. The operations team consists of the AVIRIS instrument and data system engineers and key members of their staffs. The calibration lab includes the equipment and facilities purchased or developed under system development funding, and SPAM upgrade will be done under the chief architect of the original software. A more detailed discussion of the approach to each of the six tasks under this RTOP is included in the attached T43s.

**W89-70581** **677-80-26**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**CONCEPTUAL STUDIES OF AIRBORNE MULTI-ANGLE IMAGING SPECTRORADIOMETRY**
D. J. Diner 818-354-6319

The objective of this task is to establish the design of an airborne experiment for acquiring multiangle imagery of the surface and to develop algorithms for retrieving atmospheric and surface properties from the data. Theoretical simulations, ground-based measurements, and remotely-sensed observations of aerosol-laden atmospheres and vegetated landscapes demonstrate the necessity of multiangle data for climatological and biogeophysical studies. While the spectral coverage and resolution of nadir-viewing imaging spectrometers provide invaluable information on the chemical composition of such targets, the angular variation of reflectance furnishes a robust means of inferring physical parameters such as their intrinsic geometric and optical structure. The scientific value of an instrument capable of acquiring continuous imagery in several view directions with uniform resolution at each angle includes studies of the effects of aerosols on radiation budget, particulate pollution monitoring, use of angular signature for surface classification, and collection of data necessary to perform accurate atmospheric corrections for nadir-viewing surface remote sensing instruments. An airborne instrument will be especially useful in validating algorithms developed for a future spaceborne sensor proposed for Eos. This RTOP addresses the conceptual design of such algorithms based on simulated multiangle imagery of the surface and atmosphere.

**W89-70582** **677-80-28**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**RADAR OPERATIONS**
W. E. Brown 818-354-2110
(677-80-28)

The purpose of this task is to enable a joint NASA/Defense Advanced Research Projects Agency (DARPA) activity in the development and operation of the Airborne Imaging Radar System to support research and advanced development tasks for each agency. Other than the general activities associated with improving the system reliability and performance quality, the Jet Propulsion Laboratory (JPL) will conduct a 35GHz synthetic aperture radar (SAR) study, P-Band Calibration effort and will increase the power of the C-Band transmitter to improve the C-Band transmitter to improve the C-Band SAR performance.

**W89-70583** **677-80-28**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**AIRBORNE IMAGING RADAR (AIR) OPERATIONS AND SUPPORT**
W. E. Brown, Jr. 818-354-7763

The Airborne Imaging Radar (AIR) system including the flight hardware and ground-based imaging processing will be used in conjunction with the NASA-ARC DC-8 to acquire about 100 hours of data on 32 flights in FY89. An experimental correlator will be developed for analysis of calibration data; calibration techniques will be devised for amplitude and geometrical parameters of the radar system. The approach is to acquire the data on flights specified by NASA at times scheduled by NASA-Ames Research Center. The airborne system will be installed on the DC-8, and maintained as necessary. The data will be processed by the ground-based data processor at JPL at the rate of 5 images per week. The existing correlator will be modified so that the output is calibrated. The existing and modified versions will be compared in December 1988. Special in situ measurements will be conducted in May 1989 for calibration verification.

**W89-70584** **677-80-80**
Goddard Space Flight Center, Greenbelt, Md.
**PROGRAM DEVELOPMENT (GSFC)**
Vincent V. Salomonson 301-286-6481
(677-24-01; 677-22-27; 676-59-32)

The overall purpose of this collection of investigations is to advance some high potential or key areas of effort in such a way as to amplify or strengthen the total Land Processes Program at Goddard and in NASA. The areas to be amplified or strengthened include: (1) the use of the aperture synthesis concept for long wavelength, passive microwave radiometry; (2) the applications of the Pilot Land Data System Concept to near-term needs of key scientific multi-investigator areas of effort; (3) support of the NASA Headquarters Hydrology Program/meetings; (4) improve dynamics; (5) support of NASA Headquarters Terrestrial Ecosystem Program Activities; (6) support of NASA Headquarters Geology Program Activities; (7) operations and management of Computing Facilities; (8) characterization of Thematic Mapper performance and other optical sensors; (9) SPOT Calibration Studies; and (10) Advanced Computing Facility Support. The principal results expected in the next year are: calibration and operations of synthetic aperture L-band radiometer; continued evaluation of PLDS; development of full performance laser altimeter for operation on DC-8; further characterization of spaceborne imaging sensors including calibration status and plans for the future. The collection of tasks to be pursued in this effort contribute to key technological or scientific advancements that will support land processes research.

**W89-70585** **677-80-81**
Goddard Space Flight Center, Greenbelt, Md.
**ASF RECEIVING AND PROCESSING SYSTEM DEVELOPMENT**
H. K. Ramapriyan 301-286-8744

The objective of this RTOP is to develop a receiving and processing system for the Optical Sensor data from the Japanese Earth Resources Satellite (JERS-1) and transfer it to the Alaska

SAR Facility (ASF) at the Geophysical Institute of the University of Alaska, Fairbanks, AK. The development will follow a top-down structured approach. Consistent with this philosophy, a Phase A study has been conducted during August through December 1987. The computer system for handling the OPS data is now called the Image Processor for Optical Data (IPOD) and will operate as a subsystem in the ASF. A Science Requirements Workshop was held in January 1988. Since January 1988, a Phase B study is being conducted to define the IPOD hardware and software architectures in sufficient detail to assist in the preparation of specifications for the system. The Phase B study will provide a detailed requirements definition and selection of options based on the results of the Science Requirements Workshop, a detailed specification of all external and internal products to be produced by the system, identification of candidate algorithms for generating the products, definition of interfaces leading to an interface control document which specifies the interfaces between IPOD and the remaining parts of the Alaska SAR Facility and an ADP feasibility study to assist in the procurement of hardware. An overall NASA JERS/OPS program has been submitted to Codes EEL and TS, NASA Headquarters. Subject to approval of this budget, full-scale development will be started during FY89. Procurement of hardware specified during the Phase B study and detailed design and specification of software will be started. Pre-launch calibration experiments will be designed in collaboration with NASDA. Radiometric and geometric correction algorithms product generation from IPOD will be investigated. Appropriate Science Working Team meeting(s) and design review(s) will be held. The development will continue through FY91 to ensure delivery of the hardware and a minimal build of software to the ASF to be ready by the JERS-1 launch in February 1992. (Code TS funds will be used to develop a duplicate version of hardware at GSFC, development of data capture, Level 0, software and operations to facilitate phased software development and post delivery maintenance).

**W89-70586** **677-90-00**
John C. Stennis Space Center, Bay Saint Louis, Miss.
**UNIVERSITY RESEARCH ASSOCIATES PROGRAM IN LAND-SEA INTERFACE STUDIES**
Armond T. Joyce 601-688-3832
(677-43-26)

The Universities Space Research Association has successfully managed research associates programs in conjunction with numerous NASA field center program offices. In light of a growing interest in applying remote sensing science to the study of the earth's ecological problems and the Stennis Space Center's (SSC) existing capabilities in this area, this proposal outlines the creation of a research associates program at the Earth Resources Laboratory (ERL). In order to build upon the strengths of existing ERL research and to take advantage of their strategic location, the program would focus on the land-sea interface. Through the creation of a permanent, albeit rotating, academic presence onsite at the ERL, along with the sponsorship of topical seminars and symposia, the goal of the program is to create a significant recognized center for multidisciplinary research in land-sea interface.

**W89-70587** **677-90-10**
John C. Stennis Space Center, Bay Saint Louis, Miss.
**GULF OF MEXICO PROGRAM**
E. G. Woods 601-688-2042

The Gulf of Mexico is a most valuable resource with its leading fishing, petroleum exploration, shipping, and recreation industries. The Gulf has many conflicting industries which impact the environment at the regional, national, and international level. The U.S. Environmental Protection Agency (EPA) has taken the lead with other Federal agencies and the five Gulf States to develop and organize a Gulf of Mexico Program that will direct program scientific studies and activities toward a regional system overview for environmental management. A Gulf of Mexico Commission will be established for this purpose. The EPA has located its Gulf of Mexico Program Office on the Gulf Coast at NASA's John C. Stennis Space Center (SSC). In FY88, NASA/SSC/ERL, EPA, Naval Ocean Research and Development Activity, Naval Oceanographic Office, Department of Commerce/National Oceanic and Atmospheric Administration (DOC/NOAA), Department of the Interior/United States Geological Survey (DOI/USGS), and Fish and Wildlife Services, and a number of state offices are currently located at SSC and will be working together on this program. The SSC Earth Resources Laboratory will provide EPA with program support, field studies, data acquisition, data system development and analysis as the program develops from FY89 (Major Projects) through the project's 15 to 20 year study period. The program will follow similar Great Lakes Commission and Chesapeake Foundation Programs.

**W89-70588** **677-90-20**
John C. Stennis Space Center, Bay Saint Louis, Miss.
**UNEP/GRID SUPPORT**
Bruce A. Spiering 601-688-3588

The primary objective of the proposed effort is to provide continuing hardware/software support to the United Nations Environmental Programme (UNEP); especially to the UNEP facilities located in Nairobi, Kenya and Geneva, Switzerland.

**W89-70589** **677-90-20**
John C. Stennis Space Center, Bay Saint Louis, Miss.
**SSC EOS/GRID SCIENCE APPLICATION PROJECT**
B. G. Junkin 601-688-3586

The primary purpose of this technology effort is to develop an integrated information systems capability linking the initial components of the Earth Observing System (EOS), the Earth Science and Applications Data System (ESADS) information network, and the Global Resources Information Database (GRID) to the national and international remote sensing science and application communities, and to provide these science application users with the capability to use the various disciplinary and information system techniques developed within the OSSA Earth Sciences and Applications Division. The planned research will bring to bear the technology of electronic data transfer on both the GRID and tropical forest assessment activities. Provisions will be made to give other scientists access to the data, and to provide for communication with data bases in addition to the GRID and ERL data bases. One of the initial project tasks will be to establish interface requirements for high-speed data communications between the identified ESADS discipline science/application user, John C. Stennis Space Center (SSC), GRID, and the Space Physics Analysis Network (SPAN). This will be supported by establishing SSC as a node on the SPAN network. In addition, the SSC will access other systems such as the Pilot Climate Data System (PCDS). The support capability phase will involve the translation of identified information network requirements of science/application investigations into an operational capability. The operational support phase will be an inter-active process to accommodate users with a requirement to access global data to support science and research projects. Extensive use will be made of previously developed concepts, processing algorithms, and existing data systems.

**W89-70590** **677-92-00**
Goddard Space Flight Center, Greenbelt, Md.
**IDS LAND CLIMATOLOGY PROGRAM**
Harold Oseroff 301-286-9538

The Interdisciplinary Science Land Climatology Program is conducted to investigate long-term coupled physical, chemical, and biological changes in the Earth's environment on a global scale (atmosphere, land, and oceans). Such research is intended to develop an increased understanding of processes which can only come through the integration of scientific results which are obtained from discipline-specific Earth sciences research activities. Goddard Space Flight Center (GSFC) responsibility includes the project management and several of the fundamental research tasks. Seeking new research and evaluating proposals; monitoring continuing studies; and conducting workshops, progress review meetings and conference technical sessions, as well as performing the necessary procurement activities will be continued in a manner similar to previous years.

**W89-70591** **677-92-24**
Goddard Inst. for Space Studies, New York, N.Y.
**GLOBAL ANALYSIS OF THE RELATIONSHIP BETWEEN VARIATIONS IN LAND COVER AND VEGETATION INDICES FROM AVHRR**
Inez Fung 212-678-5590
(677-92-25)

The objectives of this RTOP are: (1) quantitative evaluation of the natural variance of the Normalized Difference Vegetation Indices (NDVI) calculated from Advanced Very High Resolution Radiometer (AVHRR) radiance measurements; (2) investigation of the interannual variations of vegetation dynamics and the feasibility of detecting these variations using the AVHRR NDVI; and (3) development of quantitative relationships between seasonal and longer term variations of the NDVI and climate observables. Previous support on this RTOP has resulted in the systematic classification of vegetation cover using the NDVI. We propose to analyze the multi-year global distributions of the NDVI for the space and time variations of the NDVI within each vegetation type. Effects of atmospheric scattering and absorption and surface angle dependence on the NDVI will be estimated using the international Satellite Cloud Climatology Project (ISCCP) radiance data from which these effects have been removed. Statistical analysis of the relationships between the NDVI's and climate variables will be performed to develop algorithms to predict vegetation indices and vegetation dynamics from climate variables. These climate variables will include surface air temperature and incident solar radiation at the surface from ISCCP data archives.

## Advanced Studies--Explorers

**W89-70592** **689-11-01**
Goddard Space Flight Center, Greenbelt, Md.
**EXPLORER MISSION CONCEPT STUDIES**
George C. Keller 301-286-7934

A study will be performed of feasibility and a preliminary definition will be provided for four explorer mission concepts; LYMAN (Far Ultraviolet Spectroscopic Explorer), Mesosphere-Lower Thermosphere Explorer (MELTER), Nuclear Astrophysics Explorer (NAE) and Advanced Composition Explorer (ACE). A thorough Phase A study will be completed for each mission and will include some definition of the flight, ground and data systems. The four studies will be technically evaluated by a review committee and the studies and their evaluation will be forwarded to NASA Headquarters where one or more of the studied missions will be chosen for execution. The duration of the study and evaluation will extend from June 1988 thru September 1989.

## Crustal Dynamics

**W89-70593** **692-00-00**
Goddard Space Flight Center, Greenbelt, Md.
**CRUSTAL DYNAMICS**
R. J. Coates 301-286-8809
(693-10-00; 693-20-00; 693-30-00)

The scientific objectives are to improve the knowledge and understanding of: (1) regional deformation and strain accumulation related to large earthquakes in the plate boundary regions in western North America; (2) contemporary relative motions of the North American, Pacific, South American, Nazca, Eurasian, and Australian Plates; (3) internal deformation of continental and oceanic lithospheric plates, with particular emphasis on North America and the Pacific; (4) rotational dynamics of the earth and their possible correlation with earthquakes, plate motions, and other geophysical phenomena; and (5) regional deformation in other areas of high earthquake activity. In order to achieve these objectives, an extensive measurement program utilizing both Very-Long-Baseline Interferometry (VLBI) and Satellite Laser Ranging (SLR) is underway. Frequent high accuracy measurements of baselines between many stations in active areas near plate boundaries are being made to determine regional deformation and strain accumulation. Baselines between a global set of stations are being measured repeatedly to determine relative plate motions. Repeated measurements of baselines between several stations on the same plate are being made to determine the internal deformation of the plate. Polar motion and Earth rotation variations are derived from daily measurements with a global set of stations in stable locations.

**W89-70594** **692-30-00**
Goddard Space Flight Center, Greenbelt, Md.
**CRUSTAL DYNAMICS: VERY LONG BASELINE INTERFEROMETRY ADVANCED TECHNIQUE DEVELOPMENT (ATD)**
Thomas A. Clark 301-286-5957
(692-30-00; 692-40-00)

Crustal Dynamics Program (CDP) geodetic very long base interferometry (VLBI) techniques produce individual normal points (for 100 to 800 second integration times) with a precision of 15 psec (5 mm) which may have calibration biases of 30 to 50 k psec (10 to 15 mm). A network of 3 to 6 VLBI stations produce 300 to 1000 such measurements in a one-day measurement session. The best of these sessions yield geodetic baselines repeatable to 7 mm in horizontal components and 30 mm in vertical. The goal of this advanced technique development (ATD) activity is to improve the precision and accuracy of the VLBI technique by a factor of 2 to 4 in the next 3 years by making the following improvements: (1) improving the raw normal point measurement precision by doubling the RF bandwidth and improving instrumental sensitivity; (2) improving the instrumental calibration system; (3) improving the stability of the reference clocks; (4) improving the ability to calibrate biases due to the troposphere; (5) improving the physical models used to interpret the observations; (6) improving the ability to model mechanical deformations in antennas and our understanding of the geological stability of key sites; (7) perform extensive comparisons with other space geodetic systems to assess the intrinsic accuracy of each techniques; (8) develop new ways to tie satellite laser ranging (SLR) and VLBI coordinate frames together by performing both mono- and bi-static radar measurements of the LAGEOS satellite; and (9) develop new analysis strategies to improve our ability to isolate systematic errors.

**W89-70595** **692-40-40**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**STRAIN MODEL**
P. M. Kroger 818-354-8188
(692-60-45)

This RTOP is intended to perform an analysis of the current data base of precise positions which have been determined by the space-geodetic techniques of VLBI, satellite laser ranging (SLR), and GPS-based systems. The primary goal of this analysis is to produce a set of relative site velocities and their associated uncertainties that is based upon all available information concerning the measured positions and their uncertainties. These velocities will then be used to provide constraints on current kinematic and dynamic models of crustal deformation in regions, such as the Pacific-North America plate boundary in California, where a sufficient data base of precise positions is available. The estimated parameters in our model consist of site velocities and the site positions at a reference epoch. The weighting matrix used in the least-squares analysis contains all available information on the uncertainties of the site positions and the correlations between these uncertainties. When combining results from two or more techniques, differences in the reference coordinate systems of the techniques must be taken into account. This may be done either by including additional estimated parameters in the analysis or by applying coordinate transformations obtained from independent analyses.

**W89-70596** **692-40-60**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**DSN SUPPORT TO MOJAVE BASE STATION OF CDP**
L. E. Butcher 619-256-3038

This RTOP is intended to provide Facility, Logistical, Purchasing, and Depot Level Repair Capability to the Mojave Base Station of the Crustal Dynamics Project, located at the Goldstone Deep Space Communication Complex (GDSCC). The Deep Space Network (DSN) operated for NASA by JPL, through in-place capability at the Goldstone Deep Space Communications Complex, will provide this needed support to the Mojave Base Station. In particular, custodial, high voltage alternating current, logistical (parts issue and purchasing), depot repair of modules and test equipment, electrical, test equipment calibration, water and electrical power services will be provided by the DSN to the Mojave Base Station of the CDP. Additionally, through an in-place contract with the Government Services Administration (GSA), supplementary vehicles will be provided as needed to meet observation needs. The needed support and method of providing such support is described in more detail in a Memorandum of Agreement between the Director, Ground Networks Division OSTDS and Director, Earth Science and Applications Division OSSA, dated 28 Feb., 1985.

**W89-70597** **692-40-70**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**WVR HARDWARE AND SCIENCE SUPPORT**
M. A. Janssen 818-354-7247

This RTOP is intended to provide continuing support for water vapor radiometer (WVR) activities within the Crustal Dynamics Program. The main objective of this task in previous years has been to provide science and hardware support to Goddard Space Flight Center for the J-series WVRs. For FY88 the scope of this task was shifted to the more general problem of the absolute calibration of path delay as determined from the microwave emission of atmospheric water vapor. This calibration is to be carried out in collaboration with Dr. Peter Bender and Steve Walter of the University of Colorado, whose work is supported by separate funding. JPL's role is to provide absolutely calibrated atmospheric emission measurements, and to obtain the final expression for water vapor absorption. This result will allow radio path delay measurements to be obtained with much greater absolute accuracy than presently possible. Due to delays in completing the Water Vapor Calibrator at the University of Colorado, it has not been possible to carry out JPL's portion of this task on the schedule described in last year's RTOP. However, substantial work is expected to begin about July of this year.

**W89-70598** **692-60-42**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**VARIABLE EARTH ROTATION**
C. F. Yoder 818-354-2444

This RTOP is intended to support general scientific research related to interpretation of CDP earth orientation data (UT1, polar motion and nutation) and Lageos' orbit perturbations, particularly the secular changes in J2, J3, J4, etc. The primary topic concerning earth rotation is the construction of a more complex semi-analytic nutation model which takes into account oceans, solid friction, and earth model uncertainties. In addition, the effect of the inner core, core-mantle boundary layer, figure-figure core mantle ellipticity, solid friction Q and earth structural models. A layered earth model has already been developed to examine how viscosity structure and melting history affect present day changes in gravity field. A model describing the lateral dependence on viscosity structure shall be developed which uses the tomographic lateral velocity variations to infer temperature viscosity variations. The principal objective is to determine how well observables such as the secular change in J2 and polar motion constrain viscosity structure.

**W89-70599** **692-60-43**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**LUNAR LASER RANGING DATA ANALYSIS**
J. G. Williams 818-354-6466
(692-60-61)

The analysis of the lunar laser range data is intended to determine parameters of geophysical and geodetic interest as its final product. These parameters are station locations, their rates, GM (earth), tidal acceleration of the moon, and precession and nutations of the earth's rotation axis in space. These determinations will contribute to precision geodesy and the understanding of plate motion, tides, the moments of inertia of the earth, and the earth's interior structure. The continued processing of lunar range data will improve upon the accuracies of these determinations as newer, more accurate ranges are received. The software needs improvements at the 1 to 2 cm level to fully use the accuracy (4 cm) of the best ranges received to date. Principal among these improvements are changes in the earth tide model for variable Love numbers, solid body pole tide, and ocean loading. Also intended are upgrades in the software for operational efficiency, particularly in the calculation of dynamical partial derivatives. The lunar laser ranging (LLR) origin of terrestrial longitudes has been held fixed for several years to prevent annoying shifts from one solution to another. Solutions show that a shift of 0.02 is needed to preserve consistency between that origin, the BIH origin for universal time, and the dynamical equinox. This resetting of the origin will be done. The work of this investigation will also benefit the regular determination of earth rotation and the monitoring of data quality, tasks of a companion RTOP (692-60-61).

**W89-70600** **692-60-45**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**CRUSTAL STRAIN MODELING USING FINITE ELEMENT METHODS**
G. A. Lyzenga 818-354-6920
(692-40-40)

The objectives of this RTOP are the development and application of numerical modeling methods for understanding the time dependent deformation of the earth's crust in active tectonic zones. This research has direct relevance to the interpretation of measurements currently being carried out by the Crustal Dynamics Project. In work under a related RTOP (692-40-40), kinematic descriptions of the state of crustal deformation in monitored regions is obtained. The task described in the present RTOP addresses the underlying physical processes giving rise to the observed motions. The approach employed in this task uses the finite element method to construct time dependent models of tectonic deformation in spatially inhomogeneous domains. This approach allows the description of realistic configurations of faults and variable material properties, not amenable to analytic techniques. The utility of such models is to provide a theoretical link between geodetic observations and data derived from geological sources, as well as to constrain the physics of earth deformation processes.

**W89-70601** **692-60-46**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**GLOBAL TECTONIC MOTIONS**
R. S. Gross 818-354-3235

The proposed research is intended to continue the study of present day plate motions using earth orientation measurements, and the related production of earth orientation series which account for tectonic motions of the participating geodetic observatories. This RTOP can be divided into two tasks, analysis of publicly available earth orientation data, and the re-reduction of IRIS, POLARIS and Crustal Dynamics Program Mark 3 VLBI data at JPL using JPL software. It should be noted that the inherent accuracy of VLBI baseline orientation determinations can be equal to or better than the length estimates from the same baselines. The study of tectonic motions through orientation measurements will thus both complement the more traditional study of length changes and serve as an important source of new information, without requiring the acquisition of any additional data. The first task will involve the re-reduction of the IRIS/POLARIS VLBI data with an independent JPL software package providing both the length and orientation determinations. The length and orientation of each baseline in the network will be estimated each time it is observed to provide the detailed geodetic results necessary for a complete analysis of network deformation. These data are not currently publicly available from any source. This task will produce determinations of the velocity of relative motions between Europe and America with formal errors of 1 centimeter/year or smaller from both orientation and length data and will greatly increase the confidence in rate estimates from changes in baseline length. The second task will use publicly available earth orientation measurements (Satellite Laser Ranging (SLR), Lunar Laser Ranging, and VLBI from other sources, NASA Geodynamics Program and the Deep Space Network) together with baseline orientation results from the first task, to study the slow divergences in the observed earth orientation caused by plate motions. This task will produce tectonic motion estimates with formal errors of 1 to 3 centimeters/year or smaller from locations on the North American, European, and Australian plates. The resulting drift rate estimates will be compared with geological plate motion models and with other geodetic motion estimates.

**W89-70602** **692-60-47**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**ANGULAR MOMENTUM**
J. O. Dickey 818-354-3235

The objective of this investigation is to obtain a better understanding of the exchanges of angular momentum which cause the polar motions and changes in the earth's rotation rate, the Length of the Day (LOD). The proposed research can be divided into two tasks. Task 1 - the excitation of the long-term decade fluctuations: Our research has found excellent agreement between rapid variations in the earth's rotation rate and changes in the atmospheric angular momentum. By contrast, little is currently known about the physical processes which cause the long-term decade fluctuations in the LOD, although it is generally assumed that these are related to torques at the core mantle boundary. This task will attempt to provide better determinations of recent LOD and polar motion changes and torque estimates, and to relate these changes to estimates of core mantle torques produced elsewhere by model dependent calculations. Task 2 - the atmospheric and oceanic excitation of the polar motions: This task will continue our previous research into the excitation of the polar motions. This research has made considerable progress, with the identification of a meteorological role in the excitation of rapid polar motions and with investigation of the ocean response to atmospheric pressure loads at high frequencies. This task will involve continuation and publication of this research, together with investigations into the excitation of the Chandler and Seasonal Wobbles.

**W89-70603** **692-60-61**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**LUNAR LASER RANGING**
J. O. Dickey 818-354-3235
(692-60-43)

The analysis of lunar laser ranging (LLR) data provides a wealth of geophysical and geodetic information. Of importance to the geodynamics community has been the series of measurements permitting long-term studies of variations in the earth's rotation, as well as determination of many parameters of the earth-moon system. LLR has contributed to the determination of Universal Time (UT1); the long-term stability and temporal resolution are assets of LLR. Timely analysis of LLR data permits quick-look monitoring of the data quality and the rapid determination of earth rotation. For studying the processes which underlie variations in the earth's variation, the long span of LLR data is valuable. LLR has produced new information about the exchange of angular momentum between the solid earth and the atmosphere; its long series has had implications on the study of the longer-term fluctuations in earth rotation, the so-called decade variations. The analysis of LLR earth rotation together with LAGEOS results reveals variations in the zonal gravitational harmonic coefficient, J2, which constitutes the first unambiguous demonstration of a secular change in the earth's gravity field. Tasks planned under this activity include: (1) the analysis of LLR data in a timely fashion; (2) continued earth rotation determination and their distribution to the NASA Programs, the IERS, and the general scientific community; (3) intercomparison of LLR earth rotation results with those from other techniques; (4) generation of a new export lunar ephemeris needed for LLR analysis. With the advent of ranges with accuracies better than 5 cm, a new lunar ephemeris needed for LLR analysis. With the advent of ranges with accuracies better than 5 cm, a new lunar ephemeris is desirable and is needed. The previous ephemeris resulted from decimeter accuracy data; hence, a significant improvement is expected; and (5) interaction with the various LLR sites and stations, NASA and the Crustal Dynamics Program on data quality and quantity as well as University of Texas and University of Hawaii on normal points generation.

## Laser Network Operations

**W89-70604** **693-40-00**
Goddard Space Flight Center, Greenbelt, Md.
**CRUSTAL DYNAMICS - ADVANCED TECHNOLOGY DEVELOPMENT FOR SATELLITE AND LUNAR LASER RANGING SYSTEMS**
J. M. Bosworth 301-286-8809

The objective is to make significant improvements in the basic capabilities of the NASA satellite and lunar laser ranging systems in the areas of precision, accuracy, reliability, and operating efficiency. These improvements are in response to more stringent requirements recently established by the Crustal Dynamics scientific investigators and accepted by NASA Program Management. They include the capability to measure baselines of up to several thousand kilometers length with accuracies in the few millimeter regime. Presently, the best NASA satellite laser ranging systems can measure these baselines with single centimeter accuracy. In addition, the Crustal Dynamics scientists require that the smaller, more transportable satellite laser ranging systems be upgraded to perform daylight ranging to the Lageos satellite. Along with the requirements of the Crustal Dynamics scientists, other NASA and foreign scientific groups are requesting ranging operations for their new satellite programs. This will require upgrades in the automation and efficiency of the stations if all ranging requirements are to be met.

**W89-70605** **693-70-00**
Goddard Space Flight Center, Greenbelt, Md.
**LAGEOS 2 (INTERNATIONAL COOPERATIVE PROJECT)**
G. W. Ousley, Sr. 301-286-8073

The objectives of this RTOP are to provide a cooperative U.S./Italian spacecraft to be used by the Crustal Dynamics project. (A NASA Lageos was launched in 1976.) The approach is based on a Memorandum of Understanding between NASA and Italy. Italy will provide the spacecraft, upper stage, and apogee kick motor. NASA will provide a launch on the Space Transportation System (STS), laser tracking of the satellite and laser optical characterization of the satellite.

## Sounding Rockets

**W89-70606** **879-11-38**
Goddard Space Flight Center, Greenbelt, Md.
**SOUNDING ROCKET EXPERIMENTS**

W. M. Neupert 301-286-3756

The sounding rocket program provides unique capabilities to conduct a broad range of scientific investigations. The program is particularly important for the development and demonstration of the merit of new instruments for shuttle flights and of prototype instruments for satellites. Furthermore, the short lead time and program flexibility make it possible to follow up new discoveries and to study particular phenomena on the Sun and in the Earth's atmosphere. Extreme ultraviolet (EUV) spectra of the Sun are a valuable tool for determining the physical conditions in the solar corona and in understanding the flow of matter and energy in the Sun's outer atmosphere. For this purpose, we need to know the coronal density, temperature, gas velocity, and radiation field. The work under this task is directed toward the development and flight on sounding rockets of instruments for determining these four physical parameters in the corona. A major objective is to measure coronal gas velocity as a function of position on the solar disk. Another objective is to determine the coronal temperature, density, and line excitation processes by combining a knowledge of line profiles with the relative line strengths. A third objective is the investigation of wave propagation and dissipation, which may be fundamental to understanding energy transport in and heating of the corona.

## Mission Operations and Data Analysis

**W89-70607** **889-57-11**
Goddard Space Flight Center, Greenbelt, Md.
**DYNAMICS OF THE URANIAN ATMOSPHERE**
F. M. Flasar 301-286-3071

The objectives of this RTOP are to investigate: (1) the structure and maintenance of temperature lapse rates in Uranus' deep atmosphere; and (2) the role of the global magnetic field in focusing vertically propagating waves that can drive the planetary zonal wind system. The research in this RTOP is conducted by F. M. Flasar, F. J. Conrath, and J. A. Pirraglia of GSFC. Approaches are: (1) Voyager IRIS and radio occultation data and published data from ground-based observations at submillimeter and millimeter wavelengths are analyzed to constrain the vertical profiles of temperature in Uranus' deep atmosphere. Dynamical processes capable of maintaining this structure are modeled. Some of this modeling is done in collaboration with P. J. Gierasch of Cornell University; and (2) analytical and simple numerical modeling of the ducting of waves propagating upward from Uranus' conducting interior is performed to determine whether such waves are capable of depositing momentum into the mean zonal flow.

**W89-70608** **889-57-48**
Goddard Space Flight Center, Greenbelt, Md.
**URANIAN MAGNETOSPHERE: URANUS DATA ANALYSIS PROGRAM**
J. E. P. Connerney 301-286-5884

The Voyager 2 spacecraft encountered a strong magnetic field within the Uranian magnetosphere. We propose to utilize the magnetic field observations obtained at close-in radial distances (8 Ru less than R less than 8 Ru) to obtain a global magnetic field model and perform a systematic search for small amplitude, small scale magnetic signatures associated with Birkeland currents in the Uranian magnetosphere. Since Voyager 2 is a three-axis stabilized spacecraft, the success of the search for Birkeland currents is essentially dependent on an accurate reconstruction of the spacecraft attitude as a function of time to a level not yet achieved by standard project data products. The unambiguous detection of magnetic signatures associated with field-aligned currents will make possible the study of phenomena which are believed to occur in all planetary magnetospheres, and particularly those with satellites imbedded within. Correlative data from other Voyager investigations will be utilized where possible to remotely sense the Uranus magnetosphere and provide a check of field models obtained from the magnetic field observations.

**W89-70609** **889-57-52**
Goddard Space Flight Center, Greenbelt, Md.
**PLASMA, HOT PLASMA, AND MAGNETIC FIELDS AT URANUS**
Edward C. Sittler, Jr. 301-286-9215

The objectives of this RTOP are to produce merged data set from Voyager 2 Uranus plasma observations made between 10 eV and 1 MeV for ions and electrons and magnetic field observations. This data set will be used to obtain the plasma distribution functions within Uranus' magnetosphere in order to characterize its plasma and field properties. The experimental data will be the Voyager Plasma Science Experiment (PLS), the Low Energy Charged Particle Experiment (LECP), and the Magnetometer Experiment (MAG). Using the appropriate moments of the distribution functions and the magnetic field, and interpolating across the energy gap (6 keV to 20 keV) left unmeasured by the Voyager instruments, we will produce time series of plasma beta total energy density and momentum flux, and assess the importance of the high energy tail of the distribution. We will examine the plasma asymmetry between the day and night sides of the planet, apparent in the observations at low energies, and the different kinds of asymmetries that occur at higher energies. We will study the energy-time dependence of the plasma boundaries such as the inner edge of the plasma sheet and the inbound terminator which may be due to processes analogous to the particle substorm injection events observed at earth. Our studies will be guided by a solar wind driven convection dominated magnetosphere model.

**W89-70610** **889-57-55**
Goddard Space Flight Center, Greenbelt, Md.
**UDAP SHOCKS**
Jack D. Scudder 301-286-8365

This renewal proposal is in response to the Space Science and Applications Notice of October 30, 1986, for participation in the Voyager Uranus Data Analysis Program. A program of research that contributes to the data analysis and interpretation of the magnetic field and plasma experiments on the Voyager 2 spacecraft during the Uranus encounter is outlined. We propose to carry out comprehensive, rigorous analysis and interpretation of the structure, morphology and microphysics of the Uranian bow shock layer during both the inbound and outbound passes of the Voyager 2 spacecraft using the plasma and magnetic field data together with theory that has been improved from studying the earth's bow shock. We further propose to present models of the geometry and scale lengths of the transition that are consistent with the observations to derive the characteristics of the dissipative process in the Uranus bow shock. As a by-product we will derive new values for the solar wind electron temperature at 19AU, even though they are too cold to be directly sensed.

# OFFICE OF SPACE OPERATIONS

## Advanced Systems

**W89-70611** **310-10-23**
Goddard Space Flight Center, Greenbelt, Md.
**SOFTWARE ENGINEERING TECHNOLOGY**

Frank E. McGarry 301-286-6846
(506-44-31; 310-40-49)

The objective of this RTOP is to identify, evaluate, and refine software engineering technology as applied to the software development process for the NASA environment. The technology to be studied includes software development methodologies (such as structured implementation techniques, various testing techniques, structured analysis approached to design), software development tools (such as code auditors and analyzers, configuration management aids and PDL processors), software measures and models (such as cost and reliability estimation models), the Ada language and associated development techniques, and techniques for increasing reusability of software. The identified methodologies are intended to significantly reduce the overall life cycle costs of the software within the Mission Operations and Data Systems area. The approach to attain the stated objectives includes the utilization of an experimentation laboratory wherein proposed tools, methodologies and models may be acquired, developed, and applied and studies in an actual software production environment. This laboratory, called the Software Engineering Laboratory (SEL), first of all identifies technologies of potential benefit to the NASA software development process, identifies appropriate measures for assessing the impact of the technology and coordinates the detailed experimentation of applying and tuning the technology within selected software development projects supporting various requirements of Mission Operations and Data Systems. Each of the Projects is then carefully studied to determine the impact within the NASA software development environment and to further identify refinements or additional technologies (tools, models, methodologies, language characteristics, etc.), that could positively impact NASA software and would be directed at addressing specific NASA software shortcomings.

**W89-70612** **310-10-26**
Goddard Space Flight Center, Greenbelt, Md.
**FLIGHT DYNAMICS TECHNOLOGY**
E. V. Seidewitz 301-286-7631

The objectives of this RTOP are to develop, evaluate, and demonstrate new technology for flight dynamics in the Tracking and Data Relay Satellite System (TDRSS) and Space Transportation System (STS) era, encompassing algorithms, techniques, software, and hardware for attitude and orbit determination/prediction/analysis for both ground-based and onboard application. The technology developed under this RTOP supports the Office of Space Operations in the areas of mission computing and analysis, TDRSS operations, and data processing. The approaches are: (1) develop, demonstrate, and evaluate one-way Doppler tracking via TDRSS multiple access return link using an ultrastable oscillator onboard a user spacecraft; (2) support transition from prototype to operations and develop functional requirements for onboard navigation by user spacecraft to be supported by the Advanced Tracking and Data Relay Satellite System (ATDRSS); (3) study orbit determination using sequential filtering; (4) develop a reconfigurable PC-based attitude dynamics simulation tool; and (5) study and develop advanced, generic attitude determination methods.

**W89-70613** **310-10-60**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**ASTROMETRIC TECHNOLOGY DEVELOPMENT**
C. Edwards 818-354-4408
(310-10-61; 310-10-62; 310-10-63; 310-10-67)

The objective of this RTOP is to design and demonstrate improved techniques of astrometric data acquisition and analysis as used by the Deep Space Network (DSN) to support navigation and radio science. Central to this goal is identifying and quantifying the limiting error sources for various metric tracking data types. Starting from an understanding of the underlying physics, potential error sources are studied in the context of actual observing scenarios to determine their ultimate impact on the final navigation observable. The current approach to improving navigation accuracy largely consists of refining methods of angular spacecraft navigation using interferometric techniques, primarily Very Long Baseline Interferometry (VLBI). Much of the work in the RTOP involves the analysis of VLBI experiments design to probe particular error sources. Based on these experiments, improved modeling and calibration techniques are developed to reduce or eliminate dominant errors. In addition, optimal observing strategies are designed to improve differential spacecraft-quasar navigation measurements. These efforts are aimed towards developing a 5 nrad angular measurement accuracy by the mid-1990's. To advance the capability for target-relative navigation, several observational programs are being pursued to improve the tie between the planetary ephemeris and the radio reference frames to a comparable level. Connected element interferometry (CEI) techniques could provide more efficient and reliable angular navigation for the DSN, using baselines of 10 to 100 km in length. Realtime correlation of CEI data would reduce navigation turnaround time, while improving experimental reliability by providing on-line verification. Short baseline intracomplex interferometry experiments are currently being performed to quantify the navigation potential of CEI. Achieving angular accuracy below 50 nrad on intracomplex baselines will require reducing a variety of delay error sources to the 1 mm level. Prototype realtime correlator designs are currently being investigated, leading to a realtime navigation demonstration in future years.

**W89-70614** **310-10-61**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**EARTH ORBITER TRACKING SYSTEM DEVELOPMENT**
Stephen M. Lichten 818-354-1614
(310-10-60; 310-10-63; 676-59-31)

The objective of this RTOP is to develop the conceptual design for an integrated system to track earth satellites and to demonstrate its feasibility and role in the Deep Space Network (DSN). The goal is to surpass current tracking accuracy by roughly an order of magnitude in a system that is economically practical to deploy and operate. Nominally, the system should yield position accuracies of a few decimeters or better at altitudes below 3000 km, increasing to 1 to 5 meters at geosynchronous altitude. It will include six to ten ground terminals (three provided by NASA at the DSN sites) which will be compact and operate unattended. The system will be able to determine the non-DSN ground terminal locations with respect to the DSN reference sites with few-centimeter accuracy and will be able to provide continuous tracking for a large number of satellites. The earth orbiter system will tie DSN ground sites into a geocentric reference frame to an accuracy of better than 5 cm and will provide continuous precise media calibrations in support of DSN activities. The tracking system proposed here will employ signals from the satellites of the Global Positioning System (GPS) being developed by the Department of Defense. The technique employs differential GPS observables constructed from observations made concurrently with GPS receivers on the ground and on earth orbiters. At altitudes above 10,000 km, satellites may carry a beacon in addition to or instead of a GPS receiver. This RTOP includes system design and performance analysis; error analysis software development; study of the use of GPS for cm-level earth orientation calibration; and demonstrations of high precision tracking techniques on the GPS satellites and on future earth orbiters as opportunities arise. Related work is being done under other RTOPs and under sponsorship of the Oceanic Processes and Geodynamics branches of OSSA.

**W89-70615** **310-10-62**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**FREQUENCY AND TIMING RESEARCH**
L. Maleki 818-354-3688
(310-10-60; 310-10-61; 310-10-64)

The objective of this RTOP is to develop and demonstrate the technology of precise frequency and timing in support of the DSN missions and science activities. The frequency stability goal pursued in the RTOP is the demonstration of one part in 10 to the 16th at averaging intervals between 1 and 10,000 seconds in the Goldstone complex, by 1990. The long-term goal is the demonstration of parts in 10 to the 17th capability for averaging intervals between 1 second and 100,000 seconds in the 1990s. The work planned is in three areas: (1) the generation of precise frequencies, to meet the goals above, will be developed through the demonstration of the trapped mercury ion frequency source, the superconducting maser oscillator, and the super cooled quartz oscillator. Work will also be carried out to develop the required technology to achieve one part in 10 to the 16th stability at 1000 seconds in the hydrogen maser; (2) the distribution of precise frequencies will be demonstrated through the development of fiber-optics systems including stabilized cables. A systems study will be used to analyze, develop, and demonstrate a centralized frequency distribution system for a Deep Space Network (DSN) complex. This work will provide techniques for efficient distribution of the precise signals generated by frequency sources without stability degradation; and (3) work will be performed on the development of a frequency stability and phase noise measurement and monitor capability. This effort will provide near real time information on the status of the stability of precise frequencies generated, distributed, and used throughout a deep space station.

**W89-70616** **310-10-63**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**SPACE SYSTEMS AND NAVIGATION TECHNOLOGY**
C. S. Christensen 818-354-7408
(310-10-60; 310-10-61; 310-10-67)

The objectives of this RTOP are to: (1) investigate new navigation technologies with the goal of developing techniques to increase the accuracy of Deep Space Network (DSN) navigation products and increase the efficiency in the navigation use of DSN resources; (2) develop a synergistic relationship with advanced mission planning teams that promotes the optimum growth of both DSN and spacecraft navigation capability; and (3) evaluate system level requirements for new navigation technologies. The RTOP identifies and evaluates data strategies for improving deep space navigation accuracies, and enhancing mission capabilities. Radiometric data needs for new navigation applications, such as Asteroid and Comet orbiters, are investigated. Navigation concepts and data strategies, consistent with low-cost mission support are formulated and demonstrated using data from current missions. New and novel navigation technologies are investigated. Technology is being developed for navigation with communication links at optical frequencies in collaboration with RTOP 67. The RTOP focuses on reducing mission operations costs and increasing throughput and reliability by the automation of radiometric data processing. Technologies being pursued are: development of high-speed computer graphics capabilities, the investigation of navigation uses of expert system technology, and the initiation of automated event-driven operations and diagnostic procedures. Major deliverables have included an orbiting VLBI demonstration using the Tracking and Data Relay Satellite (TDRS).

**W89-70617** **310-20-33**
Goddard Space Flight Center, Greenbelt, Md.
**NETWORK SYSTEMS TECHNOLOGY DEVELOPMENT**
George C. Kronmiller, Jr. 301-286-7313

The objective of this RTOP is to investigate the applicability of new technology in the Tracking and Data Relay Satellite System (TDRSS) era. Selected technology will be investigated by means of feasibility studies, prototype development and demonstration, and by cost and reliability impact studies. A major goal is to investigate the effect of non-Gaussian channel characteristics on the Space Network (TDRSS and follow on) link performance and develop coding and signal designs which optimize link performance. Associated with this goal are the objectives of flight time line and utilizing expert systems techniques to enhance system operation and minimize analyst manpower requirements. Other elements associated with achieving this goal are modifications of the Communications Link Analysis and Simulation System (CLASS) to provide a network design and evaluation tool as well as a network user communications system design tool. Another major goal is to investigate the potential for use of RF to IF fiber optic technology in future ground station applications. The extremely wide bandwidth and low loss available in fiber optic cables makes this technology an attractive alternative to coax cable and waveguide. The task will concentrate on the feasibility of transmitting radio frequency (RF) signals using fiber optics. In more conventional fiber optic applications, digital signals are transmitted using the electrooptic components as switched devices whereas this experiment will utilize these devices in a linear mode.

**W89-70618** **310-20-38**
Goddard Space Flight Center, Greenbelt, Md.
**NETWORK COMMUNICATIONS TECHNOLOGY**
D. D. Wilson 301-286-7337

The objectives of this RTOP are: (1) to investigate efficient high-rate data transport systems technology; (2) to investigate techniques for interfacing with Open System Interconnection (OSI) networks; and (3) to investigate technologies to improve network configuration and operation. The objectives are being pursued under three tasks. The first task is in the second phase of developing a 300 MBPS modem for satellite links to meet user needs in the Space Station era. The second task is the beginning of a five year effort to analyze and assess the relative merits of Open System Interconnection (OSI) network technology for application in the NASA Communications Network for support of programs in the Space Station era. The third task deals with the design and development of a wiring concentrator for a fiber optics local area network operating at 100 MBPS for applications to a Center-wide environment. This is planned as a three year effort. The approach for this RTOP is to focus on three or four tasks which are selected to cover areas which can provide the maximum benefits to the Division, Directorate, Center and NASA. Each task is structured as a 2 or 3 year effort for analysis, simulation, and prototype development. Hardware and software development are included. The RTOP effort on each task will culminate in a report, software package or prototype equipment. Follow-on development work, if any, will use R and D funds.

**W89-70619** **310-20-39**
Goddard Space Flight Center, Greenbelt, Md.
**ADVANCED TRACKING TECHNOLOGY**
Philip Liebrecht 301-286-8003

The objectives of this RTOP are to design, develop, and demonstrate Advanced Tracking and Data Relay Satellite (ATDRS) era tracking systems which provide for 25 meter tracking accuracy. It is desired that this system place no load on Tracking and Data Relay Satellite System (TDRSS) user services, utilize only continental US ground stations, provide for rapid ATDRS post maneuver trajectory recovery, and potentially be shared with the user navigation system. A two phased approach will be utilized. During the first phase we will study competing approaches and develop system conceptual designs, operations concepts, and space and ground systems demonstration requirements. The second phase will concentrate on the development of the space and ground systems and demonstration via field experiments. The results of the study and development/demonstration efforts will be traded off to provide a recommendation to the ATDRS program as well as stimulate future advanced work in the advanced tracking area if warranted.

**W89-70620** **310-20-46**
Goddard Space Flight Center, Greenbelt, Md.
**ADVANCED SPACE SYSTEMS FOR USERS OF NASA NETWORKS**
R. P. Hockensmith 301-286-9067

The objective of the work under this RTOP is to achieve technological advances in radio frequency (RF) and optical systems, antenna subsystems and associated control technology, on-board data storage systems and telecommunications coding. These developments will satisfy future requirements of users of NASA networks (spacecraft, space platforms and space transportation system payloads) that require near-global coverage through evolving data relay satellite systems Tracking and Data

Relay Satellite System (TDRSS); and other networks as appropriate. The approaches for accomplishing the objective are to: (1) identify the basic operational space flight requirements; (2) investigate active and passive components and antenna systems; (3) investigate methods of reducing and controlling torque noise induced for the steering of large high gain antennas; (4) investigate methods of high density and high rate recording storage and playback; (5) investigate improvements in telecommunication coding of spacecraft generated data; (6) develop system designs to permit user projects to specify proven, reliable hardware procurement cycle; and (7) exploit necessary improvements in testing techniques that properly characterize these critical systems.

**W89-70621** **310-20-64**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**ADVANCED TRANSMITTER SYSTEMS DEVELOPMENT**
Rob Hartop 818-354-3433
(310-20-65; 310-20-66)

The objective of this RTOP is the development of advanced transmitter systems that will enhance performance, reduce costs, and improve the reliability of the Deep Space Network (DSN) transmitter functions, including uplink command capability, emergency commanding, radio science, navigation, and radar astronomy. A 20 kW CW 7.2 GHz transmitter at Deep Space Station (DSS) 13 has been used to demonstrate a complete ground station frequency stability of a few parts in 10 to the 15th when averaged over 1000 seconds. The transmitter has also been used in conjunction with 2 GHz transmitter and receiver subsystems to demonstrate simultaneous S- and X-band uplink-downlink operations for future DSN use, and it is planned to use the transmitter in conjunction with a 7.2 GHz receiver at DSS 156 for a Debris Radar test. The design of a state-of-the-art transmitter system from the output of a frequency standard at 100 MHz or higher to the feedhorn output at X- or Ka-band has been initiated. This transmitter system will feature advanced technology in several areas, including very high phase stability, high reliability, and complete microprocessor monitoring and control. The resulting transmitter technology will be applicable to many DSN requirements. Another work unit will develop techniques for combining multiple high power sources in an efficient and versatile manner, including beam waveguide environments. This RTOP also provides Ka-band systems analysis to define ground systems support requirements, such as those for the Mars Observer and Comet Rendezvous Asteroid Flyby missions, particularly in regard to the uplink. A new work unit will calibrate the 70 meter antennas at 32 GHz and prepare for multiple-feed operation as required for such Ka-band missions as Mars Rover.

**W89-70622** **310-20-65**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**ANTENNA SYSTEMS DEVELOPMENT**
Alan Cha 818-354-3509
(310-20-64; 310-20-66; 310-20-70)

The objectives of this RTOP are to develop and demonstrate electromagnetic, optical, and structural mechanical technology to increase the capabilities of the large antennas in the Deep Space Network. Capability improvements include increased frequency band coverage, simultaneous multi-frequency operation, increased gain and improved noise temperature performance, and reduced maintenance and operations costs. Recent developments initiated in this RTOP include 70 m and 34 m high-efficiency dual shaped reflector antennas as well as improved 70 m antenna surface accuracy results from using precision bonded panels and microwave holography diagnostic techniques. Wideband beam waveguide (BWG) optics and an integral ring girder design now enable a high-performance Deep Space Station (DSS) 13 BWG antenna. Present objectives are to: (1) evaluate 70 m antenna RF and structural performance for 32 GHz operations and outline an upgrade program describing affordable options; (2) achieve high accuracy and stable RF beam pointing consistent with 32 GHz performance; (3) extend BWG antenna technology to 70 m and 34 m antennas; and (4) develop technology for a 32 GHz multiple function array feed. To achieve these objectives, we use computational-intensive synthesis and analysis software appropriate to large high-frequency reflectors. In order to verify analytical models and understand critical areas needing cost-effective improvement, demonstration and tests are planned to reduce implementation risks.

**W89-70623** **310-20-66**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**RADIO SYSTEMS DEVELOPMENT**
J. Bautista 818-354-8397
(310-30-65)

The objectives of this RTOP are to develop and demonstrate low noise amplifier technology that will lead to ground-based improvements in the communications with and the navigation of spacecraft during deep space missions. The improvements sought are increased performance, reduced implementation costs, and increased reliability of receiving equipment and cryogenic systems. These improvements address future Deep Space Network (DSN) navigation, telemetry, radar, and radio science needs. A key figure of merit in the specification of the communications link to a deep space mission is the ratio G/T, that is, the gain of the ground-based antenna divided by the system noise temperature. This RTOP addresses the persistent need to keep the system noise temperature as low as technology economically permits. The primary concern of this RTOP is the development of low-noise amplifiers at 32 GHz with broad frequency bandwidths and high gain and phase stability. Amplifiers using the principle of microwave amplification by the stimulated emission of radiation (masers) and high-electron mobility transistors (HEMTs) are being developed, as well as the analytical tools and measurement systems needed to characterize these devices and design practical amplifier systems. There is a continuing effort to provide for future cryogenic refrigeration needs of low-noise amplifiers by developing a 1.5 K liquefier system appropriate for use on antennas with beam waveguide feed systems. We are also investigating the further reduction of system noise temperature by the cryogenic cooling of additional feed components made possible by a beam waveguide configuration.

**W89-70624** **310-20-67**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**OPTICAL COMMUNICATIONS TECHNOLOGY DEVELOPMENT**
James R. Lesh 818-354-2766
(310-20-63)

The objective of this RTOP is to develop and demonstrate a reliable and efficient optical communications and tracking capability for use with Deep Space Network (DSN) supported missions of the future. The work will concentrate on the definition, design, development, and analysis of communications and tracking systems that could support such missions, and will include the development of high-leverage technologies that have a major influence on the character of those systems. The RTOP will focus first on direct-detection optical technology, of greatest benefit to outer-planet missions, and second on heterodyne technology, for inner-planet missions where there are high background noise levels. This RTOP will involve the design, development, fabrication, and testing of laboratory and other ground-based demonstrations of the technology for optical communications and tracking. Flight demonstrations of the technology will be pursued only through the initial design and planning stages, so that appropriate sources of funding can be identified. Optical techniques for communication and tracking are expected to be of greatest value when used between planetary spacecraft and an earth-orbiting communications and tracking terminal. Such a terminal would probably be deployed initially in a low earth orbit, possibly aboard the Space Station, with future deployments in geosynchronous orbit. However, studies indicate that even ground-based optical systems could provide acceptable communications and tracking performance. Accordingly, this RTOP will also include examination of the design, cost and performance factors of ground-based systems. These studies will emphasize identification of the key factors which determine performance, as well as estimation of the uncertainties in those factors. Major deliverables for the RTOP are the design and analysis of a ground-based R and D reception station (FY89), creation of a preliminary optical weather model (FY89), a calibrated weather model (FY90), and laboratory demonstration of heterodyne reception (FY93).

**W89-70625** **310-30-70**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**NETWORK SIGNAL PROCESSING**
W. J. Hurd 818-354-2748
(310-30-65; 310-30-66; 310-30-71)

The purpose of the RTOP is to investigate, develop, test and demonstrate advanced signal processing systems which enable the Deep Space Network (DSN) to plan and achieve its performance requirements with improved reliability, maintainability and operability. The largest task is to develop an advanced receiver for the DSN, including carrier tracking, telemetry demodulation and detection, and Doppler extraction. Key objectives are: (1) to improve telemetry signal-to-noise ratio (SNR) performance relative to existing DSN systems by 1 dB to 3 dB; (2) increase data rate capability from approximately 500 ksymb(s) to 10 Msymb(s) in the near term and to 1 Gsymb(s) in the long term; (3) to achieve Doppler extractor frequency stability of 10 to the 17th; and (4) to improve operability over current systems. Major objectives of other ongoing tasks are: (1) to develop a new DSN spectrum surveillance system with sensitivity comparable to the weakest spacecraft signals; and (2) to develop custom very large scale integrated (VLSI) circuits to enable gigabit telemetry rates whenever cost, speed, complexity, size or reliability dictate. A new task for FY89 will develop signal processing to combine the outputs of K-band array feed elements in DSN antennas. During FY89 the main tasks are: (1) to complete demonstration of a 15 MHz bandwidth advanced receiver-Doppler extractor; (2) to complete hardware development and top-level design of an expert system control interface for the spectrum surveillance system; (3) to complete a GaAs RF digitizer chip, and design of a GaAs signal processing chip; and (4) to complete top level design of a signal processing system for K-band array feed signal combining.

**W89-70626** **310-30-71**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**COMMUNICATIONS SYSTEMS RESEARCH**
Laif Swanson 818-354-2757
(310-20-70; 310-20-72)

The objective of this RTOP is to develop digital communication systems technology required to meet the needs of Deep Space Network (DSN) supported missions for the 1990s and beyond, focusing on improving space communication capability at low cost. The work planned will involve four areas. First, coding/decoding and modulation/demodulation techniques for the future will be investigated and demonstrated, first in order to achieve a 2.0 dB reduction in required signal-to-noise ratio, and then using even more advanced error-correcting and source coding. The initial objective is being met by a coding experiment on Galileo, demonstrating a coding gain of more than 1 dB. The longer-term goal involves new research into channel codes and source codes. Second, communication efficiency will be improved for current codes and technology. For example, it has recently been noticed that the signal-to-noise ratio may not always be constant over a period of, say, ten seconds. This means that a better convolutional decoding method than the maximum likelihood decoder (MCD) may be available. Much of this work depends on analysis and computer simulation of various telemetry subsystems for use in evaluating proposed and planned changes in hardware or operations, which is an ongoing activity of this RTOP. Third, new telemetry systems are being developed using microcircuitry technology. This involves mathematical, algorithmic, and architectural research. This will lead to Deep Space Network (DSN) systems requiring less space, power, and maintenance, and most of all, will allow the implementation of telemetry systems as needed. Finally, communication and tracking in the 21st century will be studied during 1989.

**W89-70627** **310-30-72**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**VITERBI DECODER DEVELOPMENT**
Joseph I. Statman 818-354-6517
(310-30-70; 310-30-71)

The objective of this RTOP is to develop, build, test, and demonstrate a high-speed Viterbi decoder for long constraint length (K=15) convolutional codes. Such codes have the potential to improve telemetry link margin for spacecraft supported by the Deep Space Network (DSN) by up to 2 dB. This RTOP is based on previous Advanced Systems RTOP 71 accomplishments, namely the successful search for 2 dB coding gain and the development of in-house capabilities for custom and semi-custom very large scale integration (VLSI) integrated circuit design. The resulting coding gain is relatively low cost and complements alternative approaches to link performance improvement such as increasing antenna size, arraying antennas, and increasing the power transmitted from the spacecraft. The approach is to build a prototype BIG Viterbi decoder, denoted BVD, and test it using DSN facilities, e.g., CTA21. Following successful tests, the BVD will participate in a coding experiment with Galileo expected in May 1991. In this experiment, Galileo will transmit data encoded with a (15 1/4) convolutional encoder (that is being added to the spacecraft) at a rate of 134.4 Kbit(s). The BVD, located within a DSN station's telemetry chain will decode the received symbol stream in real time. If the BVD design is subsequently used for the main Galileo mission, resulting improvement in link margin, estimated to be 1.5 dB compared to (7 1/2) codes, will enable 30 percent increase in science data return, 100 percent increase in science return during Jupiter encounter, and substantial reduction in need for antenna arraying during subsequent Jupiter moons encounters. The BVD will be flexible enough to be used for similar experiments with other deep space missions, including existing probes such as Voyager, because it is designed as a fully programmable unit. Hence, any convolutional code with constraint length of up to 15 and code rate of 1/2 to 1/6 can be applied. During FY89 the main tasks are to: (1) finalize algorithms and other analysis; (2) complete VLSI design, develop and fabricate VLSI chips; (3) develop and fabricate the majority of the BVD hardware; (4) develop BVD operating software; (5) prepare test plan; (6) prepare for subsystem integration; and (7) present a critical design review (CDR) in early 1989.

**W89-70628** **310-40-37**
Goddard Space Flight Center, Greenbelt, Md.
**HUMAN-TO-MACHINE INTERFACE TECHNOLOGY**
Walter F. Truszkowski 301-286-8821

The objectives of this RTOP are to: (1) develop and apply natural man/machine interfaces for space payload and ground control systems including data base management systems; and (2) develop methodologies, models, interface evaluation tools, and guidelines which emphasize the human factors issues associated with man/machine interfaces and interactions. The intention is to apply recent advances in human factors analysis, data and information base management, and artificial intelligence (AI) to man/machine interface and interaction problems in order to realize development and operational improvements. The approach to be taken is: (1) to identify and apply state-of-the-art data/information management technology in the development of interface standards for distributed information access systems; and (2) to apply human factors analysis, information presentation guidelines and advanced knowledge engineering techniques and methodologies in the development and application of user interfaces to various data/information systems activity used in the mission and data operations environment. The RTOP is a system level RTOP supporting TDRSS operations, mission operations, mission support computing, and general systems engineering activities.

**W89-70629** **310-40-45**
Goddard Space Flight Center, Greenbelt, Md.
**MISSION OPERATIONS TECHNOLOGY**
Henry L. Murray 301-286-6149

The objective of this RTOP is to develop techniques and validate concepts that will improve Spacecraft Control Center operations efficiency and reliability and reduce mission operations costs. The intent of this effort is to apply and evaluate the latest computer graphics technologies, automation technologies and computer languages in the specific command and control environment where the technologies and languages will be used. The approach to achieving this objective has two major thrusts: (1) to study and prototype automation concepts in a spacecraft command and control environment. The spacecraft engineering analysis capability will be developed to enhance the ability of a spacecraft analyst to detect, isolate, and recover from a spacecraft problem; and (2) to assess tools for development of command and control software systems and enhancements of the human/computer language medium. This thrust is presently studying the applicability of artificial intelligence in the area of the man-machine interface for the Multi-Satellite Operations Control Center Application Processor Systems.

**W89-70630** **310-40-47**
Goddard Space Flight Center, Greenbelt, Md.
**EXPERT SYSTEMS FOR AUTOMATION OF OPERATIONS**
Dorothy C. Perkins 301-286-6887

Work under this RTOP will demonstrate the potential of expert systems to automate operations and increase operator capacity by handling routine, labor-intensive tasks and by reducing human task complexity. The development and demonstration of pilot projects which capture functions of control centers will facilitate the transfer of this technology into operations. Under this RTOP, expert systems will be developed and applied in selected areas to reduce, eliminate or assist human operator decision-making. Projects will be established with the operational divisions to develop proof-of-concept systems and transfer the technology for operational use. Systems will be developed with a phased approach to allow for early hands-on demonstration of kernel functions to potential users. The transfer of techniques, methodologies and expertise to the operational divisions will be a major goal. This RTOP will also demonstrate the architecture and effects of multiple cooperating expert systems, and will generalize from specific prototypes to multi-application frameworks. It will also support the embedding of expert systems in data systems.

**W89-70631** **310-40-48**
Goddard Space Flight Center, Greenbelt, Md.
**DATA STORAGE TECHNOLOGY**
Ward Horner 301-286-5804

The objective of this RTOP is to develop systems technology and evaluate storage components to provide high performance, low life cycle cost data storage systems to meet data capture, buffering, processing, and distribution requirements for future space missions. Commercial tape and disk subsystems have evolved functional, performance, and cost characteristics which now make them candidates in the development of high performance, cost effective mass storage systems. These systems will require distribution of data over multiple drives with appropriate failure mode control to ensure data integrity. NASA specific very large scale integration (VLSI) controllers for management of spacecraft telemetry processing and flow will be developed for use with commercial parallel disk controllers, disk drives, and standard interfaces. These elements will be used to prototype advanced data storage system architectures adaptable to a range of mission data rates. These systems will then be integrated with prototype VLSI telemetry handling systems being developed for the Data Interface Facility (DIF) and enhanced Packet Processor to perform higher level telemetry processing and routing functions.

**W89-70632** **310-40-49**
Goddard Space Flight Center, Greenbelt, Md.
**ADVANCED ENVIRONMENT FOR SOFTWARE AND SYSTEM DEVELOPMENT (SYSTEMS ENGINEERING AND MANAGEMENT TECHNOLOGY)**
Dorothy C. Perkins 301-286-6887

The objective of this RTOP is to develop and evaluate systems-level concepts and technologies which will be utilized to optimize the management, operation, and evolution of Space Tracking and Data Systems (STDS). Major subobjectives are: (1) the development of a database of network models and documentary procedures for systems modeling and simulation; and (2) the definition and phased prototype of an advanced software development environment. The RTOP approach is to develop associated tools and techniques, apply the techniques to representative problems, and evaluate both the techniques and the results prior to full utilization in STDS. This is a system-level RTOP supporting mission operations, mission support computing, spacecraft data acquisition, data processing, and Tracking and Data Relay Satellite System (TDRSS) operations.

**W89-70633** **310-40-51**
Goddard Space Flight Center, Greenbelt, Md.
**ADVANCED TELEMETRY PROCESSING TECHNOLOGY**
James A. Pritchard 301-286-7785

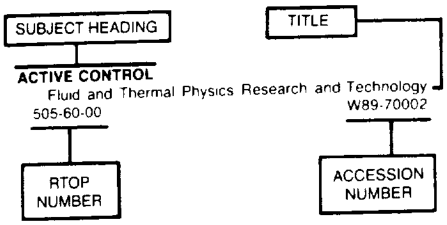
Work under this RTOP will evaluate alternative approaches to high data rate packet telemetry processing for parallel and nonparallel computer architecture developments applicable to Space Station era data systems. Current packet telemetry processing systems need to be improved by as much as three orders of magnitude in order to handle the expected data rates. New computer and system architectures and processing techniques must be explored and evaluated if new systems are to be developed to meet Space Station era processing requirements. Alternative approaches to telemetry processing (level zero processing and data handling functions) will be evaluated for parallel and nonparallel computer architecture; higher levels of telemetry processing will be studied; and telemetry processing systems architecture requirements for Space Station era data systems will also be studied. In order to evaluate alternative approaches to telemetry processing, computer architecture will be matched to high data rate telemetry processing requirements. Critical telemetry functions will be selected for benchmarking and computer architecture performance will be evaluated. Programming techniques and software conversion will also be evaluated. Level zero processing as well as higher levels of telemetry processing will be considered while investigating telemetry processing system architecture requirements. In order to accomplish the tasks, benchmarking of critical processing functions will be employed whenever possible.

**W89-70634** **310-40-73**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**NETWORK DATA PROCESSING AND PRODUCTIVITY**
N. R. Kuo 818-354-0475

The objective of this RTOP is to improve the Deep Space Network (DSN) data processing capability in anticipation of greater DSN user demand and to demonstrate the software technology which will lead to improvements in DSN software productivity. The work planned will involve five software engineering areas: (1) real-time system methodology - most of the DSN system is real-time applications: data acquisition, data monitoring, data communication, and data analysis. Research of real-time methodology will make improvements in the DSN system performance reliability, maintainability, and operability; (2) software design technique - the software design determines many of the crucial characteristics of the final system. Improvement of DSN system capability can be achieved by introducing new design techniques; (3) programming languages - modern constructs of tasking, packaging, information hiding and sophisticated data types are included in new programming languages. Programming methods using Ada and C(++) for real-time systems will be investigated to determine their value to DSN applications; (4) software scheduling - an effective software development scheduling method will enable the TDA program managers and the software developers to make accurate assessments of schedules and project plans; (5) software documentation techniques - the DSN software systems are becoming increasingly complex; documentation for maintenance and operations personnel must be more informative, up-to-date, and easier to use. Effective techniques will ensure that the transition to better documentation systems goes smoothly.

## RTOP SUMMARY

### Typical Subject Index Listing

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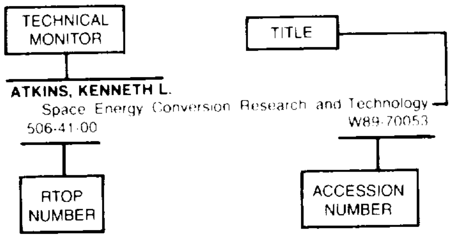


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# RESPONSIBLE NASA ORGANIZATION INDEX



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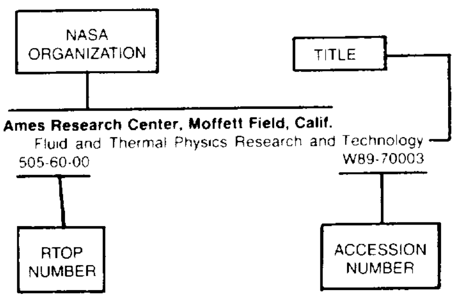


Listings in this index are arranged alphabetically by Responsible NASA Organization. The title of the RTOP provides the user with a brief description of the subject matter. The accession number denotes the number by which the citation and the technical summary can be located within the Summary Section. The titles are arranged under each Responsible NASA Organization in ascending accession number order.

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| 1. Report No. | 2. Government Accession No. | 3. Recipient's Catalog No. |
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| NASA TM-101203 | | |

| 4. Title and Subtitle | 5. Report Date |
|---|---|
| Research and Technology Objectives and Plans Summary Fiscal Year 1989 | January, 1989 |
| | 6. Performing Organization Code |
| 7. Author(s) | 8. Performing Organization Report No. |
| | 10. Work Unit No. |
| 9. Performing Organization Name and Address<br>National Aeronautics and Space Administration<br>Washington, DC 20546 | 11. Contract or Grant No. |
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15. Supplementary Notes

16. Abstract


This publication represents the NASA research and technology program for FY 1989. It is a compilation of the "Summary" portions of each of the RTOPs (Research and Technology Objectives and 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. The first section containing citations and abstracts of the RTOPs is followed by four indexes: Subject, Technical Monitor, Responsible NASA Organization, and RTOP Number.


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